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CULEX (CULEX) PIPIENS LINNAEUS (DIPTERA: CULICIDAE): CONCEPTS, TYPE DESIGNATIONS, AND DESCRIPTION[1]

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Abstract.—The history of the concept of *Culex pipiens* Linnaeus is reviewed. An illustration of a syntype published by Réaumur is designated as the lectotype of *pipiens.* A lectotype is also designated for *Culex bifurcatus* Linnaeus, which is stabilized as a synonym of *pipiens.* A neotype for *pipiens* is designated in place of the non-extant lectotype-specimen. The adult, pupal, and larval stages of the neotype are described and illustrated. Sexual differences are described and illustrated for the alloneotype. A description of diagnostic and variable characters is provided for each life stage of the species.

The present system of naming organisms originated with the work of Carolus Linnaeus, and the 10th edition of his *Systema Naturae* (1758) is the designated starting point of zoological nomenclature. In that volume, Linnaeus described six species of *Culex,* the first being *Culex pipiens.* The family Culicidae (Stephens, 1829) is based on the genus *Culex* for which *pipiens* is the type-species (Latreille, 1810). Of the other species described in 1758, only *Culex bifurcatus* remains in Culicidae, but has been treated as a synonym of *pipiens* (Martini, 1922; Edwards, 1932; Stone et al., 1959; Knight and Stone, 1977).

The Linnaean Collection is now the property of the Linnean Society of London. It includes two original mosquito specimens located in Diptera box 22 (transferred from old box 195). One of the specimens is a female bearing Linnaean labels (sense of Day and Fitton, 1978) inscribed "Culex." and "1. pipiens" (Fig. 1A–D). This specimen represents a species of *Aedes* (*Ochlerotatus*), but it is badly damaged and unidentifiable to species. The other specimen is a male of the *maculipennis* complex of *Anopheles* (White, 1978), and it bears a Linnaean label inscribed "2 bifurcatus." (Fig. 1E, F). These findings revealed the need to stabilize the Linnaean mosquito nomenclature relevant to the western Palearctic fauna (Dahl and White, 1977) and the taxonomy of the *pipiens* complex under investigation by the senior author as part of a revision of the *Culex* (*Culex*) of northern Africa and southwestern Asia.

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[1] The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the supporting agencies.

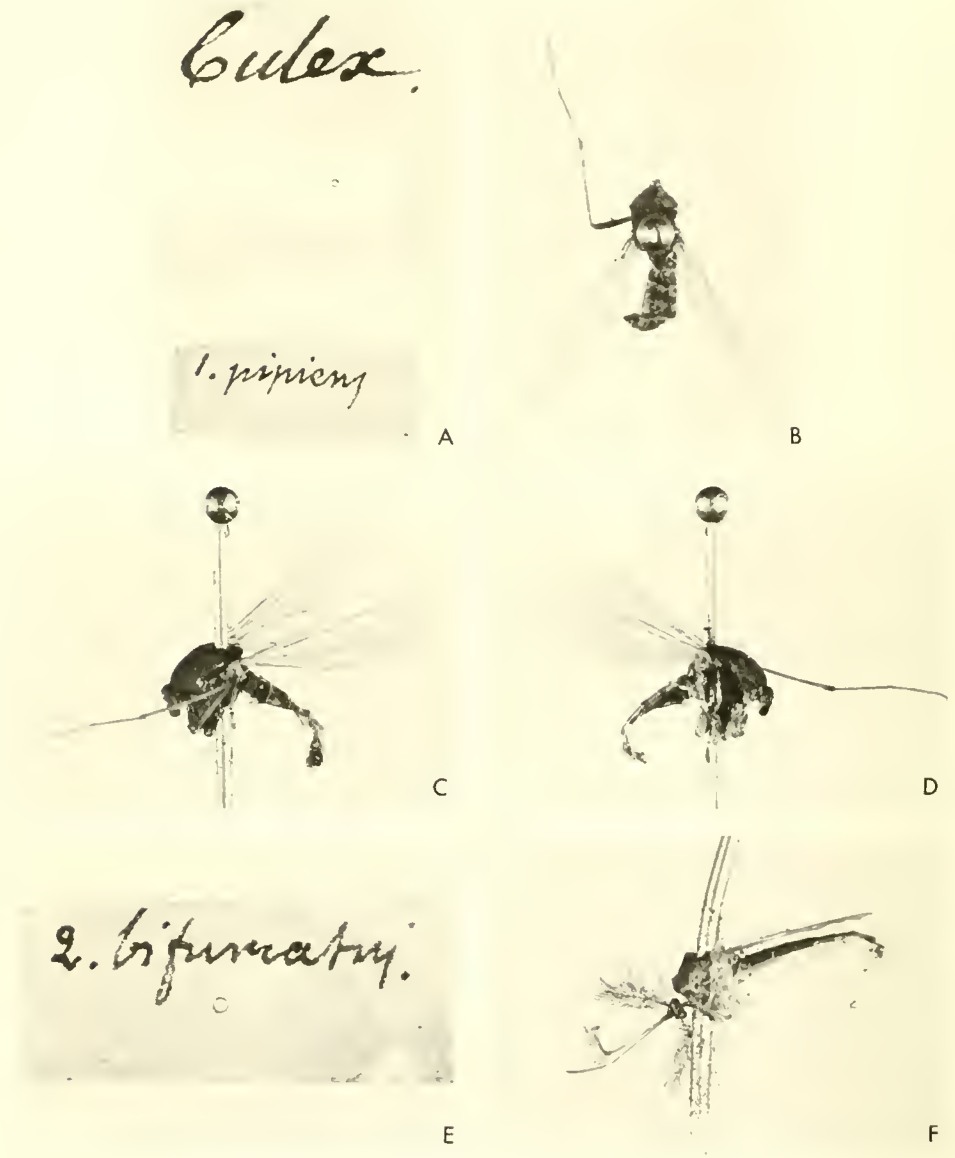


Fig. 1. A–D, Linnaean labels (A) accompanying the original female specimen (B–D) of *Culex pipiens* Linnaeus in the Linnaean Collection. The specimen actually belongs to a species of *Aedes* (*Ochlerotatus*). E, F, Linnaean label (E) accompanying the original male specimen (F) of *Culex bifurcatus* Linnaeus in the Linnaean Collection. The specimen actually belongs to a species of the *maculipennis* complex of *Anopheles*. B, dorsal aspect; C, F, left sides; D, right side.

There is no reason to doubt the authenticity of the mosquito specimens in the Linnaean Collection. Where Linnaean species are represented by a single specimen which bears a handwritten label with the specific name and the number of the species in the 10th edition of *Systema Naturae*, the specimen is likely to be a Linnaean original (Lindroth, 1957; Day and Fitton, 1978; Robinson and Nielsen, 1983). The specimen labelled *pipiens* also bears the generic name of *Culex* because it represents the first species which Linnaeus described for the genus.

The taxonomic units conceived by Linnaeus were based on conspicuous morphological characteristics, not phylogenetic interpretations. His concepts were much broader than ours. Accordingly, the genus *Culex*, as it was formalized in 1758, included species of Ceratopogonidae (*pulicaris*), Simuliidae (*reptans; equinus*) and Empididae (*sterocoreus*) in addition to Culicidae (Dyar and Knab, 1909; Knight, 1972). Regarding the Culicidae, it is obvious that Linnaeus discerned only two general kinds of mosquitoes, the twittering mosquito (*Culex pipiens*) and the mosquito with a forked beak (*Culex bifurcatus*). These concepts were published in the first edition of *Fauna Svecica* (Linnaeus, 1746, species numbers 1116 and 1115, respectively) before they appeared in the 10th edition of *Systema Naturae* along with their assigned specific names.

Reference made by Linnaeus (1746) to "Culex ipse in *sylvis*, praesitem *Lapponiae*" is evidence that he included forest *Aedes* in his concept of *pipiens*. On the other hand, Linnaeus cited illustrations in the works of Swammerdam (1737: pl. 31, Figs. 4–8; pl. 32, Figs. 1–5), Réaumur (1738: pls. 43, 44) and Joblot (1754: pl. 13, Figs. A–E, H, I, L) which unequivocally depict a species of *Culex* compatible with our modern concept of *pipiens* (see Réaumur's plates which are reproduced here in Figs. 2 and 3). Moreover, observations made by Linnaeus concerning "Hominibus & animalibus sono alarum & sanguinis suctu molestissimus" (1746) and "*Insectum pipiens, pungens*" (1758) imply that *pipiens* represented any culicine female known to him. Linnaeus (1758) recognized the ubiquity of these animals when he wrote "*Habitat in* Europae *aquosis; copiosissima in* Lapponia; *etiam in* America *obvia*." This statement is the source for what are regarded as the type-localities of *pipiens*.

Virtually all workers of the late 18th and early 19th centuries (notably: Linnaeus, 1761, 1767; Sulzer, 1761; Geoffroy, 1762; Scopoli, 1763; Schaeffer, 1766; De Geer, 1776; Fabricius, 1781, 1787, 1794, 1805; Schrank, 1781, 1803; Herbst, 1787; de Villers, 1789; Gmelin, 1790; Rossi, 1790; Olivier, 1791; Meigen, 1804; Latreille, 1809) used the name of *pipiens* in the sense of Linnaeus (1758). It was not until Meigen (1818) separated the genera of *Aedes* and *Anopheles* from *Culex* that the present concept of *pipiens* began to develop. This concept was founded on the descriptions and illustrations in the works cited by Linnaeus, particularly the detailed account of the immature stages given by Réaumur (1738) (see Figs. 2, 3). The exact identity of *pipiens* remained rather obscure until Dyar and Knab (1909) figured the male phallosome based on a comparison of specimens from Denmark, France, Hungary, and the United States. The current concept was fully realized when Martini (1925) distinguished and described *Culex torrentium*, a species previously confused with *pipiens* in Europe.

Incidentally, De Geer (1776) substituted the name of *Culex communis* for Linnaeus' concept of *pipiens*. This is evident from the synonyms De Geer lists under *communis*. Most important among these are *Culex pipiens* and the figures in Blankaart (1688), Swammerdam (1737), and Réaumur (1738) on which Linnaeus partially based his concept of this species. De Geer's two specimens of *communis* in the Naturhistoriska Riksmuseet, Stockholm, are actually species of *Culiseta*. This fact supports Linnaeus' broad concept of *pipiens* as including other culicine species. De Geer exchanged correspondence and specimens with Linnaeus

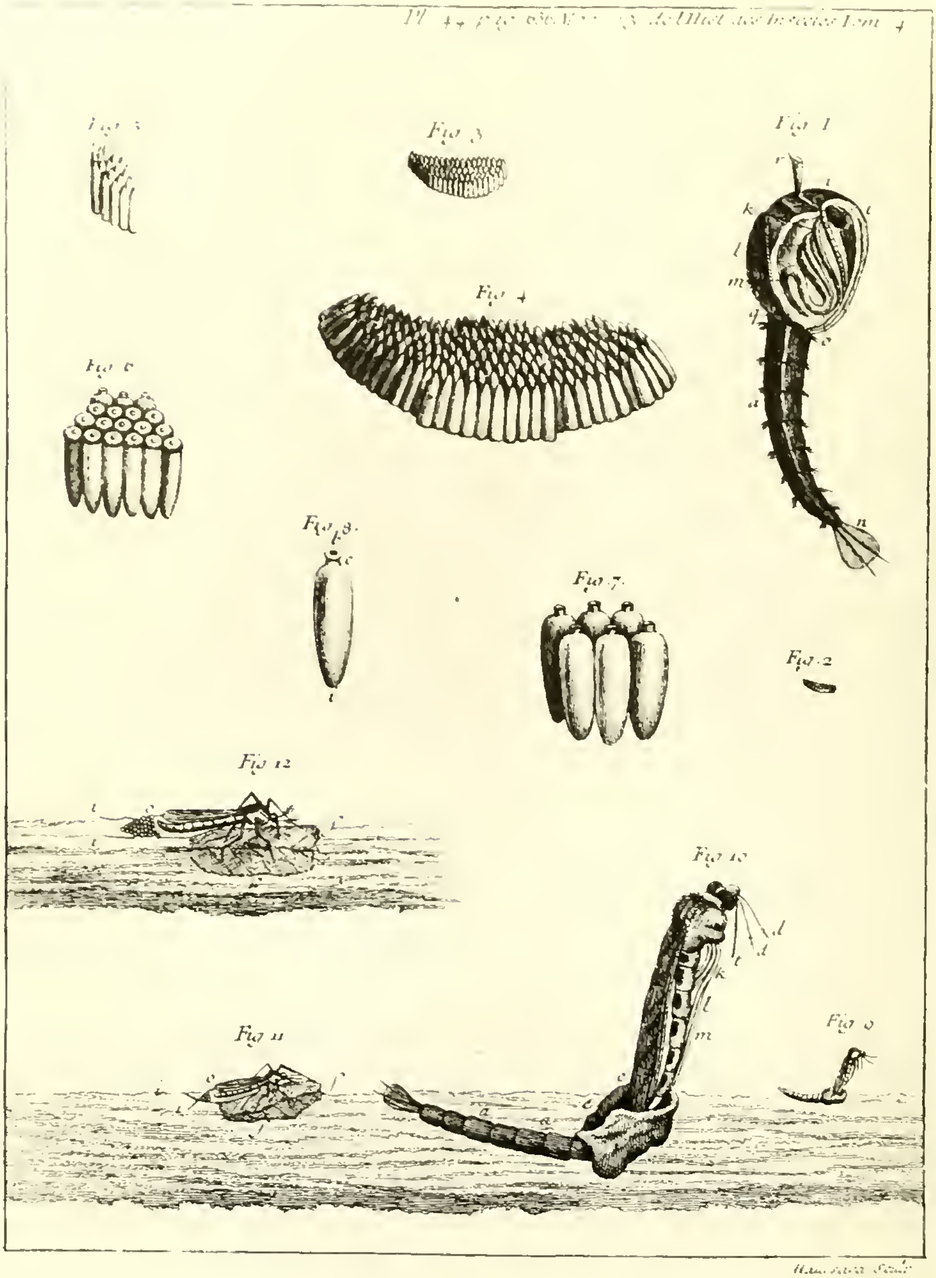


Fig. 2. Plate 44 of Réaumur (1738) on which Linnaeus (1758) partially based his concept of *Culex pipiens*. Notice that the eggs illustrated upside down bear a corolla ("col") characteristic of *Culex*.

who identified much of De Geer's material. Needless to say, *Culex communis* De Geer was treated as a synonym of *Culex pipiens* Linnaeus by most authors until Edwards (1921) revived the name for the species previously commonly referred to as *Aedes nemorosus* (Meigen). *Aedes communis* is now recognized as the nominotypical member of a sibling species complex (Ellis and Brust, 1973).

Culex pipiens is one of the most important mosquito species for reasons of its widespread abundance, biological characteristics, and taxonomic significance. Unfortunately, it belongs to a complex of species which represents one of the major outstanding problems in mosquito taxonomy. Basic to the resolution of this problem is the delimitation and fixation of the names of the taxa involved. The first step in this direction was taken by Belkin (1977) who established the priority of *Culex quinquefasciatus* Say over *Culex fatigans* Wiedemann and set the stage for Sirivanakarn and White (1978) to designate a neotype for *quinquefasciatus*. Recently, Harbach et al. (1984) designated a neotype to fix the identity of *Culex molestus* Forskål.

The need for a primary type-specimen for *Culex pipiens* is apparent. Obviously, acceptance of the venerable specimen in the Linnaean Collection as the "type" of *pipiens* (reasoning of Crosskey, 1974), or designation of this specimen as the lectotype (reasoning of Vane-Wright, 1975), would drastically upset the current concept of *pipiens* and catastrophically alter the accepted meaning of the genus *Culex*. Fortunately, the specimens portrayed in the published illustrations upon which Linnaeus founded his concept are valid syntypes of *pipiens* (Article 73b(i), *International Code of Zoological Nomenclature*, 1985). Accordingly, the larva illustrated by Réaumur (1738: pl. 43, Fig. 3) (see Fig. 3) is hereby designated lectotype of *Culex pipiens* Linnaeus. Unfortunately, Réaumur studied insects as natural history objects without preserving specimens for posterity, and the lectotype-specimen is non-extant (this does not invalidate the lectotype designation, see Article 74c of the *Code*). Furthermore, Réaumur's illustration of the lectotype does not show the characters which distinguish *pipiens* from *torrentium*. For these reasons, a neotype is designated below. It should be noted that the existence of a paralectotype (the Linnaean specimen in London) does not preclude the designation of a neotype (Article 75b(iii) of the *Code*).

The neotype designation satisfies all of the qualifying conditions of the *Code* except, perhaps, Article 75b(5) which requires that a neotype be collected as near as practicable to the original type-locality. As indicated above, the "original" type-locality of *pipiens* was very broad, comprising Europe, Lapland, and America (Linnaeus, 1758), but with the lectotype designation, the provenance of the type is restricted to France. However, the neotype selected below originated in Sweden. Thus, the neotype designation fixes a type-locality for *pipiens* which is not the same as that established by the lectotype. Nevertheless, we feel justified in selecting a neotype from elsewhere for the following reasons. First, emphasis was placed on obtaining specimens of the genus and species so well figured by Réaumur. Secondly, it seemed desirable to acquire material from a Swedish locality that could have been visited by Linnaeus. Finally, and most importantly, although material was available to us from France, none of it was individually reared and did not meet our high standards for type-material. A precedent for selecting a neotype from outside the original type-locality was established in the case of *Culex*

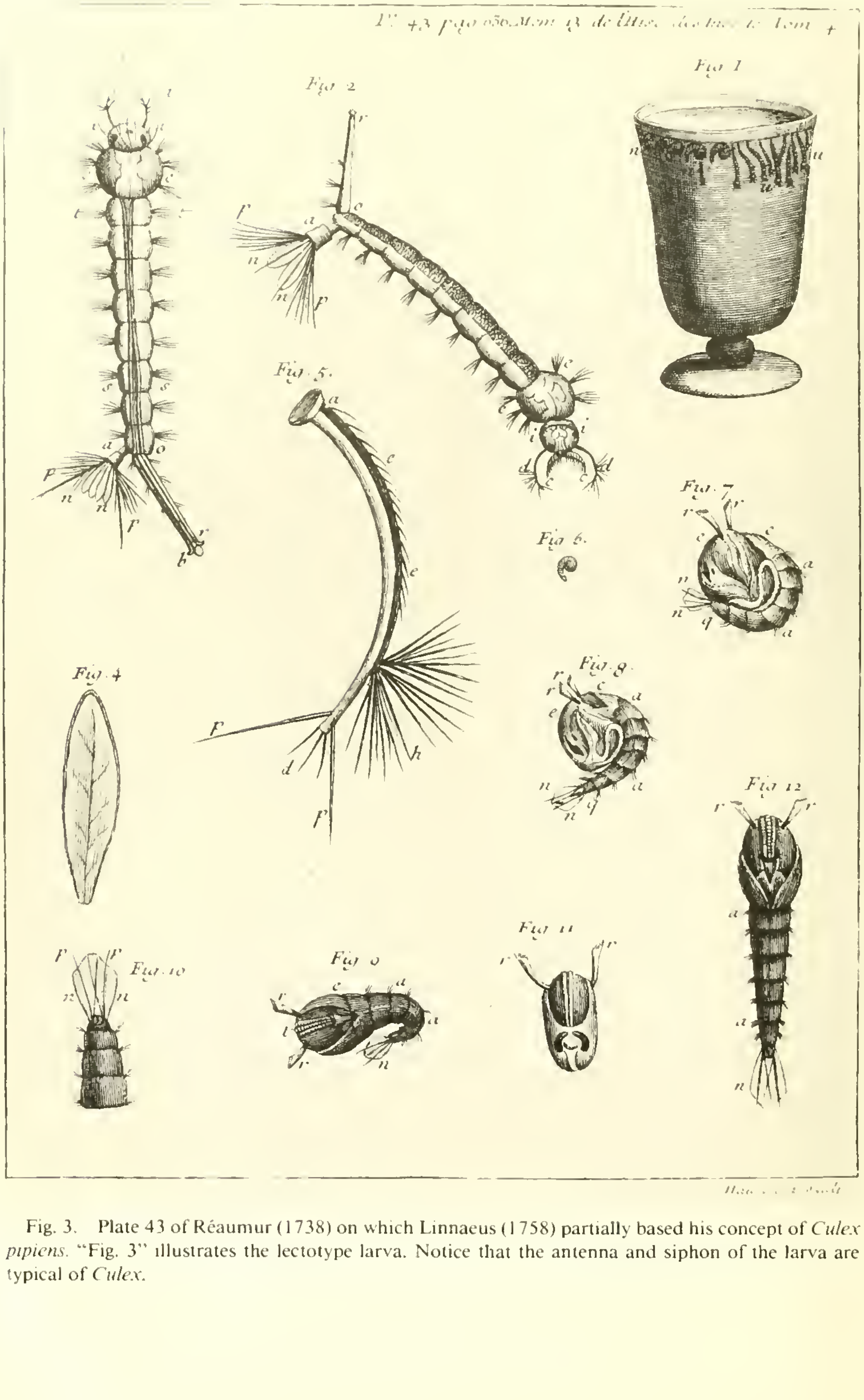


Fig. 3. Plate 43 of Réaumur (1738) on which Linnaeus (1758) partially based his concept of *Culex pipiens*. "Fig. 3" illustrates the lectotype larva. Notice that the antenna and siphon of the larva are typical of *Culex*.

aegypti Linnaeus (Mattingly et al., 1962; International Commission for Zoological Nomenclature, 1964).

The case of *bifurcatus* can be dealt with in parallel with that of *pipiens,* although neotype designation is unnecessary. When Linnaeus described *bifurcatus,* he cited figures 1 and 2 of plate 40 in Réaumur (1738) (reproduced here in Fig. 4) which clearly illustrate a *Culex* male, presumably belonging to the same species whose immature stages are illustrated on the plates which Linnaeus cites as representing *pipiens.* Unfortunately, the relation of the sexes was unclear to Réaumur, and he referred to the male as a separate species based on the character of the maxillary palpi. Furthermore, Réaumur regarded the palpi as a forked beak, and this, of course, influenced Linnaeus when he named *bifurcatus.* With this in mind, it appears that Linnaeus' concept of *bifurcatus* included any mosquito with long palpi, i.e., anophelines and male culicines. In any case, the figures cited by Linnaeus eventually led Martini (1922), the first reviser, to synonymize *bifurcatus* with *pipiens.* To stabilize this synonymy, the male illustrated by Réaumur (1738: pl. 40, Fig. 2) (see Fig. 4) is hereby designated lectotype of *Culex bifurcatus* Linnaeus. This action has the advantage of not destabilizing current usage of the name for whichever Palearctic species of *Anopheles* is represented by the Linnaean specimen.

Materials and Methods

Our original intention was to select a neotype for *pipiens* from specimens originating in Linnaeus' garden in Uppsala. To our disappointment, collections made there in the summer of 1983 contained only larvae of *Culex torrentium.* In August of the same year, two collections containing substantial numbers of larvae conforming to the prevailing concept of *pipiens* were made near Veberöd, Scania, Sweden. These were expeditiously shipped to Washington, DC, where the larvae were individually reared for study. A neotype (specific information is provided with the designation below) and an alloneotype were chosen from one of these collections. Seventy-eight adults (9 males and 6 females with pupal exuviae; 34 males and 29 females with larval and pupal exuviae) and 14 fourth-instar larvae comprised the collection containing the neotype and alloneotype. Additionally, 34 adults (9 males with pupal exuviae; 14 males and 11 females with larval and pupal exuviae) and 10 fourth-instar larvae were obtained from the second collection which was made in an old boat on the shore of Lake Krankesjö near the site where the neotype originated. The collections also yielded 392 specimens of *Culex torrentium:* some 67 males, 69 females, 136 pupal exuviae, 102 larval exuviae, and 18 fourth-instar larvae.

Detailed descriptions and illustrations of the adult, pupal, and larval stages of the neotype are provided. Characters which differ in the alloneotype are described, and some important adult sexual differences are illustrated. A description of diagnostic and variable characters for each life stage based on associated specimens is also included. Character measurements, setal counts, and setal branching counts were made on the neotype and alloneotype, and 10 specimens collected with them. The morphological terminology follows Harbach and Knight (1980), except that siphon indices were calculated using the basal width of the siphon rather than the width measured at midlength. Ratios of DV/D (Sundararaman, 1949) were determined using the method of Barr (1957).

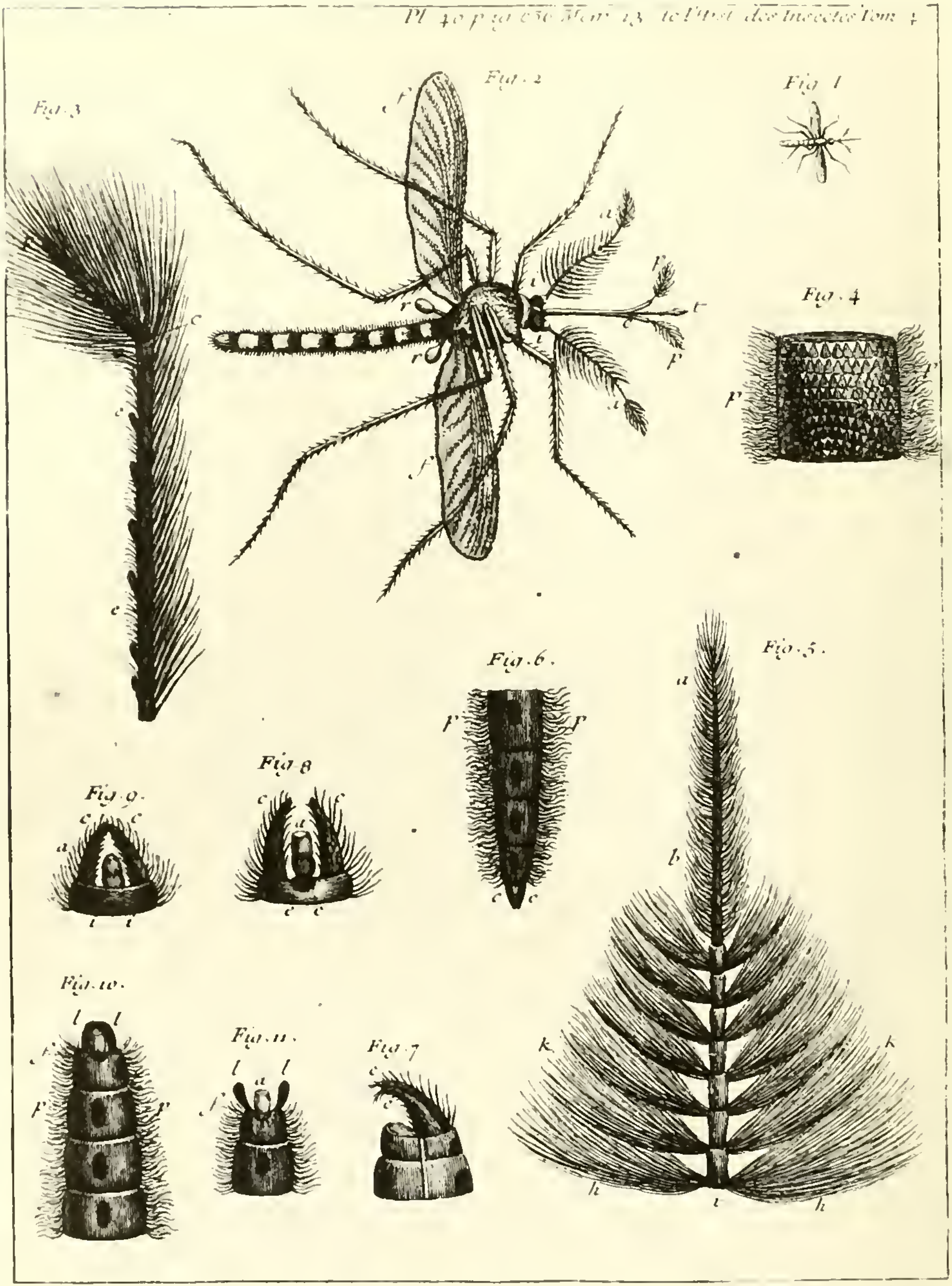


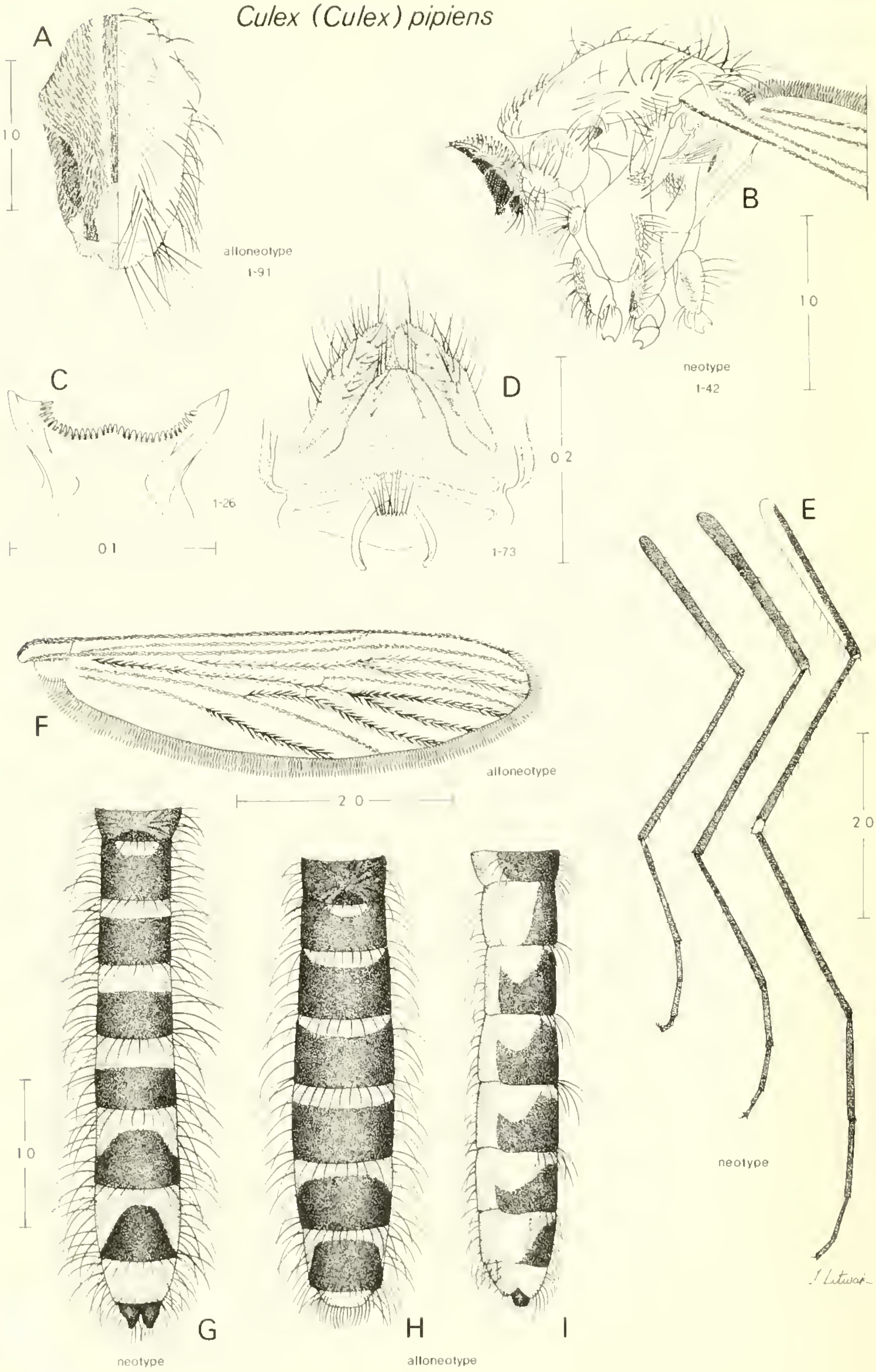
Fig. 4. Plate 40 of Réaumur (1738) showing figures 1 and 2 on which Linnaeus partially based his concept of *Culex bifurcatus*. "Fig. 2" illustrates the lectotype male.

Culex (*Culex*) *pipiens* Linnaeus

Neotype (hereby designated): ♂ (1–42) with associated larval and pupal exuviae and genitalia on slides, and with the following collection data: SWEDEN, Scania, Veberöd, Silvåkra farm, near Lake Krankesjö, open water reservoir (vessel), 15 m ASL, 23.8.1983, Coll. C. Dahl. Deposited in the National Museum of Natural History, Washington, DC, Type No. 101370.

Male (Neotype) (Fig. 5). A medium-sized mosquito closely resembling *Culex torrentium* Martini but without prealar scales and with different genitalia. Also closely resembling *Culex quinquefasciatus* Say and *Culex restuans* Theobald, but differing in the character of the scutal scaling, tergal banding, and genitalia. *Head:* Length of antennal flagellum 1.6 mm; flagellomeres 1-12 pale between whorls; flagellomeres 13 and 14 dark, combined length about 0.7 mm, approximately 0.45 of flagellum length; pedicel orange, black mesally. Proboscis mainly black-scaled, with ventral patch of white scales 0.3 to 0.7 from base; without ventral cluster of setae at false joint; length 2.2 mm, false joint 0.6 from base; labella dark. Length of maxillary palpus 2.9 mm, 1.3 of proboscis length, extending beyond tip of proboscis by length of palpomere 5; palpus mainly black-scaled, integument between palpomeres 2 and 3 pale; lateral surface of palpomere 3 with stripe of white scales 0.4 to 0.9 from base, stripe bordered ventrally by row of about 22 long black setae on distal 0.5 of palpomere, ventral surface devoid of scales and pale, with ventromesal row of about 18 small antrorsely-curved setae; palpomere 4 with nearly complete narrow ventral stripe of white scales; palpomere 5 with small patch of white scales ventrally at base; lateral surfaces of palpomeres 4 and 5 with long black setae that are longest at base of 4 and become gradually shorter toward apex of 5. Forked scales of vertex rather short, mainly dark, some pale medially; falcate scales narrow, pale yellow, slightly paler laterally; lateral spatulate scales yellowish white. Ocular setae black, antrorsely curved. Interocular space narrow, setae yellowish brown. *Thorax* (Fig. 5B): Pleural integument yellowish brown, darker anteriorly, faded posteriorly; scutal integument dark brown. Scutal scales fine, golden brown with slight reddish tint, somewhat finer on fossae and supraalar areas; integument and scales between supraalar and posterior dorsocentral setae not noticeably darker; pale yellow scales on outer margins of supraalar and prescutellar areas. Scutal setae nearly black (many prescutellar setae missing). Scutellum with narrow pale yellow falcate scales; 5 large setae on each lateral lobe (1 missing on left lobe), 8 on median lobe (6 missing). Antepronotum with 2 patches of narrow falcate scales, upper patch golden brown, scales of lower patch coarser and very pale yellow; setae mainly dark, pale ventrally. Postpronotum with golden-brown falcate scales, paler and slightly coarser posteriorly; with 5 setae on posterodorsal margin, longer and paler posteriorly. Pleural setae golden, numbers on left side as follows: 19 upper proepisternal in more or less double row, 10 prealar, 5 upper mesokatepisternal, 10 lower mesokatepisternal with uppermost seta very prominent, 7 upper mesepimeral, and 1 prominent lower mesepimeral. Pleural scales spatulate, few below upper proepisternal setae yellowish, others white and in patches as follows: patches on upper corner and lower posterior border of mesokatepisternum, anterior patch on mesepimeron at nearly same level as upper mesokatepisternal patch, and small patch before upper mesepimeral setae; without postspiracular and prealar scales. *Wing:* Length 3.4

Culex (Culex) pipiens



mm; cell R_2 2.9 of R_{2+3}; subcosta intersects costa before furcation of R_{2+3}; cell M_1 0.8 of cell R_2; scales entirely dark. Dorsal scaling: broad squame scales on costa, subcosta, R, R_1, and CuA; relatively narrow squame scales on R_{4+5}, M_1, M_2, M_{3+4}, mcu, and proximally on 1A; linear plume scales on R_s, R_{2+3}, R_2, R_3, M, M_{1+2}, and distally on 1A; remigium with 2 distinct rows of scales and 2 setae (3 on right wing) distally. Ventral scaling: squame scales on costa, subcosta, base of R_1, R_s, R_{2+3}, bases of R_2 and R_3, M_{1+2}, and bases of M_1 and M_2; plume scales on other veins and parts of veins except CuA before mcu and proximal 0.5 of 1A which are devoid of scales. *Halter:* Entirely pale. *Legs* (Fig. 5E): Anterior surface of forecoxa mainly black-scaled, with small basal patch of yellowish scales, anterior surface also with many long, nearly black, ventrally-curved setae, apex with 4 setae on posterior margin, most proximal seta nearly perpendicular to surface, others project ventrally; midcoxa with midlateral longitudinal row of 4 long dark setae and 6 or 7 short pale setae, setae margined anteriorly by longitudinal patch of white spatulate scales, anterior surface with small patch of black scales and several ventrally-projecting setae at apex; posterolateral surface of hindcoxa with longitudinal row of 7 long golden setae becoming gradually shorter from base to apex, anterolateral surface with narrow longitudinal row of nearly colorless scales and 4 short ventrally-projecting setae at apex, mesal surface with 2 dark setae at apex. Ventral surfaces of trochanters with white spatulate scales; anteroventral surface of fore- and midtrochanters with some black spatulate scales. Apices of all femora with narrow dorsal border of yellowish scales; forefemur with anterior surface black-scaled, posterior surface white-scaled; midfemur like forefemur but black scales extending over dorsal surface toward apex; hindfemur mainly white-scaled, with complete anterodorsal stripe of black scales gradually widening to extend over entire anterior and ventral surfaces just before apex. Foretibia mainly black-scaled, with white scales posteroventrally; midtibia with black scales anteriorly, white scales posteriorly; hindtibia mainly black-scaled, posteroventral surface with whitish scales, anterior and dorsal surfaces with whitish scales at apex. Tarsi black-scaled, tarsomere 1 of fore- and midlegs with some pale scales on posterior surface. Pulvilli pale. Ungues black; anterior foreunguis larger than posterior foreunguis, posterior foreunguis about 0.75 length of anterior foreunguis, both stout, anterior foreunguis with small ventral tooth near midlength, posterior foreunguis with small tooth nearer base; anterior midunguis like that of foreleg, posterior midunguis shorter and more slender than posterior unguis of foreleg but with tiny ventral tooth near midlength; hindungues very small, simple. *Abdomen* (Fig. 5G): Terga mainly black-scaled; tergum I golden setose, with posteromesal patch of black scales; posterior margins of terga II–VII with row of golden setae, median setae about length of basal band of next tergum, lateral setae longer, about 0.75 of tergum length; lateral scale-free areas of terga II–VII with long, laterally-directed, posteriorly-curved golden setae; tergum II with small basomedian spot

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Fig. 5. *Culex* (*Culex*) *pipiens* Linnaeus. A, Scutum of alloneotype female. B, Thorax of neotype male (left side). C, Female cibarial armature. D, Female genitalia. E, Legs of neotype male (anterior aspect of left legs). F, Right wing of alloneotype female (dorsal). G, Abdomen of neotype male (dorsal). H, I, Abdomen of alloneotype female (H, dorsal; I, left side). Scales in mm.

of yellowish scales; terga III–VII with basal yellowish bands 0.35 of tergum length, bands of terga V–VII produced posteriorly along lateral scale-free areas, particularly on terga VI and VII; anterior 0.5 of tergum VIII (ventral in position) with yellowish scales, posterior 0.5 with golden-brown setae and indistinct dusky scales, posterior margin without emargination in middle. Sterna II–VII mainly yellowish (scales same color as basal bands of terga), with some median black scales; sternum VIII (dorsal in position) mainly clothed with yellowish scales, with some subtle dark scales in middle; sterna II–VII golden setose, posterior margin of sternum VIII with row of golden setae. *Genitalia* (Fig. 6C–H): Ninth tergal lobes small, each with 12 setae in 2 irregular rows. Gonocoxite normal, ventrolateral setae strongly developed, these longer and stouter than lateral setae, mesal surface with 5 rows of small setae extending from base to level of subapical lobe; subapical lobe undivided, setae *a–f* in more or less straight row with gap between *c* and *d*, seta *g* immediately lateral to *d–f*, seta *h* lateral to *g*; *a–c* slightly curved, *a* stout and rodlike with blunt apex, *b* and *c* each with stout base, tapering distally and with apex hooked and pointed; *d–f* shorter than *a–c*, hooked apically, *d* and *e* slender, *f* laterally flattened and appearing broad in lateral view; *g* foliform, longer than broad, slightly asymmetrical, apex not sharply produced; *h* slender, bent distally. Gonostylus stout, curved, concave dorsal surface with 2 small, slender setae on distal 0.3; gonostylar claw short, broadest apically, troughlike. Phallosome longer than broad with lateral plates and aedeagus of nearly equal length; lateral plate with definite dorsal, lateral, and ventral arms, dorsal arm broad, apex nearly truncate, diverging laterally from its mate of the opposite side, appearing slightly sinuous in lateral view; lateral arm broad in lateral view, its posterior margin more or less trilobed, the ventral lobe more prominent than the others and bent ventrolaterally, base of lateral arm with thumblike dorsal process, base of this process continuous mesally with dorsal aedeagal bridge; ventral arm narrow and sharply curved with apex directed laterally; DV/D −0.03. Aedeagus subcylindrical, narrowed distally; ventral aedeagal bridge relatively wide, joining aedeagal sclerites just beyond midlength. Proctiger without distinctive features; paraproct with small, conical basal lateral arm, crown dark with numerous short, spinelike spicules. Cercal sclerite elongate, somewhat kidney-shaped, caudal margin irregular; 6 and 5 cercal setae on left and right sides, respectively. Tergum X rectangular, adjoining paraproct below and behind basal lateral arm.

Alloneotype: ♀ (1–91) with associated larval and pupal exuviae and same data as neotype.

Female (Alloneotype). Like neotype except as follows. *Head:* Length of antennal flagellum 2.1 mm, entirely dark, pedicel and flagellomere 1 with tiny pale scales on mesal surface. Ventral surface of proboscis with creamy-white scales 0.1 to 0.7 from base. Maxillary palpus entirely black-scaled; length 0.36 mm, about 0.16 of proboscis length. Forked scales of vertex more numerous, more pale scales medially. *Cibarial armature* (Fig. 5C, described and illustrated from specimens collected with the alloneotype): Cibarial crest concave, slightly produced in middle; with about 28 short, blunt teeth. Cibarial dome nearly elliptical in dorsal outline, produced anteriorly in middle; surface largely granular, imbricated posteriorly. *Thorax* (Fig. 5A): Scutal and pleural scales and setae same as neotype except scales and integument between supraalar and posterior dorsocentral setae noticeably darker, forming a pair of ovoid spots, and upper proepisternal scales more numerous, with small patch of indistinct dusky scales on mesal side of setae; postpronotum with 6 setae and few narrow spatulate scales interspersed with pale falcate scales posteriorly; numbers of pleural setae on left side differ as follows: 8 upper proepisternal, 8 prealar, 8 lower mesokatepisternal, and 9 upper mesepimeral. *Wing* (Fig. 5F): Length 4.3 mm; cell R_2 5.2 of R_{2+3}; subcosta intersects costa beyond furcation of R_{2+3}; cell M_1 0.75 of cell R_2; remigium of both wings with 2 setae. *Legs:* Like neotype except midcoxa with 5 large and 5 small setae in midlateral row; hindcoxa with 9 setae on posterolateral surface. Pulvilli distinct. Ungues small, simple, black; fore- and midungues stouter than hindungues. *Abdomen* (Fig. 5H, I): Tergum II with basomedian spot of yellowish scales and lateral patches of white scales; terga III–VII with basal bands of yellowish scales and basolateral spots of white scales, spots becoming gradually larger on succeeding posterior terga and actually cover entire lateral surfaces of tergum VII, bands 0.25 of tergum length, slightly convex on terga III and IV and not quite reaching spots, straight on terga V–VII and contiguous with spots, bands of terga VI and VII slightly produced posteriorly along mesal side of spots; tergum VIII clothed with whitish scales. Sterna II–VII like those of neotype; sternum VIII with whitish scales on lateral margins, broad median area without scales. *Genitalia* (Fig. 5D, described and illustrated from specimens collected with the alloneotype): Sternum VIII with rounded median posterior emargination. Tergum IX narrow, posterolateral margin with 6–8 setae. Upper vaginal lip narrow, distinct; 8–11 insular setae in dense cluster immediately anterior to indistinct lower vaginal lip. Upper vaginal sclerite distinct, U-shaped. Postgenital lobe short, apex evenly rounded, with submedian row of 7 setae extending from dorsal to ventral surface over apex. Cercus short, laterally compressed, apex bluntly rounded, lateral and ventral surfaces setose; cercus/dorsal postgenital lobe index about 2.3.

Specimens collected with the neotype and alloneotype exhibited the following variation. *Head:* Proboscis length 2.16–2.26 mm, mean 2.20 mm. Maxillary palpus of female sometimes with some pale scales dorsally on palpomere 4, length 0.36–0.40 mm, mean 0.39 mm; length of palpus in male 2.80–3.00 mm, mean 2.9 mm, often extending beyond tip of proboscis by less than length of palpomere 5. *Thorax:* Ovoid spots of scutum usually moderately distinct in dorsal aspect, usually indistinct in lateral view; acrostichal and fossal scales often as dark as ovoid spots in females. Postpronotum with 5–9 setae, most often with 5. Pleural setae as follows: females with 8–13 and males with 18–25 upper proepisternal; both sexes with 8–12 prealar, 4–7 upper mesokatepisternal, 8–13 lower mesokatepisternal, and 5–12 upper mesepimeral. Prealar area occasionally with few inconspicuous pale scales immediately below setae (present on one side in 5♂ and 5♀ of 108 specimens examined). *Wing:* Length 4.3–4.5 mm in females, 3.4–3.7 mm in males; cell R_2/R_{3+4} 4.9–5.5 in females, 2.6–3.6 in males; cell M_1/cell R_2 0.72–0.82. *Abdomen:* Basal bands of terga always yellowish, usually 0.25–0.40 of tergum length in males, 0.15–0.35 in females, bands in males usually like those of neotype, bands in females variable as follows: basomedian spot of tergum II often nearly lost, tergum III frequently with convex basomedian spot, bands of terga VI and VII often very narrow, that of VII sometimes absent in middle. Tergum VIII of female with yellowish or whitish scales, scales usually paler than those of basal bands of proceeding terga; sometimes with some dark scales posteriorly in middle. Sterna almost always with dark scales medially, dark scales sometimes on proximal 0.5 only, sometimes arrayed as speckles, often forming complete stripe; sternum VIII of males (dorsal in position) usually largely pale with dusky scales posteriorly in middle, sometimes entirely pale. *Genitalia* (of male): DV/D zero to −0.19, mean −0.09 (for 15 specimens).

Pupa (Neotype) (Fig. 6A, B). Character and positions of setae as figured. *Cephalothorax:* Lightly tanned, legs, scutum, metanotum, and metathoracic wings darker. *Trumpet:* Moderately tanned, subcylindrical, gradually widened distally, index 4.9; tracheoid area darker, extending 0.3 from base; pinna oblique, about length of tracheoid area. *Abdomen:* Lightly tanned, terga I–VI darker in middle; length 2.9 mm. *Genital lobe:* Lightly tanned; length 0.3 mm. *Paddle:* Lightly tanned, midrib and buttress darker; outer margin without distinct spicules; midrib distinct except at apex; length 0.9 mm, width 0.6 mm, index 1.5.

The alloneotype resembles the neotype except as follows: trumpet index 5.4, abdominal length 3.3 mm; genital lobe length 0.2 mm; paddle 1.0 × 0.7 mm with index 1.4.

Table 1 lists the range and modal number of branches for pupal setae observed in the neotype, alloneotype, and 10 associated specimens. Diagnostic and variable characters follow. *Cephalothorax:* Setae 1, 2-CT with 3–5 branches; 3, 4-CT with 2 or 3 branches, commonly 3; 5-CT usually with 5 branches (3–6); 6-CT usually with 3 branches (1–4); 7, 9, 11-CT double; 10-CT frequently with 6 branches (6–13); 12-CT usually double (2–4). *Trumpet:* Index 4.8–6.9, mean 5.5. *Abdomen:* Seta 6-I, II single; 7-I, II usually double; 1-II usually with more than 20 branches (15–26); 1-III–V frequently with at least 6 branches, 1-III usually with 8 branches (6–10), 1-IV usually with 6 or more branches (3–8), 1-V most often with 6 branches (4–6); 2-II, VII lateral to seta 1, 2-III–VI mesal to 1; 5-IV usually triple, sometimes with 4 or more branches; 5-V–VII almost always double; 6-III, IV most often with 3 branches, 6-V, VI most often with 4 branches. *Paddle:* Index 1.2–1.6, mean 1.4.

Larva (Neotype) (Fig. 7). Character and placement of setae as figured. *Head:* Wider than long, length 0.7 mm, width 1.0 mm; approximately anterior 0.5 lightly tanned, labiogula, lateralia posterior to seta 10-C, and dorsal apotome behind seta 5-C moderately tanned. Median labral plate narrow but distinct, anterior margin slightly emarginate between insertions of seta 1-C. Labiogula narrower anteriorly than posteriorly, length about same as posterior width; hypostomal suture complete, extended posterolaterally from posterior tentorial pit to near collar. Collar best developed along lateralia, heavily tanned. Mouthparts developed for filter-feeding. Dorsomentum with 8 and 9 teeth on left and right sides of median tooth, respectively. *Antenna:* Length 0.5 mm, 0.7 length of head; moderately tanned, mesal surface with dark spot at base; seta 1-A 0.7 from base, part proximal to seta 1-A with strongly-developed aciculae mainly on dorsal and lateral surfaces, distal part slender and smooth except for few short aciculae laterally near seta 1-A. *Thorax:* Integument hyaline, tubercles of all large setae

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Fig. 6. *Culex* (*Culex*) *pipiens* Linnaeus, neotype male. A, B, Pupa (A, dorsolateral aspect of cephalothorax, left side; B, dorsal and ventral aspects of left side of metathorax and abdomen). C–H, Genitalia, aspects as indicated (C, gonocoxite; D, phallosome; E, F, lateral plate and aedeagal sclerite; G, tergum IX; H, proctiger and terga X). Scales in mm.

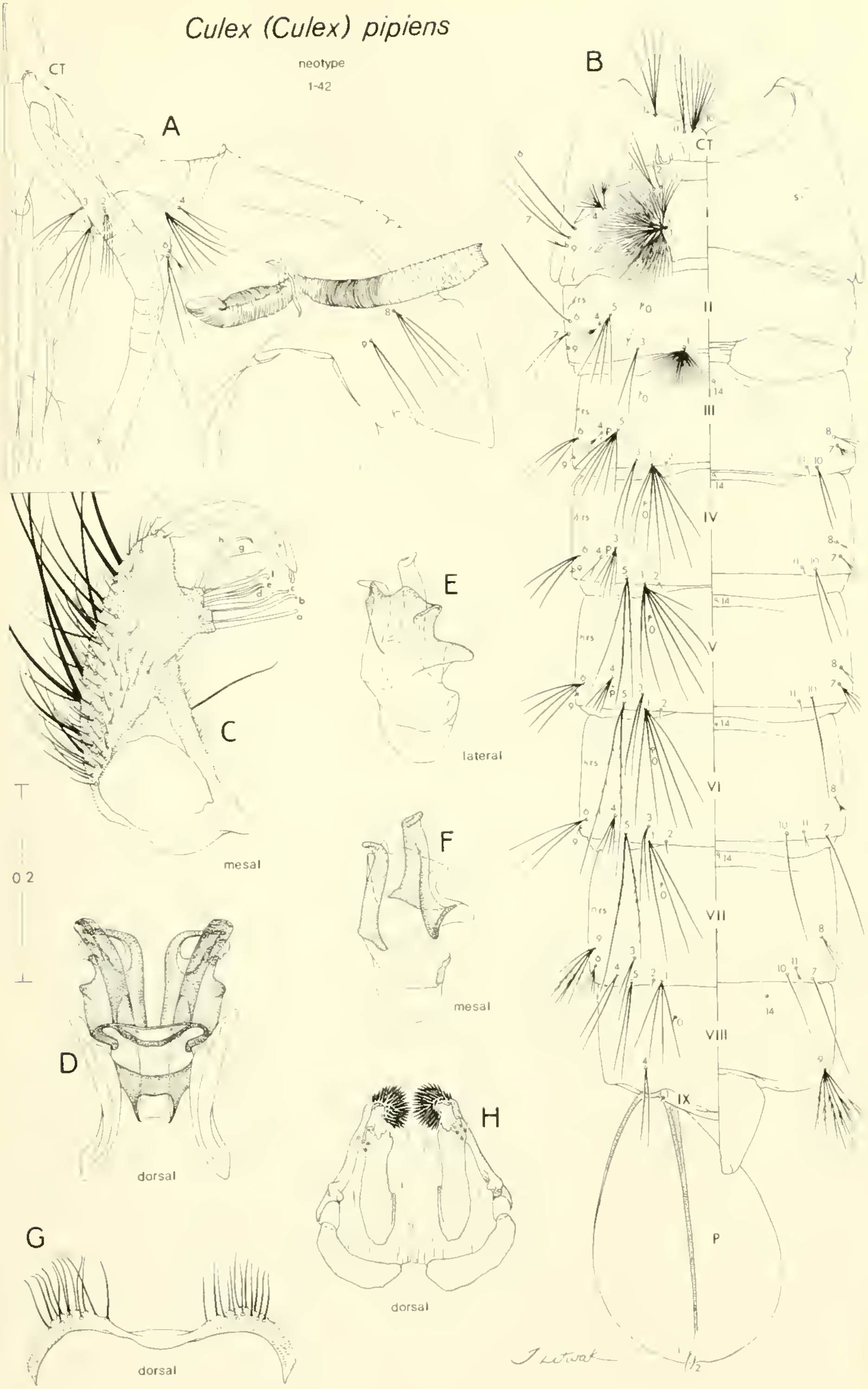

Culex (Culex) pipiens
neotype
1-42
A
CT
B
CT
I
II
III
IV
V
VI
VII
VIII
IX
P
C
mesal
E
lateral
F
mesal
D
dorsal
H
dorsal
G
dorsal
0 2
1 0
J Lutwak

Table 1. Number of branches for pupal setae of *Culex* (*Culex*) *pipiens* Linnaeus.[a]

Seta Number	Cephalothroax CT	Abdominal Segments I	II	III	IV	V	VI	VII	VIII	IX	Paddle P
0	—	—	1	1	1	1	1	1	1	—	—
1	3–5 (4)[b]	33–77 (60)	15–26 (24)	6–10 (8)	3–8 (6)	4–6 (6)	3–5 (4)	3–6 (4)	—	1	1, 2 (1)
2	3–5 (4)	1	1, 2 (1)	1	1	1	1	1	—	—	1
3	2, 3 (3)	2, 3 (2)	2	2	4–7 (6)	2	2	2, 3 (2)	—	—	—
4	2, 3 (3)	4–8 (6)	3–6 (4)	3–7 (5)	1–4 (2)	3–6 (4)	2–5 (4)	2	2	—	—
5	3–6 (5)	4–6 (4)	3–7 (5)	4–8 (5)	2–6 (3)	2	1–3 (2)	1, 2 (2)	—	—	—
6	1–4 (3)	1	1	2–4 (3)	2–4 (3)	3–5 (4)	2–5 (4)	2–6 (4)	—	—	—
7	2	2, 3 (2)	2	3–7 (6)	2–5 (3)	3–6 (4)	1	1	—	—	—
8	3–6 (4)	—	—	3–6 (5)	2–4 (3)	2–5 (3)	3–5 (4)	2–4 (4)	—	—	—
9	2	1, 2 (1)	1	1	1	1	1	3–5 (4)	5–9 (6)	—	—
10	6–13 (6)	a[c]	—	2	2	1	1	1	—	—	—
11	2	1, 2 (2)	—	1	1	1, 2 (1)	1–3 (2)	2–5 (3)	—	—	—
12	2–4 (2)	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—
14	—	—	—	1	1	1	1	1	1	—	—

[a] Based on counts made on the neotype and alloneotype, and 10 specimens collected with them.

[b] Range (mode).

[c] Alveolus only.

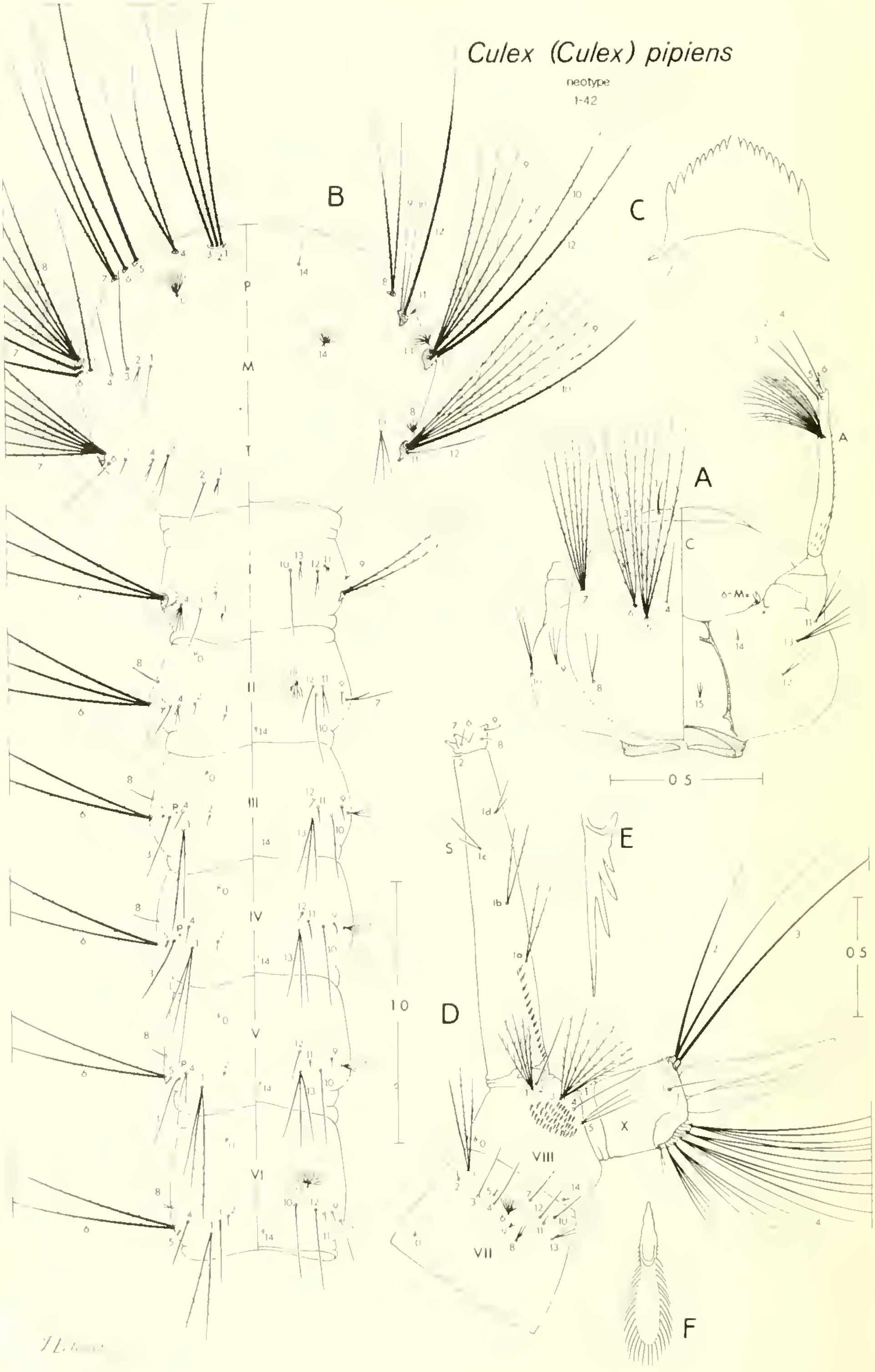
moderately tanned; setae 1-3-P and 9-12-P, M, T on common tubercles. *Abdomen:* Integument hyaline, tubercles of setae 7-I, 6-I-VI and 1, 3-VIII moderately tanned, tubercle of setae 2, 3-X heavily tanned. *Segment VIII:* Comb consisting of 40 and 42 scales on left and right sides, respectively; scales short, evenly fringed on sides and apex, arranged in 4 irregular rows. *Siphon:* Index 5.0; subcylindrical, broadest at base, slightly sigmoid in lateral view; moderately tanned, darker at base; acus attached, longer on posterior side of attachment. Pecten on basal 0.3 of siphon, that of left and right sides with 14 and 11 spines, respectively, spines increasing in size from base of siphon, larger spines with 3 long basal denticles. Seta 1-S in 4 pairs, 1a-S very near most distal pecten spine, 1c-S distinctly out of line with others. *Segment X:* Saddle complete; moderately tanned, darker dorsally; posterodorsal area with minute spicules; length 0.3 mm. Ventral brush (seta 4-X) with 6 pairs of setae arising from grid, setae increasing in length posteriad, most posterior seta 7.5 length of most anterior. Anal papillae elongate, subacutely tapered; dorsal pair longer than ventral pair, dorsal pair twice length of saddle.

The alloneotype resembles the neotype except for minor differences in the number of branches of some setae, and principally as follows: length of head 0.8 mm, width the same; comb with 49 and 52 scales on left and right sides, respectively; siphon index 4.9, pecten with 17 and 16 spines on left and right sides, respectively.

Table 2 lists the range and modal number of branches for larval setae determined from the neotype, alloneotype, and 10 associated specimens. Diagnostic and variable characters include the following. *Head:* Seta 1-C slender, tapered distally, slightly bent mesad; 3-C distinct; 2-C absent; 4-C single, rather long; 5-C frequently with 4 branches (4–6); 6-C most often with 4 branches (3–5); 7-C resembles 5, 6-C, with 6–10 branches; 8, 10-C usually double (2, 3); 11, 12, 13-C double or triple, 13-C occasionally with 4 branches; dorsomentum most often with 10 teeth (8–11) on either side of median tooth. *Thorax:* Setae 1-3-P single, nearly of equal length; 4, 7, 8-P double rarely single; 11-P usually with 4 or 5 branches (3–7). Seta 1-M usually single, occasionally double, about 0.5 length of 3-M; 3-M single; 4-M usually double, occasionally single. Seta 1-T short, 0.5 or less length of 2-T, most often double (1–4); 2-T usually single or double, infrequently with 3 or 4 branches. *Abdomen:* Seta 3-I, VII usually single, sometimes double (3-I double on at least one side in 27 of 112 specimens examined; 3-VII double in only 16); seta 6-I-VI long, 6-I, II usually with 3 branches (2–4), 6-III–VI double; 7-I resembles 6-I, almost always double; 1-III-VI usually double, one branch longer than the other. *Segment VIII:* Comb with 37–57 scales, mean 44; seta 1-VIII most often with 5 branches; 3-VIII frequently with 7 branches; 5-VIII with 3 or 4 branches, more often with 4. *Siphon:* Always slightly S-shaped in lateral view; index 4.5–5.8, mean 5.0; pecten with 11–17 spines, most often with 14; usually with 4 pairs of seta 1-S (in 112 specimens examined, 3 with 3 on one side, 9 with 5 on one side and 2 with 5 on both sides). *Segment X:* Seta 1-X usually single (double on one side in 10, and both sides in 3, of 112 specimens examined); ventral brush (seta 4-X) almost always with 6 pairs of setae.

DISCUSSION

Culex pipiens and *Cx. torrentium* are the only species of *Culex* (*Culex*) known to occur in central and northern Europe. As mentioned earlier, *Cx. torrentium*



Culex (Culex) pipiens

neotype

1-42

was confused with *pipiens* until Martini (1925) recognized it as a separate species. Since these species frequently occur together in the same habitat, it is possible that the figures published by the authors cited by Linnaeus (1758) were based on specimens of either *pipiens* or *torrentium* or both. Nevertheless, the concept of *pipiens* which has been handed down to us is that explicitly defined by Dyar and Knab (1909). This is the species we collected, reared, and selected as the neotype, alloneotype, and associated specimens of *Culex pipiens.*

In the adult stage, *Cx. pipiens* is reliably differentiated from *torrentium* by the character of the male genitalia. In *torrentium,* the posterior margin of the lateral plate bears a spiculate lobe and the dorsal arms are pointed. Mattingly (1951) denoted that *torrentium* could be distinguished from *pipiens* by the presence of prealar scales, but this character is not totally reliable (Service, 1968; Jupp, 1979; Onyeka, 1982). Prealar scales are occasionally absent in *torrentium* and sometimes present in *pipiens.* We have noted that specimens of *torrentium* contained in our two collections bear an inconspicuous dorsal pale spot at the apex of the foretibia. The potential diagnostic value of this character needs to be investigated in other populations of *torrentium.*

The larvae of *pipiens* and *torrentium* are similar. Natvig (1948) could not differentiate them and considered all larvae examined from Scandinavia and Finland to be *pipiens.* Sicart (1954) reported that the character of seta 1-X might be useful for separating the larvae of these species. He observed that seta 1-X was single in *pipiens* and double in *torrentium.* Later, Callot (1957) and Doby and Rault (1960) relied on this character to separate *pipiens* and *torrentium* in France. But as Service (1968) discovered, this seta may be single or double in either species, and cannot be used to separate them with confidence. As a matter of course, we examined the larval chaetotaxy of *torrentium* for comparison with that of *pipiens.* In so doing, we found that *torrentium* could usually be separated from *pipiens* by the character of seta 1-T. The length of this seta was normally greater than one-half the length of seta 2-T in *torrentium* and less than one-half in *pipiens.* In cases where this seta was missing, obstructed from view, or its length was questionable, the following combination of characters identified *torrentium*: setae 3-I, VII and 1-X usually double with 3-I sometimes triple. These setae are usually, but not always, single in *pipiens.* Never were all three setae single in any one specimen of *torrentium* or double in any one specimen of *pipiens.* Seta 3-I was never triple in *pipiens.*

The taxonomy of the *pipiens* complex is an enigma complicated by interpretational difficulties and controversy associated with a number of bewildering morphological, behavioral/physiological, and genetic issues. An understanding of these issues is intimately related to the resolution of the *pipiens* complex. On the other hand, the delimitation and fixation of the concepts and their names for the taxa involved is fundamental to all taxonomic, morphological, behavioral/physiological, and genetic studies. Neotypes have now been designated for the three

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Fig. 7. *Culex* (*Culex*) *pipiens* Linnaeus, neotype male, larva. A, Head (dorsal and ventral aspects of left side). B, Thorax and abdominal segments I–VI (dorsal and ventral aspects of left side). C, Dorsomentum. D, Abdominal segments VII–X (left side). E, Pecten spine. F, Comb scale. Scales in mm.

Table 2. Number of branches for setae of the fourth-instar larva of *Culex* (*Culex*) *pipiens* Linnaeus.[a]

Seta Number	Head	Thorax			Abdominal Segments								
	C	P	M	T	I	II	III	IV	V	VI	VII	VIII	X
0	1	9–18 (11)[b]	—	—	—	1	1	1	1	1	1	1	—
1	1	1	1, 2 (1)	1–4 (2)	1–5 (3)	1–3 (1)	2–4 (2)	2, 3 (2)	2, 3 (2)	2, 3 (2)	2–4 (3)	4–6 (5)	1, 2 (1)
2	—	1	1–4 (2)	1–4 (1)	1	1	1	1	1	1	1	1	2
3	1	1	1	1–6 (3)	1, 2 (1)	1	1	1	1	1	1	4–8 (7)	1
4	1, 2 (1)	2	1, 2 (2)	2–6 (4)	4–10 (6)	2–5 (5)	1–3 (1)	1	2–4 (3)	1, 2 (2)	1	1	1–7 (5)
5	4–6 (4)	1	1	1	2–7 (4)	1–3 (1)	1–3 (1)	1–3 (1)	1–3 (2)	2–4 (2)	2–4 (3)	3, 4 (4)	—
6	3–5 (4)	1	1	1, 2 (1)	2–4 (3)	2, 3 (3)	2	2	2	2	8–17 (10)	1a–S	—
7	6–10 (7)	2	1, 2 (1)	5–9 (7)	1, 2 (2)	2–5 (4)	3–7 (6)	4–8 (5)	4–6 (5)	1	1	2, 3 (2)	—
8	2, 3 (2)	1, 2 (2)	4–6 (5)	6–16 (9)	—	1	1	1	1	2–4 (2)	2–5 (3)	1b–S	—
9	3–6 (4)	1	4–7 (5)	5–7 (6)	1–3 (2)	1	1	1	1	1, 2 (1)	2–7 (5)	2, 3 (2)	—
10	2, 3 (2)	1	1	1	1	1	1	1	1	1	1	1c–S	—
11	2, 3 (3)	3–7 (4)	1–4 (2)	1–4 (2)	3–7 (6)	1–4 (2)	1, 2 (2)	1–3 (2)	1, 2 (2)	1–3 (3)	1–4 (2)	2–4 (2)	—
12	2, 3 (2)	1	1	1	2, 3 (2)	1–3 (2)	1, 2 (1)	1, 2 (1)	1	1	1	1d–S	—
13	2–4 (3)	—	15–26 (18)	3–6 (4)	1–4 (2)	9–21 (12)	2–6 (3)	3, 4 (3)	3, 4 (3)	19–35 (24)	2–4 (3)	2–4 (2)	—
14	1, 2 (1)	1, 2 (2)	12–30 (17)	—	—	—	1	1	1	1	1	1	—
15	2–4 (3)	—	—	—	—	—	—	—	—	—	—	—	—

[a] Based on counts made on the neotype and alloneotype, and 10 specimens collected with them.

[b] Range (mode).

principal nominal forms of the *pipiens* complex: *Culex quinquefasciatus* Say, *Culex molestus* Forskål, and *Culex pipiens* Linnaeus. With this, an important step has been taken toward resolving the taxonomy of this important group of species.

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LITERATURE CITED

Barr, A. R. 1957. The distribution of *Culex p. pipiens* and *C. p. quinquefasciatus* in North America. Am. J. Trop. Med. Hyg. 6: 153–165.

Belkin, J. N. 1977. *Quinquefasciatus* or *fatigans* for the tropical (southern) house mosquito (Diptera: Culicidae). Proc. Entomol. Soc. Wash. 79: 45–52.

Blankaart, S. 1688. Schou-Burg der Rupsen, Wormen, Ma'den, en Vliegende Dierkens daar uit voorkomende. Door eigen ondervindinge by een gebragt. Amsterdam. vi + 232 pp., 17 pls.

Callot, J. 1957. Sur *Culex torrentium* Martini. Ann. Parasitol. Hum. Comp. 32: 438–442.

Crosskey, R. W. 1974. The British Tachinidae of Walker and Stephens (Diptera). Bull. Br. Mus. (Nat. Hist.) Entomol. 30: 267–308.

Dahl, C. and G. B. White. 1977. Culicidae, pp. 390–395. *In* Illies, J., ed., *Limnofauna Europaea*. Gustav Fischer Verlag, Stuttgart.

Day, M. C. and M. G. Fitton. 1978. Re-curation of the Linnaean Hymenoptera (Insecta), with a reassessment of the taxonomic importance of the collection. Biol. J. Linn. Soc. 10: 181–198.

De Geer, C. 1776. Mémoires pour servir à l'histoire des insectes. Vol. 6. Stockholm. 523 pp., 30 pls.

de Villers, C. J. 1789. Linnaei entomologia, faunae suecicae descriptionibus aucta; D. D. Scopoli, Geoffroy, De Geer, Fabricii, Schrank, &c. speciebus vel in systemate non enumeratis, vel nuperrime detectis, vel speciebus Galliae australis locupletata, generum specierumque rariorum iconibus ornata. Lugduni. ii + 656 pp., 4 pls.

Doby, J. M. and B. Rault. 1960. Complément a l'étude des caractères morphologiques différentiels de *Culex pipiens* Linné, 1758 et de *Culex torrentium* Martini, 1924 (Diptera Culicidae). Cah. Nat. 16: 113–121.

Dyar, H. G. and F. Knab. 1909. On the identity of *Culex pipiens* Linnaeus. Proc. Entomol. Soc. Wash. 11: 30–39.

Edwards, F. W. 1921. A revision of the mosquitoes of the Palaearctic Region. Bull. Entomol. Res. 12: 263–351.

———. 1932. Genera Insectorum. Diptera. Fam. Culicidae. Fascicle 194. Belgium. 258 pp.

Ellis, R. A. and R. A. Brust. 1973. Sibling species delimitation in the *Aedes communis* (Degeer) aggregate (Diptera: Culicidae). Can. J. Zool. 51: 915–959.

Fabricius, J. C. 1781. Species insectorum exhibentes eorum differentias specificas, synonyma, auctorum, loca natalia, metamorphosin adjectis observationibus, descriptionibus. Vol. 2. Hamburgi et Kilonii. 517 pp.

———. 1787. Mantissa insectorum sistens species nuper detectas adjectis characteribus genericis, differentiis specificis, emendationibus, observationibus. Vol. 2. Hafniae. 382 pp.

———. 1794. Entomologia systematica emendata et aucta, secundum classes, ordines, genera, species adjectis synonymis, locis, observationibus, descriptionibus. Vol. 4. Hafniae. vi + 472 pp.

———. 1805. Systema Antliatorum secundum ordines, genera, species adjectis synonymis, locis, observationibus, descriptionibus. Brunsvigae. xiv + 372 pp. + 31 unnumbered pages.

Geoffroy, E. L. 1762. Histoire abrégée des insectes qui se trouvent aux environs de Paris; Dans laquelle ces animaux sont rangés suivant un ordre méthodique. Vol. 2. Paris. 690 pp., 22 pls.

Gmelin, J. F. 1790. Caroli a Linné, Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Ed. 13, Vol. 1, Pt. 5. Lipsiae, pp. 2225–3020.

Harbach, R. E. and K. L. Knight. 1980. Taxonomists' glossary of mosquito anatomy. Plexus Publishing, Inc., Marlton, New Jersey. xi + 415 pp.

Harbach, R. E., B. A. Harrison, and A. M. Gad. 1984. *Culex* (*Culex*) *molestus* Forskål (Diptera: Culicidae): neotype designation, description, variation, and taxonomic status. Proc. Entomol. Soc. Wash. 86: 521–542.

Herbst, J. F. W. 1787. Kurze Einleitung zur Kenntniss der Insekten für Ungeübte und Anfänger. Vol. 3. Berlin und Stralsund. 200 pp., 48 pls.

International Code of Zoological Nomenclature. 1985. Third edition. International Trust for Zoological Nomenclature, London. xx + 338 pp. [Publication of the Code was originally scheduled for 31 December 1984. In the preparation of this manuscript, the authors were kindly permitted by a member of the Editorial Committee to quote from the final draft of the Code in anticipation of its publication in 1984. The provisions of the Code are effective as of 1 January 1985 (Bull. Zool. Nomencl. 1984, 41: 196).]

International Commission for Zoological Nomenclature. 1964. Opinion 711. *Culex aegypti* Linnaeus, 1762 (Insecta, Diptera): validated and interpreted under the plenary powers. Bull. Zool. Nomencl. 21: 246–248.

Joblot, L. 1754. Observations d'histoire naturelle, faites avec le microscope, sur un grand nombre d'insectes, & sur les animalcules qui se trouvent dans les liqueurs préparées, & dans celles qui ne le sont pas, &c. avec la description & les usages des differens microscopes, &c. Vol. 1, Pt. 2. Paris. 124 pp. + 15 pls.

Jupp, P. G. 1979. *Culex* (*Culex*) *pipiens* and *Culex* (*Cx.*) *torrentium* (Diptera: Culicidae) in England: Notes on their taxonomy and biology. Mosq. Syst. 11: 121–126.

Knight, K. L. 1972. History of mosquito systematics Part I. Eighteenth century. Mosq. Syst. 4: 10–15.

Knight, K. L. and A. Stone. 1977. A catalog of the mosquitoes of the world (Diptera: Culicidae). 2nd edition. Thomas Say Found. 6: 1–611.

Latreille, P. A. 1809. Genera crustaceorum et insectorum secundum ordinem naturalem in familias disposita, iconibus exemplisque plurimis explicata. Vol. 4. Parisiis et Argentorati. 399 pp., 4 pls.

———. 1810. Considérations générales sur l'ordre naturel des animaux composant les classes des Crustacés, des Arachnides et des Insectes avec un tableau méthodique de leurs genres disposés en familles. Paris. 444 pp.

Lindroth, C. H. 1957. The Linnaean species of carabid beetles. Linn. Soc. J. Zool. 43: 325–341.

Linnaeus, C. 1746. Fauna Svecica sistens Animalia Sveciae Regni: Qvadrupedia, Aves, Amphibia, Pisces, Insecta, Vermes, distributa per classes & ordines, genera, & species. Cum differentiis specierum, synonymis autorum, nominibus incolarum, locis habitationum, descriptionibus insectorum. Stockholmiae. xxiv + 411 pp., 2 pls.

———. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Ed. 10, Vol. 1. Holmiae. 824 pp.

———. 1761. Fauna Svecica sistens Animalia Sveciae Regni: Mammalia, Aves, Amphibia, Pisces, Insecta, Vermes. Distributa per classes & ordines, genera & species, cum differentiis specierum, synonymis autorum, nominibus incolarum, locis natalium, descriptionibus insectorum. Editio Altero. Stockholmiae. xlv + 578 pp., 2 pls.

———. 1767. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Ed. 12 (ref.), Vol. 1, Pt. 2. Holmiae. pp. 533–1327.

Martini, E. 1922. Zur Nomenclatur der für Mitteleuropa wichtigsten Stechmücken. Entomol. Mitt. 11: 106–126.

———. 1925. Zwei bemerkenswerte Culiciden von einem eigenartigen Biotop. Int. Rev. Hydrobiol. Hydrogr. 12: 333–337.

Mattingly, P. F. 1951. *Culex* (*Culex*) *torrentium* Martini, a mosquito new to Britain. Nature (Lond.) 168: 172.

Mattingly, P. F., A. Stone, and K. L. Knight. 1962. *Culex aegypti* Linnaeus, 1762 (Insecta, Diptera); proposed validation and interpretation under the plenary powers of the species so named. Bull. Zool. Nomencl. 19: 208–219, 1 pl.

Meigen, J. W. 1804. Klassification und Beschreibung der europäischen zweiflüglichen Insekten (Diptera Linn.). Vol. 1, Pt. 1. Braunschweig. xxviii + 152 pp., 8 pls.

———. 1818. Systematische Beschreibung der bekannten europäischen zweiflügligen Insekten. Vol. 1. Aachen. xxxvi + 333 pp., 11 pls.

Natvig, L. R. 1948. Contributions to the knowledge of the Danish and Fennoscandian mosquitoes—Culicini. Nor. Entomol. Tidsskr. (Suppl. I). xxiii + 567 pp., 12 pls., 1 map.

Olivier, G. M. 1791. Encyclopedie methodique. Histoire naturelle. Insects. Vol. 6. Paris. 704 pp.

Onyeka, J. O. A. 1982. The taxonomic value of pre-alar scales in the identification of *Culex* (*Culex*) *pipiens* L. and *Culex* (*Cx.*) *torrentium* Martini (Diptera: Culicidae). Mosq. Syst. 14: 41–52.

Réaumur, R. A. F. de. 1738. Mémoires pour servir à l'histoire des insectes. Vol. 4. Paris. xxxvi + 636 pp., 44 pls.

Robinson, G. S. and E. S. Nielsen. 1983. The microlepidoptera described by Linnaeus and Clerck. Syst. Entomol. 8: 191–242.

Rossi, P. 1790. Fauna Etrusca sistens Insecta quae in provinciis Florentina et Pisana praesertim collegit. Pt. 1. Liburni. xxii + 348 pp. + 6 unnumbered pages, 10 pls.

Schaeffer, J. C. 1766. Elementa Entomologica. Einleitung in die Insektenkenntniss; 135 ausgemahlte Kupfertafeln. Regensburg. ix + 135 pp., 135 pls.

Schrank, F. von P. 1781. Enumeratio insectorum Austriae indigenorum. Augustae Vindelicorum. xxii + 548 pp. + 4 unnumbered pages, 4 pls.

———. 1803. Fauna Boica. Vol. 3, Pt. 1. Landshut. 272 pp.

Scopoli, J. A. 1763. Entomologia Carniolica exhibens insecta Carnioliae indigena et distributa in ordines, genera, species, varietates methodo Linnaeana. Vindobonae. xxxvi + 420 pp.

Service, M. W. 1968. The taxonomy and biology of two sympatric sibling species of *Culex*, *C. pipiens* and *C. torrentium* (Diptera, Culicidae). J. Zool. (Lond.) 156: 313–323.

Sicart, M. 1954. Présence de *Culex torrentium* dans les Pyrénées et comparaisons avec *Culex pipiens* du même gite. Bull. Soc. Hist. Nat. Toulouse 89: 228–230.

Sirivanakarn, S. and G. B. White. 1978. Neotype designation of *Culex quinquefasciatus* Say (Diptera: Culicidae). Proc. Entomol. Soc. Wash. 80: 360–372.

Stephens, J. F. 1829. A systematic catalogue of British insects: being an attempt to arrange all the hitherto discovered indigenous insects in accordance with their natural affinities. Part II. Balwin and Cradock, London. 388 pp.

Stone, A., K. L. Knight, and H. Starcke. 1959. A synoptic catalog of the mosquitoes of the world (Diptera, Culicidae). Thomas Say Found. 6: 1–358.

Sulzer, J. H. 1761. Die Kenntzeichen der Insekten nach Anleitung des Konigl. Schwed. Ritters u. Leibarztes Carl Linnaeus durch 24 Kupferfeln erläutert und mit derselben natürlichen Geschichte erläutert; mit einer Vorrede des Herrn Johannes Geesners. Zürich. xxviii + 67 pp.

Sundararaman, S. 1949. Biometrical studies on intergradation in the genitalia of certain populations of *Culex pipiens* and *Culex quinquefasciatus* in the United States. Am. J. Hyg. 50: 307–314.

Swammerdam, J. J. 1737. Bybel der natuur, door Jan Swammerdam Amsteldammer. Of histoire der Insecten etc. Joannis Swammerdammii Amstelaed. Biblia naturae; sive Historia Insectorum, in classes certas redacta, nec non exemplis, et anatomico variorum animaliculorum examine, aeneisque tabulis illustrata. Insectis numerosis rariorum naturae observationibus. Omnia Lingua Batava, Auctori vernacula, conscripta. Accedit Praefatio, in quo vitam Auctoris descripsit Hermannus Boerhaave Med. Prof. Latinam versionem adscripsit Hieron. Vol. 1. Leydae. 550 pp. + 56 unnumbered pages.

Vane-Wright, R. I. 1975. The butterflies named by J. F. Gmelin (Lepidoptera: Rhopalocera). Bull. Br. Mus. (Nat. Hist.) Entomol. 32: 19–64, 6 pls.

White, G. B. 1978. Systematic reappraisal of the *Anopheles maculipennis* complex. Mosq. Syst. 10: 13–44.

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A EUROPEAN PRIVET SAWFLY, *MACROPHYA PUNCTUMALBUM* (L.): NORTH AMERICAN DISTRIBUTION, HOST PLANTS, SEASONAL HISTORY AND DESCRIPTIONS OF THE IMMATURE STAGES (HYMENOPTERA: TENTHREDINIDAE)

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Abstract.—*Macrophya punctumalbum* (L.), a widespread European sawfly known in North America previously from Ontario, Quebec and British Columbia, is recorded from New York; this is a new United States record. Known host plants are members of the Oleaceae, with privet (*Ligustrum* spp.) appearing to be the primary food plant. Seasonal history and habits were studied at Ithaca, New York, during 1982-83. Overwintering occurs in the last larval (or prepupal) stage. Adults begin to appear in mid- to late May. Eggs, laid under the upper epidermis of leaves, begin to hatch by early to mid-June, larvae mature by early to mid-July, and drop to the ground by late August to construct earthen cocoons. Adult feeding produces irregular "rasping" marks and rectangular holes on the upper leaf surfaces, and larvae chew circular holes in the leaves. A diagnosis of the adult is given, and the egg and last instar larva are described and illustrated.

Macrophya punctumalbum (L.), a European privet sawfly, occurs widely in all of Europe (including the British Isles) to the Caucasus (Benson, 1952; Schwenke, 1982). It is the only species of the genus *Macrophya* Dahlbom known from the Nearctic and Palearctic Regions. Presumably introduced into Canada from Europe some time in the early 1900s or before, it is now well established in eastern Canada (numerous records given by Gibson, 1980). Earliest records are from Toronto, Ontario, in 1932, and Vancouver, British Columbia, in 1934 (Gibson, 1980).

Our attention first focused on this introduced sawfly as early as the spring of 1979, when one of us (WTJ) noticed unfamiliar feeding damage to an ornamental planting of California privet (*Ligustrum ovalifolium* Hassk.) on the Cornell University campus (Ithaca, New York). At that time, no adult or larval insect could be associated with the damage. It was not until late May 1983, when we collected adult females of *M. punctumalbum*, that we were able to implicate this sawfly as the pest species involved.

In this paper we review the North American distribution of this introduced species and give new United States records based on our own collecting in New York. We also summarize our observations on the biology, habits, and seasonal history at Ithaca, New York; provide recognition features for the adults; and describe and illustrate the egg and last instar larva.

North American Distribution

In addition to published records from Ontario, Quebec and British Columbia (Gibson, 1980: 133), the following new records for the United States can be given.

New York: Tompkins Co., Ithaca (Cornell University campus, Red Barn), 24 May 1982, early June 1982, and additional collections in May and early June 1983. *Niagara Co.*, Niagara Falls, 12 June 1983 (this record is based solely on adult feeding damage to California privet (*L. ovalifolium*) in a hedge of a private residence). A thorough examination of undetermined sawflies in the Cornell University Insect Collection produced a single female specimen collected at Ithaca, NY, in late May 1975.

HOST PLANTS AND DAMAGE

Known host plants of *M. punctumalbum* are members of the olive family, the Oleaceae. *Fraxinus* and *Ligustrum* appear to be the primary hosts across its native European range (Enslin, 1913; Korolkov, 1913; Schwenke, 1982). *Fraxinus excelsior* L. and *Ligustrum vulgare* L. are recorded as hosts in the British Isles (Cameron, 1882; Benson, 1952). Pomerantzev (1930) observed the species causing "considerable damage to ash [*F. excelsior*] in European Russia." Korolkov (1913) noted that larvae of this sawfly severely damaged ash trees in the Alexander Garden (Moscow, Russia), "the leaves being skeletonized."

In North America (eastern Canada), Gibson (1980) recorded "*Fraxinus penns.*" [= *F. pennsylvanica* Marsh.] and "*F. americana*?" as hosts, citing ecological data from labels affixed to specimens examined during the course of his studies of North American *Macrophya*. Since 1940, *M. punctumalbum* has been found infesting privet hedges in the Toronto area (Ontario) (Anon., 1949; Brown, 1942; Foott, 1973). In addition, it has caused "serious injury to privet hedges" in the St. Catharines area (Niagara Peninsula, Ontario) (Anon., 1959), and in Montreal, Quebec (Anon., 1965).

Gibson (1980) noted that *M. punctumalbum* has been reared from *Syringa* (lilac) in Canada; *Syringa villosa* Vahl. was cited as an associated host plant at Etobicoke Twp. (Toronto metropolitan area). At our study site, at least two species of *Syringa* (*S. vulgaris* L. and *chinensis* Willd.) occur within 15 meters of the privet hedge where our observations were made; foliage of only the common lilac (*S. vulgaris*) showed some feeding damage by *M. punctumalbum.*

On California privet, adult feeding damage consisted of irregular "rasping" marks on the upper epidermis of leaf surfaces (Fig. 1). Adult sawflies also produce shiny, black fecal material which is deposited as irregular tarlike spots (up to 2 mm in diameter) on the upper leaf surfaces and new shoots (Fig. 1). These fecal spots wash or drop off the leaves by late summer.

Early instar larvae excavate circular holes (1–3 mm in diameter) in the interior of the leaves (Fig. 2). Larval feeding occurs primarily, if not exclusively, on the lower surfaces, except in the final feeding stage. The young larvae move into a curled (head to tail) posture to feed. Mature, full-grown larvae (Fig. 3), which reach a maximum length of about 18 mm, are capable of consuming the foliage, leaving only the midrib and lateral veins intact.

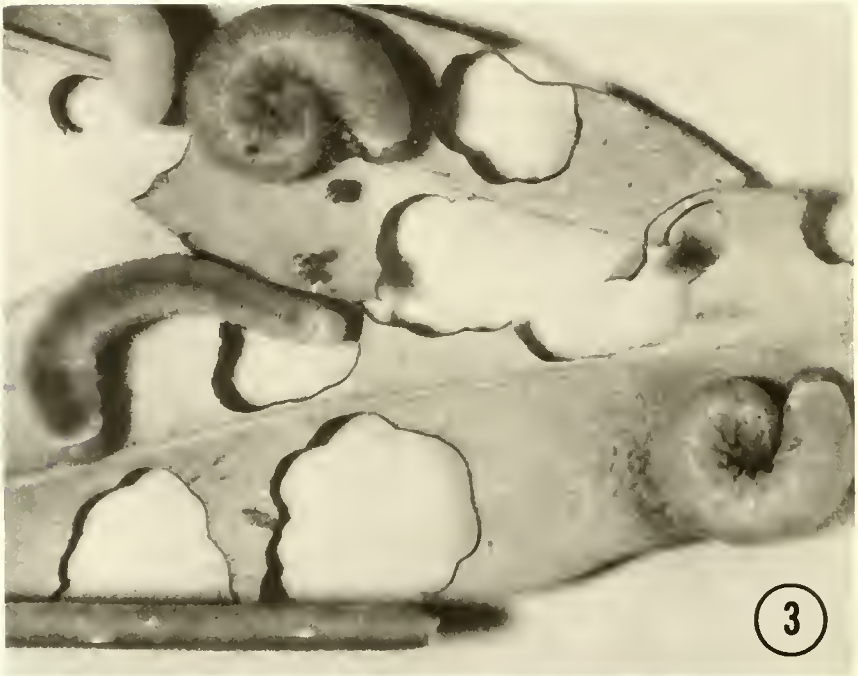
SEASONAL HISTORY AND HABITS

The biology and habits of *M. punctumalbum* in Europe given by Pomerantzev (1930), Korolkov (1913), and Mrkva (1965) are similar to what we report here, based on our observations at Ithaca, New York, during 1982–83.

Adults (predominantly females; males are generally scarce) first appeared on

Figs. 1–2. Privet foliage damaged by European privet sawfly, *Macrophya punctumalbum*. 1, Privet foliage damaged by adult sawfly feeding, characterized by the irregular "rasping" marks and rectangular holes, and the tarlike spots. 2, Feeding damage by adults and larvae; the small round holes in the interior of the leaves and the irregular leaf margins are caused by larvae.

privet foliage and began feeding by mid- to late May of both seasons, producing characteristic "rasping" marks and rectangular holes on the leaf surfaces. By June 6 (in 1982), females had oviposited under the upper epidermis of leaves, with eggs placed singly or in chains of 2–7. The oviposition site is marked by a small "blister" (per single egg), usually at the apex or periphery of the leaf (Fig. 5A, B). The embedded eggs are also visible from the under surface of the leaf. Also on June 6, early instar larvae were present on the foliage and beginning to feed. Females apparently oviposit over an extended period as first instar larvae can be found in the field until late June. Adult females become scarce by mid- to late June, and disappear shortly thereafter. By early July, nearly mature larvae were found on the foliage, together with various intermediate stage larvae. By early August, fewer larvae can be found; mature larvae have dropped from the foliage and presumably go into the soil to construct earthen cocoons. However, some mature and intermediate stage larvae have been observed on the foliage as late as August 24 (in 1982). The last stage larva (or prepupa) probably overwinters. A single generation is produced annually on privet in New York. We collected or



Figs. 3–4. Life stages of the European privet sawfly, *Macrophya punctumalbum*. 3, Mature (feeding stage) larvae; note feeding damage and fecal pellets (length of mature larvae ranges from 14.4–18 mm). 4, Adult female on privet leaf.

observed very few adult males; the species is mainly parthenogenetic, with males poorly represented in most populations (Benson, 1952; Novak, 1976).

ECONOMIC IMPORTANCE

Macrophya punctumalbum is expected to be of economic significance in North America. If adults and larvae occur in large numbers, its primary food plant (privet) can be defoliated. From our field and laboratory observations, feeding and oviposition occurs primarily on foliage of the tender, terminal shoots, and often on foliage of the shaded portions of the plantings. Recommended control measures, especially when the host plant is used in an ornamental hedge, may be simplified by hedge trimming in late spring before the larvae can mature.

LABORATORY STUDIES

In 1982 we attempted to rear *M. punctumalbum* under caged conditions in a room with natural lighting and no temperature control. Temperatures during these studies ranged from 26°C (in the summer) to 11°C (in the winter). Six adult females were caged on May 19, 1982, with two potted, nursery-grown plants of *Ligustrum ovalifolium*. The cage (30.5 × 30.5 × 91.5 cm) was covered on 3 sides and the top with a fine mesh ninon fabric; the front, a sliding door, was made of clear Plexiglas, approx. 3 mm thick.

The adult sawflies immediately began feeding. As foliage was depleted, twigs from uninfested *L. ovalifolium* plants were stuck into the pots as a food supplement. By May 27 the potted plants were nearly defoliated and were removed from the cage. The supplemental twigs were placed in a container of water-saturated sand and all remaining foliage from the potted plants was removed and attached to the supplemental food plants. Two days later 2 new potted plants, *Ligustrum* × *vicaryi* Rehd., also nursery grown, were placed in the cage. Within two days all adult sawflies were dead, presumably killed by a residual insecticide on the foliage of these new plants. Eggs had been laid in leaves of new plants and also were apparent in the supplemental foliage, as well as foliage taken from the original potted plants. On June 2 the progeny were found—14 days after the adults were first introduced into the cage. The larvae developed slowly. By mid-July the second pair of potted plants had been defoliated by larval feeding. From this time all food was from supplemental sources. By August 24, there were 35 larvae of various stages of development on the foliage. By September 10, larvae were abundant but there was little movement or feeding. By December, only 3 live, but quiescent, larvae were observed on the foliage. Observations were not made again until March 1983; no live larvae were found at that time. The soil and duff were removed from the cage and filtered through 3 sieves (screen sizes 8, 10 and 18). Twenty-two dead, shriveled larvae were found and no pupae. Thus, the rearing conditions were not suitable for pupation and the colony was lost.

DESCRIPTION

Adult recognition features.—Females of *M. punctumalbum* are unlikely to be confused with those of any other North American species of *Macrophya*. The bright, rufous hind femora, contrasting with the predominantly black body, distinguishes this attractive species (Fig. 4). All other North American *Macrophya*

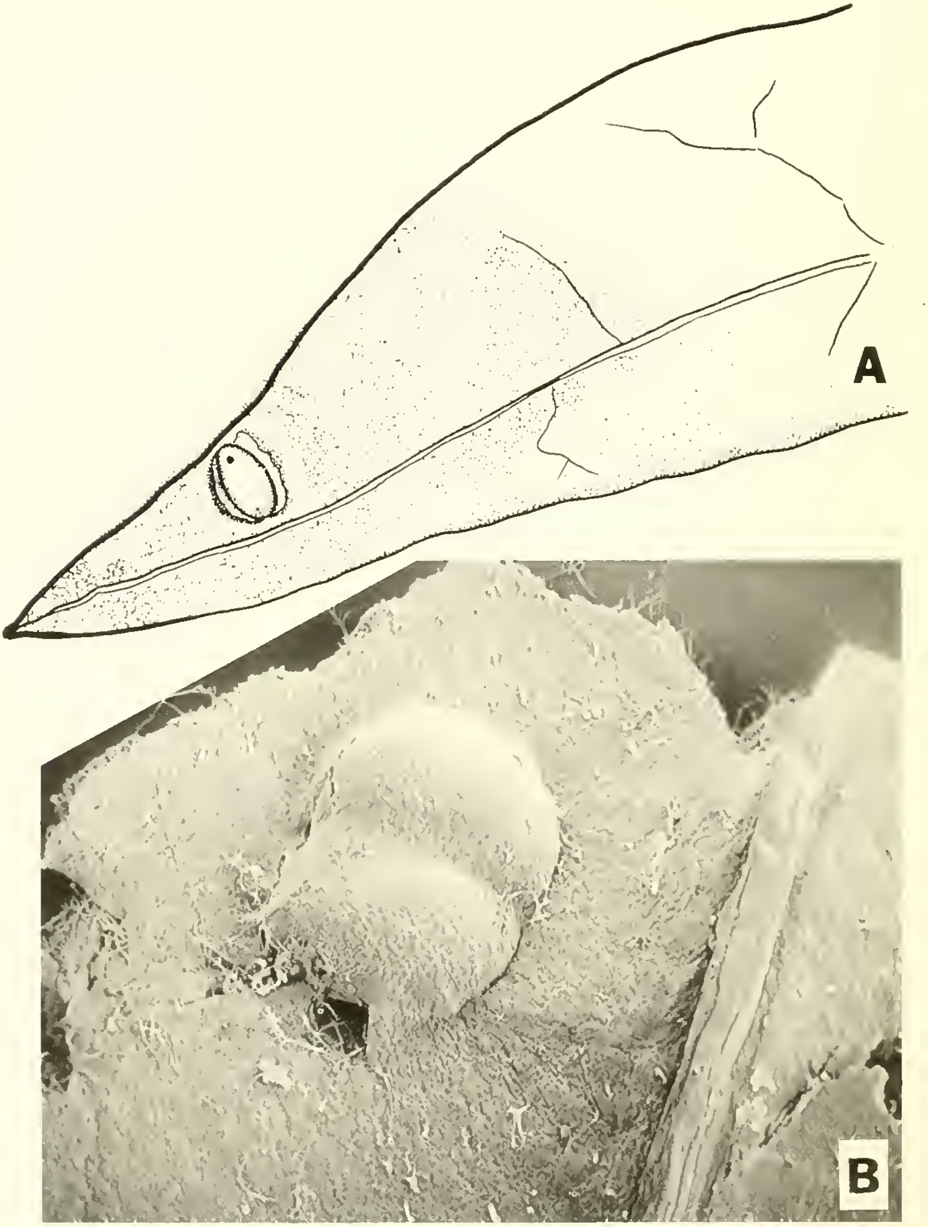


Fig. 5. Oviposition site of the adult female of *Macrophya punctumalbum*. A, schematic drawing illustrating the "blisterlike" oviposition wound. B, scanning electron photomicrograph of the same (30×).

have a black or black and white hindfemur. The body and appendages of the female are black with the following areas white or white-yellow: small spots along the occipital carina of the head; broad area along the posterior margin of the pronotum; large spot over most of the scutellum, and the scutellar appendage;

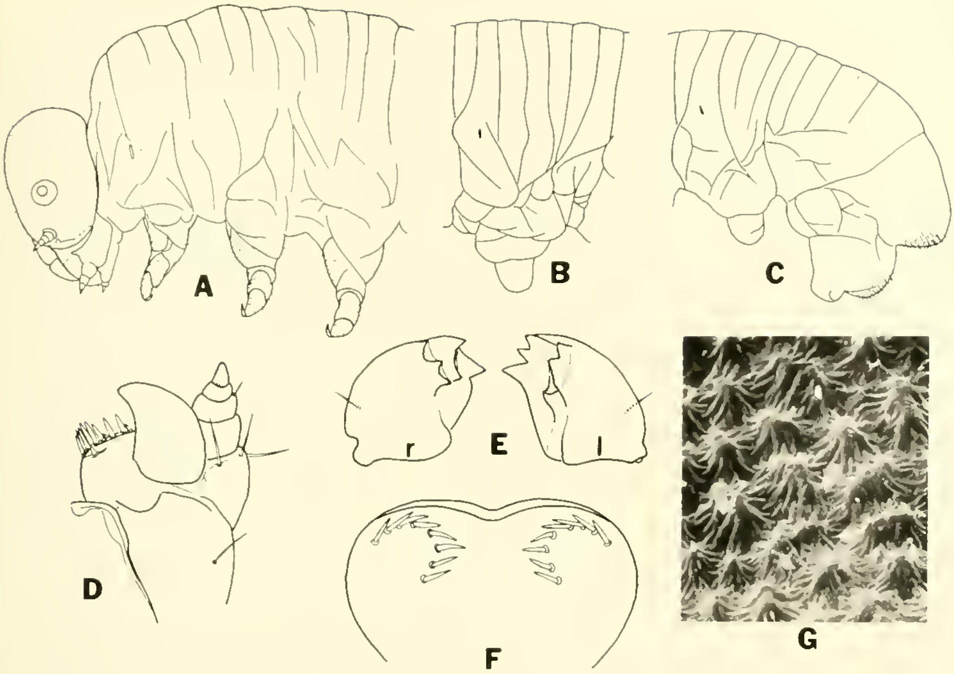


Fig. 6. Mature (feeding stage) larva of *Macrophya punctumalbum*. A, Head and thorax. B, Third abdominal segment. C, Eighth, ninth and tenth abdominal segments. D, Maxilla, dorsal. E, Right (r) and left (l) mandibles, ventral. F, Epipharynx. G, Integument of abdominal annulet, scanning electron photomicrograph (700×).

anteroapical surfaces of the femora, and anterior surfaces of the tibiae and tarsi of the fore and middle legs; basolateral spot on the hindcoxa and elongate subapical spot on the hindtibia; and lateral tergal spots and ninth tergite dorsally of the abdomen. The male, which is usually smaller than the female, is almost entirely black. There are small white spots on the dorsoapical margin of the pronotum adjacent to the scutellum, and the fore and middle legs are similar in coloration to those of the female.

Description of egg, Fig. 5A, B.—Length 1.36–1.44 mm ($\bar{x}$ = 1.40 mm; n = 3); maximum width 0.68–0.88 mm ($\bar{x}$ = 0.76 mm; n = 3). Elongate-ovoid, somewhat depressed along the long axis. Chorion minutely sculptured at extremely high magnification (>2000×), otherwise nearly smooth at lower ranges of magnification (250–500×).

Description of larva, Fig. 6A-G.—Known larvae of Nearctic *Macrophya* are variously patterned with spots or bands on the head and body (Gibson, 1980). Mature larvae of *M. punctumalbum* are entirely lime green, except for the yellowish head capsule and a black eye spot. Lorenz and Kraus (1957) gave a brief description of the larva of *M. punctumalbum* and included it in a key to larvae of European *Macrophya*. Gibson also provided a short diagnosis of the larva.

In late instar (feeding stage), head capsule pale yellow-brown with black eye spot; thoracic legs pale green; body lime green above, somewhat paler below. Integument as in Fig. 6G. Length 14.5–18.0 mm ($\bar{x}$ = 16.6 mm; n = 11).

Clypeus usually with 2 setae on each side (individiuals sometimes with 3 setae on one side and 2 on the other; see remarks below). Labrum with 3 setae on each side, apical margin emarginate at middle; epipharynx with 8 clavate spines located in arcuate row on each anterolateral half (Fig. 6F). Each mandible with 1 seta on outer lateral surface; left mandible with 2 ventral teeth, 3 lateral teeth, and 1 molar tooth (Fig. 6E); right mandible with 3 lateral teeth and 3 molar teeth (Fig. 6E). Maxillary palpus four-segmented; second segment of palpus with 1 seta on outer surface at apex; palpifer with 3 setae; stipes with 1 seta; galea large, digitlike; lacinia with 8–9 clavate spines (Fig. 6D). Labial palpus three-segmented; 3 setae on each side of prementum at apex; second labial palpal segment with 1 seta on inner surface at apex.

Thorax without spines, tubercles or glandubae. Thoracic legs normal; femur longer than tibia; setae present on all surfaces of each segment. Prothoracic spiracles not winged.

Abdominal segments 1 through 8 each with 7 dorsal annulets (typical segment shown in Fig. 6B); without spines, tubercles or glandubae. Eighth, ninth and tenth segments as in Fig. 6C; also without spines, tubercles or glandubae. Fine setae numerous on suranal and subanal areas of tenth segment. All abdominal spiracles not winged.

Remarks.—The subgenus *Pseudomacrophya*, originally proposed by Enslin (1913) for the single species *M. punctumalbum*, differs from the nominate subgenus by the degree of convergence of the inner orbits of the eyes of the adults. Lorenz and Kraus (1957) stated that the larva of *M. punctumalbum* has 3 setae on the clypeus (on each side). They suggested, on the basis of this character and the one seta on each mandible, that *Pseudomacrophya* might be considered a valid genus. Of 22 mature larvae examined in our studies (by ERH), 18 had 2 setae on each side of the clypeus; however, 4 larvae had 3 setae on one side and 2 on the other. Also, in the New York populations, larvae lacked tubercles or glandubae on annulets 2 and 4 of the typical abdominal segment (Abd. 3) that Lorenz and Kraus (1957) reported for European material.

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LITERATURE CITED

Anonymous. 1949. Insects affecting greenhouse and ornamental plants. Can. Agric. Insect Pest Rev. 27: 153, 177–178.

———. 1959. Insects on ornamentals. Can. Agric. Insect Pest Rev. 37: 246–247.

———. 1965. Pests of ornamentals. Can. Agric. Insect Pest Rev. 43: 118.

Benson, R. B. 1952. Hymenoptera (Symphyta). Family Tenthredinidae, pp. 51–137. *In* Royal Entomological Society of London, Handbooks for the identification of British insects, v. 6, pt. 2(b). London.

Brown, A. W. A. 1942. Summary report from the forest insect survey, 1942. Can. Agric. Insect Pest Rev. 20: 265–276.

Cameron, P. 1882. A monograph of the British phytophagous Hymenoptera. Vol. 1. 340 pp. + 21 pls. London.

Enslin, E. 1913. Die Tenthredinoidea Mitteleuropas. Deutsch. Ent. Z., Beiheft, 1913, pp. 99–202.

Foott, W. H. 1973. Garden pests in and around Toronto. Can. Agric. Insect Pest Rev. 51: 35–37.

Gibson, G. A. P. 1980. A revision of the genus *Macrophya* Dahlbom (Hymenoptera: Symphyta, Tenthredinidae) of North America. Mem. Entomol. Soc. Can., No. 114: 116 pp.

Korolkov, D. M. 1913. [Insects injurious to gardens: materials for the study of the injurious insects of the Government of Moscow during the year 1912]. Moscow: Zemstvo of the Government of Moscow; 1912–1913: pp. 1–25.

Lorenz, H. and M. Kraus. 1957. Die Larvalsystematik der Blattwespen (Tenthredinoidea und Megalodontoidea). Berlin, 339 pp.

Mrkva, R. 1965. [Contribution on the morphology, bionomics and parasites of *Tomostethus nigritis*.]. Práce Ṽyzkumn. Ćst. Lesn. CSSR, n. 30, pp. 33–64. [In Czech. with Russian and German summaries.]

Novak, V. 1976. Atlas of insects harmful to forest trees, vol. 1, pp. 7–123 (incl. 115 pls.). Elsevier Scientific Publishing Company, Amsterdam, The Netherlands.

Pomerantzev, D. V. 1930. On the biology of the sawflies of the ash-tree. Bull. N. Cauc. Pl. Prot. Sta., Rostov, Don. 6–7: 27–32. [In Russian with German summary.]

Schwenke, W. 1982. Die Forstschädlinge Europas. Band 4, Hautflügler und Zweiflügler. Paul Parey, Hamburg and Berlin, 392 pp.

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A NEW GENUS AND TWO NEW SPECIES OF ANTILLOCORINI FROM THE NEOTROPICS, WITH NOTES ON RELATED TAXA (HEMIPTERA: LYGAEIDAE)[1]

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Abstract.—*Schuhocoris gracilis* is described as a new genus and species of Antillocorini from Peru, Brazil and Panama. Its phylogenetic position is discussed. The dorsal aspect of the adult and anatomical details of the abdomen, paramere, and sperm reservoir are illustrated. *Paradema antennata* is described as a new species from Brazil. There is a discussion of variability in *Paradema oculata* Slater. New records include *Bathydema cubana* from Puerto Rico and *Caeneusia obrienorum* from Brazil.

The tribe Antillocorini in the Neotropics has been the subject of two recent papers (Slater, Sweet, and Baranowski, 1977; Slater, 1980). Recently I have had the opportunity to study additional material including a striking new genus with a somewhat ozophorine habitus and an undescribed species of *Paradema*. Also included is additional information on several previously described species. All measurements are in millimeters.

Schuhocoris New Genus

Dorsal surface chiefly pruinose. Head and abdomen subshining, remainder of body dull. Head granulose not conspicuously punctate. Pronotum, scutellum and hemelytra coarsely punctate; clavus with three distinct rows of punctures. Head non-declivent, vertex strongly convex. Pronotum with lateral margins deeply sinuate, much broader across rounded humeri than across anterior lobe; margins bluntly calloused or "subcarinate"; transverse impression complete; calli little differentiated from remainder of pronotal surface. Posterior margin of pronotum straight before base of scutellum, produced laterad of scutellum posteriorly as rounded lobes. Scutellum with a prominent Y-shaped elevation. Apical corial margin shallowly concave near inner end. Hemelytral membrane hyaline. Gular trough elongate, nearly reaching base of head, terminating in a tapering acute point. Metathoracic scent gland auricle strongly curved posteriorly so that distal end projects caudally. Evaporative area occupying only inner ½ of metapleuron, convexly rounded on outer margin. Abdomen with well developed scent gland scars present between terga 3–4, 4–5, and 5–6. Inner laterotergites present on segments 4, 5, and 6 (Fig. 2). All spiracles ventral, those of sterna 3, 4, and 5

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located on sternum below sternal shelf (Fig. 6). Suture between sterna 3 and 4 reaching marginal shelf, that between sterna 4 and 5 obsolete dorsally. Trichobothria of sternum 5 located as follows: anterior trichobothrium placed near 3–4 suture; two posterior trichobothria located close together dorso-ventrally and well forward of spiracle of abdominal sternum 5 (Fig. 6). Antennae very elongate and slender, terete; first segment slightly "bent," exceeding apex of tylus by more than ½ its length. Legs elongate, slender. Fore femora not incrassate, mutic. Ovipositor short, not dividing 6th sternum. Posterior margin of 6th abdominal sternum with a small truncate median posteriorly produced projection. Sperm reservoir of "generalized" type, not reduced; ejaculatory tube not greatly enlarged (Figs. 4, 5).

Type species: *Schuhocoris gracilis* new species.

It is a pleasure to dedicate this interesting genus to Randall T. Schuh (American Museum Natural History) for his important contributions to the systematics of the Hemiptera.

The systematic position of *Schuhocoris* within the Antillocorini and its perplexing "mix" of characters is an indication of how much remains to be understood of the phylogeny of these interesting insects. *Schuhocoris* will not run to any genus in my (Slater, 1980) key to Western Hemisphere genera. The apical corial margin is only slightly concave which might cause it to be assigned to the first half of couplet 1 where it would run to *Paradema* at couplet 2. It is not at all related to this genus which has rounded lateral pronotal margins, an only slightly posteriorly curved metathoracic scent gland auricle, spiracle four located on the sternal shelf, etc. More importantly, as discussed below, *Schuhocoris* has a conventional sperm reservoir and thus lacks the enormously enlarged ejaculatory reservoir of *Paradema* (see Slater, 1980), If one follows the second half of couplet 1, *Schuhocoris* will key to *Antillocoris* at couplet 10 (except for the position of spiracle four). It differs from *Antillocoris* in many ways: general habitus (body elongate and slender in *Schuhocoris*, short and stout in *Antillocoris*); spiracle of abdominal sternum 4 located below the sternal shelf in *Schuhocoris*, on the shelf in *Antillocoris*. *Antillocoris* lacks a well developed scent gland opening between terga 3–4, in *Schuhocoris* it is strongly developed; in *Antillocoris* the posterior trichobothria are located below spiracle 5, in *Schuhocoris* well anterior to it. In *Schuhocoris* the metapleuron is pruinose, in *Antillocoris* it is shining.

The systematic position of *Schuhocoris* within the Antillocorini is very interesting but also perplexing. My (Slater, 1980) cladogram of Western Hemisphere antillocorine genera is inadequate to accommodate this genus. In that cladogram the development of the incomplete suture between sterna 4 and 5 is hypothesized as having been evolved twice. This does not present a problem here as in one case (*Paradema*) the suture loss is in a clade with taxa having highly apomorphic sperm reservoirs and ejaculatory ducts. In *Schuhocoris* the reservoir and duct clearly show the plesiomorphic condition (Figs. 4, 5). *Schuhocoris* thus clearly belongs to the alternate clade for while it does not have elongate body hairs and the apical corial margin is only shallowly concave, the lateral pronotal margins are conspicuously calloused, the spiracle on abdominal tergum 4 lies below the sternal shelf and the abdominal scent gland openings between terga 3–4 are well developed.

My 1980 cladogram has three factual mistakes. (1.) There is no synapomorphy

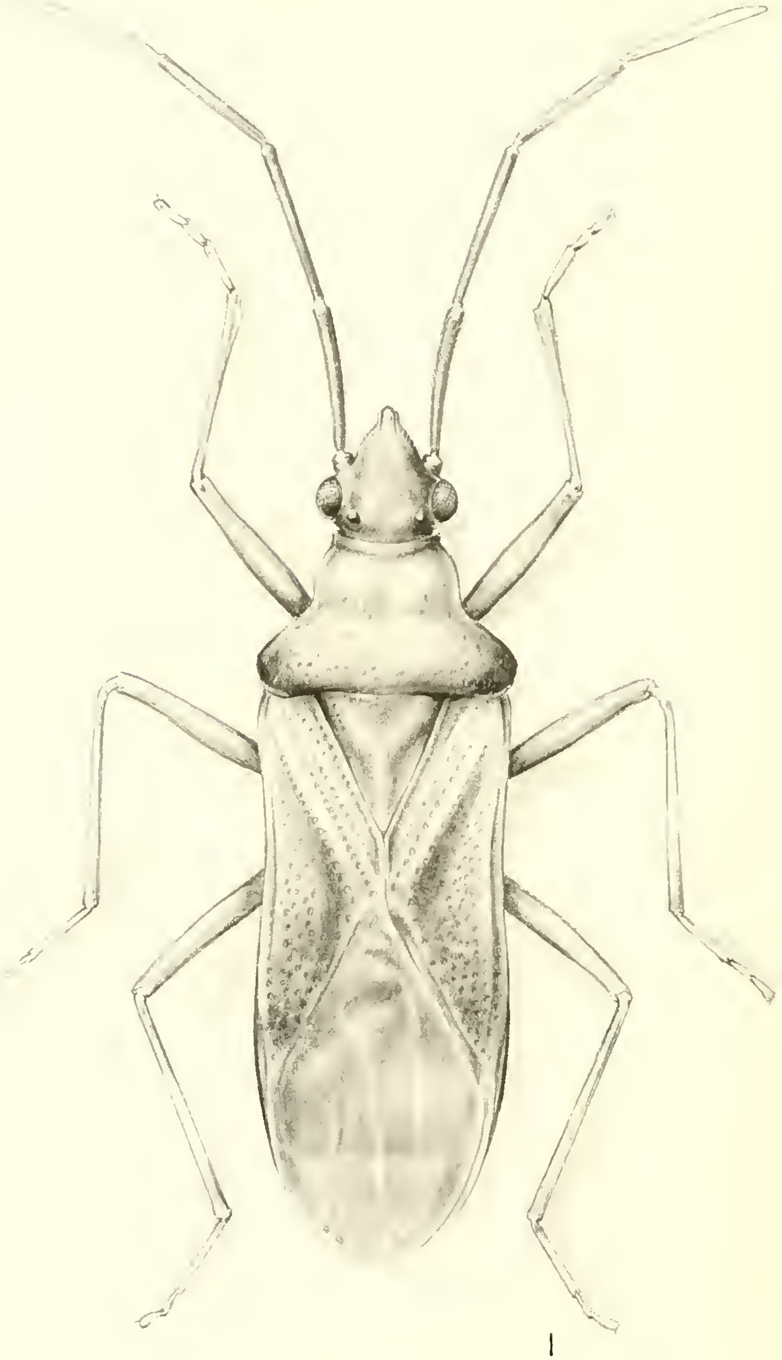
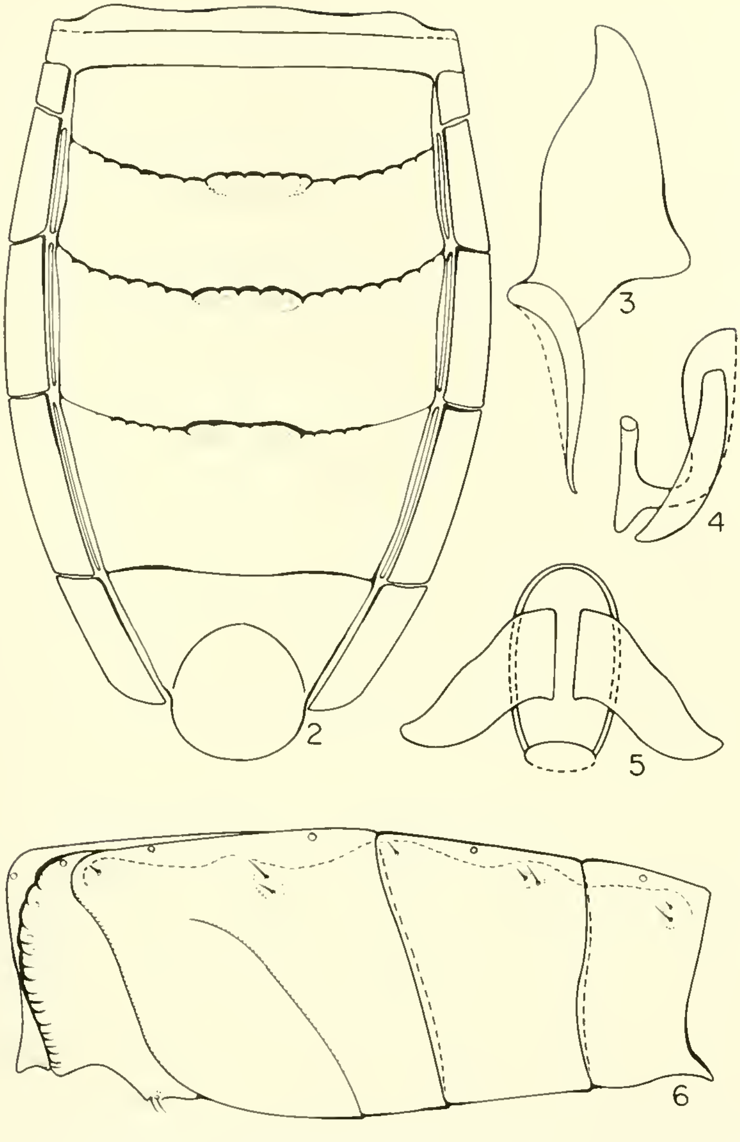


Fig. 1. *Schuhocoris gracilis*, dorsal view.



Figs. 2–6. *Schuhocoris gracilis.* 2, Abdomen, dorsal view. 3, Paramere, 4, Sperm reservoir, lateral view. 5, Sperm reservoir, dorsal view. 6, Abdomen, lateral view.

in the cladogram linking *Paurocoris, Botocudo* and *Cligenes.* This was a lapsus and the synapomorphy should be "pronotal margins carinate." However, there are a number of species at present placed in *Botocudo* where the lateral pronotal margins are actually calloused rather than sharply carinate. (2.) Some species now placed in *Botocudo* have the posterior trichobothria of sternum five placed dorsoventrally rather than being on the same level (linear). It is obvious that a study of species now considered to belong to *Botocudo* must at least have reached the stage where the basic "groups" can be established before the phylogeny of the *Antillocorini* can be much better understood. (3.) The statement that the deeply grooved prosternum is a synapomorphy that will distinguish *Cligenes* from *Botocudo* is true for the type species *Cligenes distinctus* but is not true of *Cligenes subcavicola* Scudder, Darlington, and Hill.

Schuhocoris shows derived conditions in the placement of the abdominal spiracles, strongly posteriorly curved scent gland auricle, calloused pronotal margins and contrastingly shining head and pruinose body. The well-developed 3–4 abdominal scent gland auricle precludes it at present from the clade with *Antillocoris* and its allies. However, that clade is based on a loss character. I suggest that until the complexity of *Botocudo* is better understood that *Schuhocoris* should be tentatively considered as the plesiomorphic sister group of the *Antillocoris* et al. clade, which has retained the original 3 abdominal scent gland condition and has an only slightly concave apical corial margin.

***Schuhocoris gracilis* New Species**

Figs. 1–6

General coloration nearly uniformly bright reddish brown including antennal segments 1, 2, and 3, becoming slightly darker on distal ½ of corium. Fourth antennal segment completely white. Legs uniformly pale yellow. Body clothed above with scattered, short, but rather conspicuous, erect or suberect hairs.

Head acuminate anteriorly. Eyes large, occupying most of lateral head surface but set away from antero-lateral pronotal margin. Ocelli conspicuous, elevated, set much closer to compound eye than to one another. Head length 0.60, width 0.60, interocular space 0.30. Pronotum with well defined punctate anterior "collar" area; posterior lobe more elevated than anterior but broadly depressed in middle. Pronotal length 0.64, width across anterior lobe 0.66, width across humeri 1.10. Scutellar length 0.54, width 0.56. Hemelytra with lateral corial margins nearly straight, very shallowly concave at level of apex of scutellum; radial vein strongly elevated. Length of claval commissure 0.26. Midline distance apex clavus-apex corium 0.60. Midline distance apex corium-apex membrane 0.76. Abdomen with areas about bases of trichobothria pale, pruinose and conspicuously differentiated from subshining abdominal surface. Labium extending between mesocoxae, first segment remote from base of head. Labial segment lengths I 0.40, II 0.38, III 0.30, IV 0.26. Antennal segment length I 0.64, II 0.72, III 0.60, IV 0.64. Total body length 3.48.

Bulb of sperm reservoir elongate-elliptical. Reservoir wings sloping moderately caudally, elongate tapering (Fig. 5). Basal area of ejaculatory duct with a right angled curvature with a short thick basally directed projection at angle (Fig. 4). Paramere broad, without an inner projection, but produced along outer margin (Fig. 3).

Holotype: ♂ PERU: Junin: San Ramon de Pangoa, 40 km SE Satipo, 750 meters, (soil litter layer in high secondary forest), 25.III.1972 (R. T. & J. C. Schuh). In American Museum Natural History. Paratypes: 1 ♂, 1 ♀, same data as holotype. 5 ♂, 7 ♀, same 23.III.1972. 1 ♂, same 30.I.1974. PANAMA: 1 ♀, Bocas d. T. Corriente Grande, 100 meters, 9°17′30″N, 82°32′11″W, 4.IV.1980 (Henk Wolda). BRAZIL: 1 ♂, Sao Paulo, Jacupiranga XII.1963 (F. Plaumann). 1 ♂, Rio de Janeiro, Silva Jardin, VIII.1974 (F. M. Oliveira). In American Museum of Natural History, Instituto de Biologia UNAM Mexico D.F., P. D. Ashlock and J. A. Slater collections.

Three specimens show antennal oligomery. In one specimen (from Brazil) the second and third segments of the right antenna appear to be fused to form an elongate segment, with segments one and "four" normal. Two Peruvian specimens have the left antenna identically modified. In these specimens the left antenna although three segmented is nearly as long as the right antenna, but the second segment is longer than the normal second. The third (terminal segment) is mostly white but has a dark brown basal portion which suggests that there has been fusion of the normal third and fourth segments.

This species probably is part of the large fauna of Lygaeidae that feed on the fallen seeds of *Ficus*. R. T. Schuh took an adult and nymphs representing two instars at the type locality on 30.I.1974 below a large fig tree in litter that contained an abundance of fig seeds.

Description of Nymphs

Third Instar Nymph (type locality).—Head, legs and first three antennal segments dull yellow, fourth antennal segment white. Head suffused with brown posteriorly behind eyes. Thorax above and below nearly uniformly brown. Abdomen mottled with red. First abdominal tergum with a narrow transverse well differentiated strap-like sclerite across central area. Dorsal abdominal scent gland openings present and of equal width between terga 3–4, 4–5, and 5–6. None of these openings surrounded by extensive darkened sclerotized plates. Sterna also lacking median sclerotized plates. Sternum 7 with a conspicuous median spine at posterior margin (as in adults).

Head convex across vertex; epicranial stem well developed. Tylus extending only to proximal ½ of first antennal segment. Head length 0.54, width 0.42, interocular space 0.28. Pronotum subquadrate. Pronotal length 0.28, width 0.50. Mesothoracic wing pads very slightly produced over antero-lateral margins of metanotum. Wing pad length 0.20. Abdomen much broader than head or thorax, maximum width (across segment 5) 0.88. Labium slightly exceeding metacoxae, first segment remote from base of head. Labial segment lengths I 0.30, II 0.38, III 0.24, IV 0.24. Antennal segment lengths I 0.44, II 0.44, III 0.40, IV 0.48. Total body length 2.30.

Fifth Instar Nymph (from type locality).—General coloration and structure as above but with head, thorax and mesothoracic wing pads nearly uniformly dull yellow. Reddish coloration of abdomen obscure. Pronotum more strongly tapering from humeral angles to anterior margin with lateral margins acute and slightly concave. Mesothoracic wing pads almost attaining suture between abdominal terga three and four. Labium extending posteriorly only between mesocoxae. Head length 0.68, width 0.60, interocular space 0.40. Pronotal length 0.46, width 0.80. Mesothoracic wing pad length 1.00. Abdominal length 1.56. Labial segment lengths I 0.38, II 0.50, III 0.26, IV 0.26. Antennal segment lengths I 0.70, II 0.70, III 0.58, IV 0.66. Total body length 3.24.

Paradema antennata NEW SPECIES

Head and anterior pronotal lobe black, former shining, latter covered with gray pruinosity except for two large quadrate calli patches. Pronotal pruinosity con-

Table 1. Comparison of interocular distance and antennal segment lengths in females of *Paradema oculata* Slater and *Paradema antennata* new species.

	Interocular Distance			Length of Antennal Segments					
				II		III		IV	
	N	Mean	Range	Mean	Range	Mean	Range	Mean	Range
antennata	3	.53	(.50–.54)	.82	(.78–.84)	.53	(.50–.56)	.85	(.82–.88)
oculata									
Rio Calcoene	8	.48	(.46–.48)	.70	(.66–.74)	.47	(.46–.50)	.58	(.56–.58)
Serra Lombard	7	.49	(.48–.52)	.70	(.68–.76)	.48	(.46–.54)	.57	(.54–.66)
Serra do Navio	5	.50	(.50)	.77	(.70–.80)	.52	(.48–.54)	.60	(.60)

tinued as a posteriorly tapering 'V' on meson of anterior ⅔ of posterior pronotal lobe; a broad dark brown area present on either side of this pruinosity and on humeral angles; remainder of posterior pronotal lobe yellow. Scutellum dark reddish-brown, elevated areas paler. Hemelytra variegated, dark red brown and yellow to almost white. Pale hemelytral markings as follows: an elongate streak on basal ½ of clavus just within claval suture and entire distal end of clavus; a stripe on basal ½ of corium adjacent to claval suture and a second interrupted stripe running along outer margin of corial furrow to level of end of claval commissure; most of lateral explanate corial flange (but with dark patches at level of middle of scutellum, at level of end of claval commissure and at apex of corium); the pale area between dark apex and median dark area extending inward as a broad comma-shaped macula. Membrane with variegated patches of dark and light coloration. Antennae almost uniformly dark red brown. Femora darkened subdistally, with pale distal ends; fore femora darker than middle and hind femora. Remainder of legs pale yellow except for third tarsal segment which is dark red brown. Body surface as in *oculata* with numerous elongate upstanding hairs present.

Body shape and proportions as in *oculata*. Labium extending between metacoxae. Fore femora with a prominent ventral spine. Head length 0.66, width 0.90, interocular space 0.54. Pronotal length 1.02, width 1.46. Scutellar length 0.90, width 0.78. Midline distance apex clavus-apex corium 1.00. Midline distance apex corium-apex membrane 0.60. Labial segment lengths I 0.70, II 0.74, III 0.54, IV 0.36. Antennal segment lengths I 0.40, II 0.84, III 0.56, IV 0.88. Total body length 4.60.

Holotype: ♀ BRAZIL: Marituba 24.X.1961 (J. & B. Bechyne). In American Museum Natural History. Paratypes: 1 ♀ same data as holotype. 1 ♀ same 1.VI.1961. In P. D. Ashlock and J. A. Slater collections.

P. antennata is certainly closely related to *P. oculata* Slater, agreeing with the latter in having a fore femoral spine, similar protruding eyes, and in pronotal shape, color and overall habitus. *P. antennata* may eventaully prove to be a subspecific geographic isolate of *oculata*. However, the extremely elongate fourth antennal segment of *antennata* falls so far out of the range of *oculata* that a distinct population is evident and I am according it specific status at this time (Tables 1 and 2). The length of the fourth antennal segment of *oculata* as given by Slater (1980) has the numbers reversed. The length is 0.62 not 0.26 mm.

Table 2. Ratios of interocular distance to antennal segment III and of antennal segment III to antennal segment IV in females of *Paradema antennata* and *Paradema oculata*.

		Ratio Antennal Segment IV/Interocular Distance		Ratio Antennal Segment IV/Antennal Segment III	
	N	Mean	Range	Mean	Range
antennata	3	1.61	(1.59–1.64)	1.60	(1.57–1.64)
oculata					
Rio Calceone	8	1.22	(1.17–1.26)	1.22	(1.16–1.26)
Serra Lombard	7	1.16	(1.08–1.27)	1.20	(1.13–1.26)
Serra do Navio	5	1.20	(1.20)	1.15	(1.07–1.25)

All three females of *antennata* have the lateral corial margins evenly meeting the membrane which, if its remains constant when a larger series is available, will separate *antennata* from those females of *oculata* with an angulate corial-membrane junction (see below).

Paradema oculata **Slater**

Paradema oculata Slater, 1980: 214–215.

This species was originally described from the holotype male from Colombia and a single paratype female from Guyana. It was readily distinguishable by being the only member of the genus to have a ventral spine on the fore femur. It was placed in a group with *longisetosa* Slater and *bathydemoides* Slater, characterized by the lateral corial margins of the females joining the membrane at a distinct angle.

P. D. Ashlock has recently made available for study a long series representing several Brazilian localities. To my surprise this material clearly indicates that the condition of the corial membrane junction is variable in females of this species. This suggests caution in the use of couplet 2 of my (Slater, 1980) key to species as the condition could prove to be variable in other species as well.

There is evidently geographic variation in the expression of this feature as may be seen in Table III. There do not seem to be any other significant differences between these populations, and one must conclude that we are dealing with a single species.

Bathydema cubana **Slater & Baranowski**

Bathydema cubana Slater and Baranowski, 1977: 349, 351.

Slater, Sweet, and Baranowski (1977) recognized eight species in the genus *Bathydema* and subdivided the genus into three groups. Of these the "*obscura*-group" has subsequently been elevated to generic status under the name *Antillodema* by Slater (1980).

The "*darlingtoni*-group" comprised three species, one each on the Greater Antillean Islands of Jamaica (*darlingtoni*), Cuba (*cubana*) and Hispaniola (*hispaniola*).

Through the kindness of Drs. C. W. and L. B. O'Brien, I have now been able to examine the first specimens of *Bathydema* from Puerto Rico, a macropterous female from "Guilarte For. Res. Hwy. 131 & 158, 23.VI.1979 (G. B. Marshall)"

Table 3. Comparison of corial margin conditions in *Paradema oculata* slater.

	N		Number with Angulate Corial Margins	Number with Non-angulate Corial Margins
Locality	Males	Females	Females	Females
Rio Calceone lg. do Tigre Brazil 6/8.8 1961 (J. & B. Bechyne)	2	8	8	
Serra Lombard, Limão, Brazil (J. & B. Bechyne)				
2.8.1961		1	1	
15.8.1961	1	1	1	
20.8.1961		1		1
21.8.1961		1	1	
27.8.1961	1	2	2	
31.8.1961		1	1	
19.8.1961	1			
1.9.1966	2			
Serra do Navio, Brazil 11.7.1961 (J. & B. Bechyne)	7	6		6
Regina, Brazil 14.8.1961 (J. & B. Bechyne)		1	1	
Ozémar, Brazil (Diniz)	1			

and a macropterous male and two females from "Carib. N.F. el ToroNegroD Hwy. 143, K16H4, 21.VII.1979 (L. B. O'Brien)" (in J. A. Slater collection). They will key to *cubana* in Slater, Sweet, and Baranowski (1977) although the head ratios differ slightly from those given for *cubana.* Measurements of the Guilarte For. Res. specimen are: head length 0.44, width 0.60, interocular space 0.34; ratio width head/interocular space 1.76, ratio length head/interocular space 1.29. All of the specimens resemble Cuban material in being of a predominently dark color. *Bathydema cubana* has a much shorter head than does *hispaniola.* While these specimens may represent a distinct species they are so similar to *cubana* that specific recognition does not seem warranted.

It is important to note that the "*darlingtoni*-group" (the plesiomorphic one) is now known from all of the four main islands of the Greater Antilles.

Caeneusia obrienorum **Slater**

Caeneusia obrienorum Slater, 1980: 211–212.

This species was originally described from near Tingo Maria, Peru. I have recently examined a single typical female from Serra Lombard, Brazil (2.VIII.1961 J. & B. Bechyne).

ACKNOWLEDGMENTS

I am indebted to R. T. Schuh (American Museum of Natural History) for the collection and loan of the greater part of the type series of *Schuhocoris* and for the use of his field notes; to P. D. Ashlock (University of Kansas), Harry Brailovsky (University of Mexico), Dodge Engleman (Coco Solo, Panama) and C. W. and L. B. O'Brien (Florida State University) for the loan and/or gift of important material; and to Mary Jane Spring and Elizabeth Slater (University of Connecticut) for

preparation of the illustrations and aid in preparation of the manuscript, respectively.

LITERATURE CITED

Slater, J. A. 1980. Systematic relationships of the Antillocorini of the Western Hemisphere (Hemiptera:Lygaeidae). Syst. Entomol. 5:2: 199–226.

Slater, J. A., M. H. Sweet, and R. M. Baranowski. 1977. The systematics and biology of the genus *Bathydema* Uhler (Hemiptera:Lygaeidae). Ann. Entomol. Soc. Am. 70:3: 343–358.

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EUCARAZZIA ELEGANS (FERRARI), AN APHID NEW TO THE WESTERN HEMISPHERE, WITH ARCHIVAL DATA (HOMOPTERA: APHIDIDAE)

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Abstract.—The collection and identification of alates of *Eucarazzia elegans* (Ferrari) from five counties in southern California constitute a new record for North America and the Western Hemisphere. In the literature, the aphid has been reported from the Mediterranean area, the Canary Islands, India on various hosts in the plant family Labiatae, the mints. While only viviparous females have been collected and while *E. elegans* has been collected on a wide variety of hosts in California, there is no indication that the true host or hosts are not a plant or plants in the Labiatae. Information is given on those hosts and locations reported in California and in the literature, the collection data of specimens in the U.S. National Collection of Insects, the history and synonymy of this genus and species, and characteristics useful in the identification of live and slide-mounted females.

This paper is provided to call attention to the first collection of *Eucarazzia elegans* (Ferrari, 1872) in North America and the Western Hemisphere. Information is given on those hosts and locations reported in California and in the literature, the collection data of specimens in the U.S. National Collection of Insects, the history and synonymy of this genus and species, and characteristics useful in the identification of live and slide-mounted females.

On April 6, 1984, I identified as *Eucarazzia elegans* (Ferrari) two alate aphids collected 3-30-84 on bell peppers (*Capsicum annuum*) [Solanaceae] in Mecca, Riverside County, California, and one alate aphid collected March 16, 1984 on *Fuchsia* sp. [Onagraceae] in Fallbrook, San Diego County, California. Kono and Reeves (1984) published the first report of this genus and species in North America and the Western Hemisphere. Alates of *E. elegans* have now been collected in California in the additional counties of Imperial, Orange, Santa Barbara, and San Bernardino. Since the first two submissions, alates have been collected from the following plants: red root pigweed (*Amaranthus retroflexus*) [Amaranthaceae]; rose periwinkle (*Catharanthus roseus*), oleander (*Nerium oleander*) [Apocynaceae]; taro (*Colocasia esculenta*) [Araceae]; chrysanthemum (*Chrysanthemum* sp.), prickly lettuce (*Lactuca serriola*), sow thistle (*Sonchus* sp.), sunflower (*Helianthus* sp.), mare's-tail [reference slip lists *Erigeron canadensis*, not *Hippuris vulgaris*] [Compositae]; watermelon (*Citrullus lanatus*) [Cucurbitaceae]; sweet corn (*Zea mays*) [Gramineae]; mint (*Mentha* sp.), catnip (*Nepeta cataria*), basil (*Ocimum* sp.), thyme (*Thymus* sp.), rosemary (*Rosmarinus* sp.), sage (*Salvia* sp.) [Labiatae]; unspecified bean plant, snail vine (*Vigna caracalla*) [Leguminosae]; mallow (*Malva* sp.) [Malvaceae]; eucalyptus (*Eucalyptus* sp.) [Myrtaceae]; privet (*Ligustrum* sp.) [Oleaceae]; fan palm (*Livistona* sp.) [Palmae]; *Pittosporum tobira 'Variegata'*

[Pittosporaceae]; rose (*Rosa* sp.), strawberry (*Fragaria* sp.) [Rosaceae]; Sierra currant (*Ribes nevadense*) [Saxifragaceae]; petunia (*Petunia* sp.) [Solanaceae]; lantana (*Lantana* sp.) [Verbenaceae]. Four alates were collected in water-pan traps, 7 alates were collected on yellow sticky boards, and 1 alate was "found in an office."

Immatures (1st-instar nymphs) have been collected only from Riverside County, California and only from the following hosts: basil (*Ocimum* sp.) [Labiatae], Thermal, April 11, 1984, 10 immatures, 3 alates; mint (*Mentha* sp.) [Labiatae], Riverside, April 14, 1984, 1 immature, 2 alates; mallow (*Malva* sp.) [Malvaceae], Thermal, April 18, 1984, 2 immatures, 2 alates; Sierra currant (*Ribes nevadense*) [Saxifragaceae], Idyllwild, May 4, 1984, 1 immature, 5 alates. While *E. elegans* has been collected on a wide variety of hosts in California, I believe that these hosts represent accidental alightings and that the true host or hosts will probably prove to be plants in the Labiatae. Alates have been collected many different times over a wide area; only 1–5 alates have ever been collected at any one time on any one plant. Despite the fact that developing populations have not been found in California, it is assumed that this aphid will not be important economically. Rearing experiments are now being conducted in California by the U.S. Department of Agriculture to establish whether *E. elegans* can reproduce on non-Labiatae hosts. Its proficiency as a virus vector is also to be tested. Starý et al. (1971) reported that *Praon volucre* Haliday is a parasite of *E. elegans* on *Salvia* sp. in France.

In the literature, only viviparous females of *E. elegans* have been described or reported and only on plants in Labiatae. Hille Ris Lambers (1953) stated that *E. elegans* had been collected on various Labiatae (*Coleus* sp., *Lavandula* sp, *Mentha* sp., *Salvia* sp.) around the Mediterranean (Italy, Spain, Morocco, Asia Minor, Egypt). Specific collections have been reported as follows: CANARY ISLANDS on *Mentha* sp. (Gomez-Menor, 1963; Tambs-Lyche, 1971); FRANCE on *Salvia* sp. (Starý et al., 1971); INDIA on an unknown plant (Ghosh, 1974); ISRAEL on *Salvia* sp. (Bodenheimer and Swirski, 1957); ITALY (del Guercio, 1921); KENYA in suction trap (Eastop, 1957); SICILY (Barbagallo and Stroyan, 1978, 1982) on *Clinopodium vulgare*, *Mentha pulegium*, *M.* ×*sativa*, *Nepeta cataria*, *Salvia officinalis*, and *S. verbenaca* (Barbagallo and Stroyan, 1982); PORTUGAL on *Lavandula latifolia* and *Salvia verbenaca* (Ilharco, 1979) and in Moericke trays (Lourenco and Ilharco, 1982); SOUTH AFRICA in yellow tray (Müller and Schöll, 1958); SPAIN on *Lavandula stoechas* (Mier Durante and Nieto Nafría, 1979) and on *Lavandula pedunculata* (Mier Durante and Nieto Nafría, 1983); and TURKEY on *Mentha piperita* (Tuatay, 1972). The collection in the British Museum (Natural History), London, contains, in addition to several of the above, material from IRAQ (mint), IRAN (*Salvia splendens*), and ZIMBABWE (yellow trap) (V. F. Eastop, pers. comm.).

The National Collection of Insects contains the following slide-mounted material: (1) originally identified as *Rhopalosiphoninus salviae* Hall on *Lavandula stoechas* [Labiatae]—Rabat, Morocco, February 1936; Mamora, Morocco, July 31, 1936 and January 20, 1939; (2) intercepted in quarantine at Boston and originally identified as *Rhopalosiphoninus chicotei* Gomez-Menor—with *Mentha* sp. [Labiatae] from Portugal, November 19, 1963; with *Mentha* sp. from Azores, October 14, 1968; on unknown plant from Portugal, November 15, 1975; (3) identified as *Eucarazzia elegans* (Ferrari)—on *Mentha* sp. from Cyprus, December

Figs. 1–2. *Eucarazzia elegans.* 1, Alate female, in life, illustrating the waxy bands on the head, thorax, and abdomen and the black patch on the dorsum of the abdomen. 2, Slide-mounted alate female illustrating the dark spots on the wing margin at the end of the veins, the black patch on the dorsum of the abdomen, the short cauda, and the distinctively swollen cornicles.

17, 1967; (4) intercepted in quarantine at Boston and identified as *Eucarazzia* sp.—on *Mentha* sp. from Azores, November 14, 1969.

In 1872 Ferrari described *elegans* and placed it in the genus *Rhopalosiphum.* In 1921 del Guercio described as new the species *picta* from aphids collected in

1919 from leaves of *Nepitella* sp. in Sicily. Del Guercio stated that *picta* had generic characteristics similar to those of *Rhopalosiphum*; however, because *picta* lacked antennal tubercles and a well-defined cauda, del Guercio described the new genus *Eucarazzia* and included *Rhopalosiphum calthae* Koch (1854) and *R. najadum* Koch (1854) with his *picta*. Eastop and Hille Ris Lambers (1976) placed *calthae* Koch in *Rhopalosiphoninus*, treated *najadum* Koch as a synonym of *Rhopalosiphum numphaeae* (L.), and listed *Eucarazzia picta*, *Anuraphis* (*Clavisiphon*) *elegans* del Guercio (1930), *Rhopalosiphoninus chicotei* Gomez-Menor (1950), and *Rhopalosiphoninus salviae* Hall (1926) as synonyms of *Eucarazzia elegans* (Ferrari). A full discussion of the history and synonymy of this genus and species is given in Hille Ris Lambers (1953). Besides *E. elegans*, only *E. caucasicus* (Aizenberg, 1956), described from alates collected on leaves of *Pterocarya fraxinifolia* in Abkhazia, ASSR, USSR, is now in the genus *Eucarazzia* (Eastop and Hille Ris Lambers, 1976).

In life an alate female of *E. elegans* (Fig. 1) is striking in appearance with a silvery, waxy covering on its head and thorax and in bands on those abdominal segments not bearing a large, black patch. Each vein of the forewing ends in a dark spot on the wing margin, and the anal vein has a fuscous border for its entire length. This wing coloration is distinctive and it, along with the silvery and black coloration, readily identifies an alate in the field. An apterous female also is covered with silvery wax, but it does not have a large, black, dorsal patch on its abdomen.

A slide-mounted alate female of *E. elegans* (Fig. 2) is readily identified by the ornamented wings, the black, dorsal abdominal patch, antennal segment III with 16–27 large, tuberculous sensoria, and antennal segment IV with 3–9 sensoria. An apterous female does not have a black, dorsal abdominal patch; but it does have 2–20 tuberculous sensoria irregularly distributed on the distal portion of antennal segment III and 2–9 on antennal segment IV. Both alate and apterous females have distinctive cornicles that are strongly swollen on the distal half and that have 3–4 rows of reticulations apically. The cornicles are dark except for the proximal ¼th in the alata and are pale except for the swollen area which is brownish in the aptera. Both forms have a pale cauda that is hardly longer than wide, is acute, and has 5–7 setae. A full discussion of the characteristics of the alate and apterous females of *E. elegans* is given in del Guercio (1921) and Hille Ris Lambers (1953).

At first glance the distinctively swollen cornicles of *E. elegans* suggest that this species is in the genus *Rhopalosiphoninus*, but closer examination reveals that the two genera share almost no other morphological characters. In his description of *E. caucasicus*, Aizenberg (1956) noted Hille Ris Lambers' (1953) treatment of *E. elegans* and concluded that ". . . there are differences in the marking, in the configuration of the wing, etc." According to Aizenberg, his *caucasicus* has flocky waxen powder only on the abdomen and, in addition to the triangular spots on the margin at the end of all of the veins, a light-brown band running the length of the cubitus in the forewing.

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LITERATURE CITED

Aizenberg, E. E. 1956. New data on the systematics of aphids (Aphidoidea, Homoptera). Trudy Vses. Entomol. Obshchest. 45: 155.

Barbagallo, S. and H. L. G. Stroyan. 1978. Rilievi preliminari sulla composizione dell'afidofauna Siciliana. Proc. XI Cong. Naz. Ital. Entomol. (Portici-Sorrento) p. 249.

———. 1982. Osservazioni biologiche, ecologiche e tassinomiche sull'afidofauna della Sicilia. Frustula Entomol. 3: 139.

Bodenheimer, F. S. and E. Swirski. 1957. The Aphidoidea of the Middle East. Weizmann Science Press of Israel, Jerusalem, p. 277.

Eastop, V. F. 1957. The periodicity of aphid flight in East Africa. Bull. Entomol. Res. 48: 306.

Eastop, V. F. and D. Hille Ris Lambers. 1976. Survey of the World's Aphids. Dr. W. Junk b.v., Publishers, The Hague, p. 193.

Ferrari, P. M. 1872. Species Aphididarum Hucusque in Liguria lectos. Ann. Mus. Civ. Stor. Nat. Genova 3: 217.

Ghosh, A. K. 1974. A list of aphids (Homoptera: Aphididae) from India and adjacent countries. J. Bombay Nat. Hist. Soc. 71: 210.

Gomez-Menor, J. 1950. Algunas especies nuevas de afidos (Homoptera, Aphidae) Rev. Espan. Entomol. 1: 110–113.

———. 1963. "Aphidoidea" de las Islas Canarias. II. Anu. Estud. Atlanticos 9: 519–605.

Guercio, G. del. 1921. Specie nuove e nuovi generi per l'afidofauna Italica. Redia 14: 129–136.

———. 1930. Osservazioni intorno al Gen. *Anuraphis* del Guercio. Redia 19: 194.

Hall, W. J. 1926. Notes on the Aphididae of Egypt. Min. Agric. Egypt, Tech. Sci. Serv. Bull. 68: 42–44.

Hille Ris Lambers, D. 1953. Contributions to a monograph of the Aphididae of Europe. V. Temminckia 9: 31–35.

Ilharco, F. A. 1979. 1. Aditamento ao catalogo dos afideos de Portugal continental. Agron. Lusit. 39(4): 265.

Koch, C. L. 1854. Die Pflanzenlause Aphiden, getreu nach dem Leben abgebildet und beschrieben. Durk von Fr. Campe & Sohn, Nürnberg. Heft II, p. 45–49.

Kono, T. and E. Reeves. 1984. *Eucarrazia elegans* (Ferrari), an aphid new to North America (Homoptera: Aphididae). Calif. Plant Pest Disease Rpt. 3: 53–54.

Lourenço, A. and F. A. Ilharco. 1982. Análise das capturas de afídeos efectuadas por armadilhas de Moericke num campo de favas en Oeiras - Outubro 1978/Maio 1979. Agron. Lusit. 41(3–4): Chart 1.

Mier Durante, M. P. and J. M. Nieto Nafria. 1979. Nuevos datos afidológicos para la provincia de Salamanca (Hom. Aphidoidea). Bol. Asoc. Esp. Entomol. 3: 159.

———. 1983. Aportaciones a la afidofauna de Galicia, II (Hom. Aphidoidea). Bol. Asoc. Entomol. 6: 329.

Müller, F. P. and S. E. Schöll. 1958. Some notes on the aphid fauna of South Africa. J. Entomol. Soc. South. Africa 21: 398.

Starý, P., G. Remaudière, and F. Leclant. 1971. Les Aphidiidae (Hym.) de France et leurs hôtes (Hom. Aphididae). Entomophaga 5: 35.

Tambs-Lyche, H. 1971. Aphids from the Canary Islands. Entomol. Scand. 2: 128.

Tuatay, N. 1972. Aphidoidea: Aphididae. *In* Muzesi's Bocek Katalogu (1961–1971). Turkiye Cumhuryeti Tarim Bakanligi Zurai Mucadele ve Zirai Karantina Genel Mudurlugu Yayinlari, Mesleki Kitaplar Serisi, Ankara, p. 20.

PROC. ENTOMOL. SOC. WASH.
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STUDIES OF CECIDOMYIID MIDGES (DIPTERA: CECIDOMYIIDAE) AS COCOA POLLINATORS (*THEOBROMA CACAO* L.) IN CENTRAL AMERICA

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Abstract.—The role of cecidomyiids (Diptera: Cecidomyiidae) as floral visitors and pollinating agents of "cocoa," *Theobroma cacao* L. (Sterculiaceae), was examined in Costa Rica and, to a lesser degree, in Belize. Emphasis was placed on: (1) describing the mechanism of pollination, (2) determining the most abundant pollinating species, (3) estimates of adult population densities of midges in cocoa flowers, (4) confirmation of pollinating ability with the use of experimental field cages, (5) describing diurnal activity patterns of cecidomyiids in cocoa farms and in relation to similar patterns of anthesis in cocoa flowers, (6) description of communal roosting in spider webs by some species in cocoa farms, (7) observations on how midges interact with specific floral parts in cocoa, (8) estimates of seasonal changes in abundance of midges in cocoa flowers and in relation to annual flowering patterns of cocoa, and (9) determination of breeding microhabitats of cecidomyiids in cocoa farm habitats. By far the most abundant species in cocoa flowers at two localities in Costa Rica (Finca La Tigra and Finca Experimental La Lola) were *Clinodiplosis* sp. 1 and *Mycodiplosis* sp. 1, both new to science. Adults possess functional elongate mouthparts adapted for sucking liquids such as floral nectar, unusually long abdominal and leg hairs that trap cocoa pollen grains, very large compound eyes, and dusk-night-dawn activity patterns that match well the diurnal cycle of flower opening and pollination receptivity in cocoa. Female cecidomyiids are far more abundant as cocoa flower visitors than males, and both crawl inside enclosed floral parts associated with reproductive behavior in cocoa. The mechanism of pollination is similar to that described for ceratopogonids, but one major difference is the exploitation of the vivid yellow petal ligules as feeding sites by cecidomyiids, while these structures are largely ignored by ceratopogonids. Cecidomyiids feed at stomate-type nectaries lining petal ligules and the inner surfaces of petal hoods. Although as many as ten genera and 14 species of cecidomyiids occur in cocoa farms in Central America, only a few of these behave as consistent floral visitors to cocoa and related species of *Theobroma*. Cocoa flower-visiting forms are free-living with larval stages thriving in fungus-infected rotting organic debris, most of which is arboreal and includes: animal-generated holes in cocoa pods, rotting diseased cocoa pods and wilted cherelles, and epiphytic mosses. The observations of cecidomyiid densities being somewhat elevated in flowers during the drier months of the year may be due to either concentration of populations in shaded areas of cocoa or an actual increase in abundance at these times. Some cecidomyiids breed in the dry exocarp of rotting pods in trees during the dry season. Communal roosts in spider webs are re-used over several successive days as daytime resting sites for midges, probably as a predator (primarily anoles, mantids, and jumping spiders)-escape adaptation. The "pollinator reward syndrome" in cocoa and other *Theobroma* species is discussed from the standpoint of cecidomyiids, ceratopogonids, and wild bees as natural pollinating agents.

Several studies in different cocoa-growing regions (*Theobroma cacao* L.) of the world have concluded that tiny biting midges (Diptera: Ceratopogonidae) are the primary effective pollinators, although not exclusively so (e.g. Jones, 1912; Wellensiek, 1932; Cope, 1939; Billes, 1941; Posnette, 1942, 1944; Soetardi, 1950; Gnanaratnam, 1954; Van Der Knapp, 1955; Saunders, 1959; Walker, 1959; Dessart, 1961; Glendenning, 1962; Gorrez, 1962; Hernandez, 1965; Sampayan, 1966; Vello and Magalhaes, 1971; Edwards, 1973; De La Cruz and Soria, 1973; Kaufmann, 1973a, b, 1974, 1975a, b, c; Amponsah, 1972; Winder, 1972; 1977a, b, 1978a, b; Winder and Silva, 1975; Wirth and Waugh, 1976; Bystrak and Wirth, 1978; Young, 1982, 1983). Relative to the many genera and species of ceratopogonids suspected or proven to be effective pollinators of cocoa, several workers have noticed high abundances of similarly-sized cecidomyiid midges (Diptera: Cecidomyiidae) in cocoa farms, both in the New and Old World tropics (e.g. Privat, 1979; Winder, 1977c; Kaufmann, 1973b; Soria et al., 1980, 1981; Lucas, 1981), although the role of these midges in cocoa pollination is thought to be minimal (Winder, 1977b, 1978a). Yet Kaufmann (1937b), using experimental cages, demonstrated effective but low frequency pollinating activity of one species of cecidomyiid midge during the dry season in Africa, and subsequent studies using isotopes demonstrate that these midges transport cocoa pollen grains on their bodies in high frequency in some African farms (Decazy et al., 1980). Herein I present data indicating that several genera and species of Cecidomyiidae are effective cocoa pollinators in Central America, most notably in Costa Rica, and also summarize new ecological and behavioral information as related to the role of these midges as pollinators, and to their adaptation for breeding in cocoa farm habitats. I tentatively conclude that both ceratopogonids and cecidomyiids constitute one constellation of cocoa pollinators, but that other major pollinators (bees) have played equally important roles in the evolution of cocoa as a tropical rain forest tree species. Some studies have emphasized the role of small Diptera as effective, opportunistic pollinators of various plant species in shaded, moist forest habitats (e.g. Mesler et al., 1980; Levesque and Burger, 1982), environments that tend to accumulate high species density of Diptera (e.g. Vanhara, 1981), including cocoa farms (Bigger, 1981). Although it is generally maintained that Diptera are occasional pollinators (Percival, 1965; Kevan and Baker, 1983), several studies indicate more consistent associations with some plant species (Baumann, 1978; Vogel, 1978; Mesler et al., 1980; Gilbert, 1981; Steiner, 1983; Philbrick, 1983; Young, 1984a). With respect to *Theobroma* species (Sterculiaceae) overall, it may well be that Diptera are opportunistic "minor" pollinators that thrive best in moist, shaded habitats in the tropics, while "major" pollinators, ones coevolved with the floral structure and its associated physiology, are primarily wild bees (A. M. Young, in preparation) associated with *Theobroma* populations in more open, exposed habitats. Small flying insects such as tropical Cecidomyiidae are most active in shaded moist habitats (e.g. Mamaev, 1975; Fisher and Teetes, 1982; Barnes, 1930; Summers, 1975; Petralia et al., 1979; Shazli and Mostafa, 1980; Mogal et al., 1979; Kaufmann, 1973b) where they often exhibit marked diurnal cycles of activity (e.g. Shazli and Mostafa, 1980; Summers, 1975; Brewer, 1981; Brown and McGavin, 1982) and immature stages of free-living forms associated with fungi, molds, and rotting organic substrates such as leaf litter (e.g. Winder, 1977a; Gagné, 1977; Parnell, 1969). Because cecidomyiids and other allied dipterans often exhibit marked cycles in adult activity and breeding, both in the temperate zones and the tropics (e.g. Fontanilla-Barroga, 1962; Charlwood et al., 1982; Chiang, 1968; Kay, 1983), determination of potential roles in pollination of specific plant species such as cocoa has to be related to the known diurnal cycles of flower opening and anthesis (Wellensiek (1932) for cocoa). Because even decaying organic substrates can be limiting factors in the breeding structure of dipteran populations (e.g. Carpenter, 1983; Binns, 1980; Fallis and Snow, 1983; Siefert, 1980; Siefert and Barrera, 1981; Kaufmann, 1973b; Privat, 1979; Winder, 1977a), it is also necessary to determine whether or not cecidomyiids as cocoa pollinators breed within the cocoa farm environment, and this was done in the present studies. Although very few published reports indicate a possible role of cecidomyiids as pollinators (e.g. Soderstrom and Calderón, 1971), Winder (1977b) found cecidomyiids bearing cocoa pollen grains and also entering the petal hoods of cocoa flowers where they came into contact with viable pollen. Winder (1977b) suggests that the high abundance of these midges in cocoa farms indicates a possible role in cocoa pollination. Others, however, suggest that these midges are of negligible importance in cocoa pollination (e.g. Entwistle, 1972).

Localities and Study Methods

The following studies were conducted between 1978 and 1983 primarily at two localities on the Atlantic watershed of Costa Rica: (1) mechanism of pollination of cocoa by cecidomyiid midges and determination of most effective pollinating species; (2) breeding habits and life cycles of some species pollinating cocoa; (3) estimates of adult population densities in cocoa flowers at various times of the year; (4) experimental tests with cages to determine pollinating abilities of cecidomyiids; (5) estimation of overall cecidomyiid faunas associated with cocoa farms; (6) communal roosting habits of adult cecidomyiids in cocoa farms and relation to pollinating activity; (7) diurnal activity patterns of adult cecidomyiids in relation to cocoa tree flowering patterns and availability of possible pollination "rewards" in flowers. The greater portion of these studies were conducted at "Finca Experimental La Lola, near Siquirres (10°06′N, 83°30′W), Limon Province (see also Young (1983) for further desceiption of this site), and fewer studies at "Finca La Tigra," near La Virgen (10°23′N, 84°07′W), Heredia Province (see Young (1982) for additional information on this locality). In addition to these Costa Rican studies, I made preliminary surveys of adult cecidomyiids on cocoa flowers, and the larval microhabitats of some species, at the Hummingbird Hershey Cocoa Farm (approx. 17°08′N, 88°38′W), near Belmopan, Belize. Visits were made to all three localities during both wetter (rainy) and drier (dry) times (seasons) for one to three years. Because rainfall pattern has a marked influence on both the cycles of flowering in cocoa (e.g. Wellensiek, 1932; Alvim, 1977; Hutcheon, 1981;

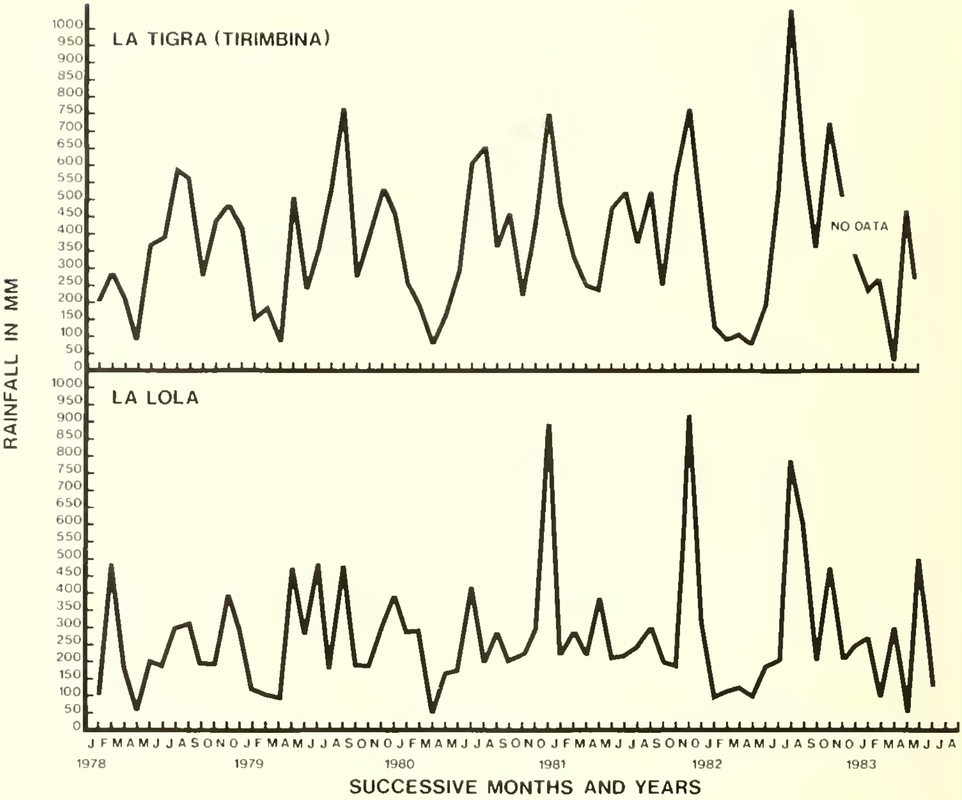

Fig. 1. Monthly patterns of rainfall, over several years and including the study periods, for "Finca La Tigra" and "Finca Experimental La Lola" in the Atlantic (Caribbean) lowlands of Costa Rica.

Myers, 1930; Allen, 1981; Young, 1982, 1983, 1984b) as well as on the population dynamics and associated densities of pollinating insects (e.g. Winder and Silva, 1975; de la Cruz and Soria, 1973; Leston, 1969; Soria and Abreu, 1976; Soria et al., 1981; Kaufmann, 1973b; Young, 1982, 1983, 1984a), monthly patterns of rainfall for "La Lola" and "La Tigra" are summarized here (Fig. 1).

The rainfall data (Fig. 1) encompass the periods of midge study at both localities, and it is apparent in the data from both localities that the driest times of the year are generally the months January through March, although the duration of reduced rainfall periods varies greatly from year to year. For the purposes of this paper, I assume that both localities have a short and irregular "dry season" ("veranillo") generally falling between January and March each year. Other studies (Young, 1982, 1983, 1984b) have shown that the dry season is a period of drastically reduced flowering in cocoa at these localities.

The study areas at La Lola include heavily-shaded cocoa, with the predominant shade tree being *Erythrina* sp. (Leguminosae), although other areas at the same locality have little shade. The La Lola studies included surveys of cecidomyiids in both the shaded (Area A) and unshaded (Area B) UF-29 cocoa studied in Young (1983) as well as a well-shaded clonal garden area with several clonal varieties (UF-677, UF-613, Pound-7, etc.). The La Tigra study area consisted of many varieties of cocoa planted beneath a thinned-out natural canopy of advanced secondary forest. At La Tigra there is a high incidence of rotting cherelles on cocoa trees while at La Lola these are removed quickly as they appear. In the La Tigra study area, many trees have sizable accumulations of epiphytic mosses and other epiphytes on the lower branches.

During both wetter and drier periods between 1978 and 1983, observations were made at both localities on the behavior of adult cecidomyiid midges at freshly-opened cocoa flowers at various hours of the day and night. Daylight transects through cocoa trees were taken by walking slowly and examining open flowers on each tree to determine the presence of cecidomyiids on or inside flowers. When a midge was encountered, it was scored as either "resting" motionless on an external portion of the flower, or as moving inside the flower. In the latter case, notes were kept on where the midge was located in the flower. Time of day was also recorded. These surveys generated a series of voucher specimens for those cecidomyiids actually found in contact with cocoa flowers. Other voucher series of cecidomyiids were obtained by collecting adult midges from communal roosts in spider webs in cocoa trees, and occasionally by rearing midges from larval samples.

Daylight observations at open cocoa flowers generally extended at intermittent intervals from 0600 to 1800 hours in both sunny and rainy weather, and nighttime samples from 1900 to 2300 and from 0400 to 0530 hours. Nighttime observations were aided by using red cellophane over a flashlight and occasionally by using a Night Vision infra-red viewing scope outfitted with a 50mm macrolens. Whenever midges were found moving inside flowers, detailed observations were made on this behavior. Additionally, behavior suggesting that midges were feeding on specific floral parts was followed up as much as possible. For example, early into the studies, I discovered that cecidomyiids (eventually determined to be *Mycodiplosis* sp. 1 and *Clinodiplosis* sp. 1) had their mouthparts embedded into the pliable, spongy tissue of the blade-like ligules extending from the petal hoods of cocoa flowers (see Cuatrecasas, 1964 for a detailed discussion of gross floral structure in cocoa), and when encountered in the field, observations were extended until the feeding stopped. Through brief observations at various times, I was able to determine how cecidomyiids interact with cocoa flowers and how this behavior relates to pollinating activity.

Opportunistically, immature stages of cecidomyiids breeding in cocoa farms were obtained by surveying rotting cherelles, arboreal and ground-cover leaf litter beneath cocoa trees, and by collecting repeated samples of epiphytic moss. The emphasis here was on obtaining a qualitative picture of breeding substrates rather than a quantitative sampling of population densities of immature stages. Collected breeding substrate samples were usually confined to tightly-shut large clear plastic bags to allow larvae to complete development and adults to eclose. Voucher series of larvae and adults were kept for determination studies. For all cecidomyiid voucher samples obtained, the insects were preserved in the field in vials of 70% ethanol and later shipped to the Insect Identification and Beneficial Insects Introduction Institute, ARS, USDA at Beltsville, Maryland for identification.

To estimate the densities of adult cecidomyiids in open cocoa flowers, I made repeated censuses of 70 mature trees, consisting of a mix of clonal varieties UF-677, UF-613, and Pound-7, in one of the clonal gardens at La Lola; the same set of trees was censused at various times of the year and data were also kept on the abundance of open flowers at each census for each tree. These censuses were usually taken at the same time of day each time (generally between 0900-1100 hours) and in both cloudy (overcast) and sunny weather. I attempted always to examine all open flowers within easy eye-viewing at each tree.

As these studies progressed, with the assistance of Raymond J. Gagné of the Systematic Entomology Laboratory, IIBIII, in Washington, D.C., it was possible to narrow down the number of genera and species of these midges most consistently found in cocoa flowers, and this allowed me to conduct some preliminary field tests with small experimental cages to determine the potential for these midges to pollinate cocoa. Such tests can only give a possible indication of pollinating activity, however, and the results may have little or nothing to do with whether or not these same species of midges actually pollinate cocoa under natural conditions. The bias and pitfalls of this sort associated with cage tests involving small flying insects as potential pollinators has been pointed out by Winder (1978a) in the case of cocoa. In the present field studies, small sleeves of fine-mesh silk bolting cloth (Tetkco Co., Elmsford, New York) were stretched over wire frames embedded into sections of branches on cocoa trees bearing lots of floral buds and open flowers. Details of this methodology are outlined in Young (1983). These tests were conducted at La Lola using the self-compatible UF-29 variety of cocoa, a condition that permitted confined insects such as cecidomyiids to fertilize confined flowers successfully without the need for cross-pollination with other varieties. A total of ten cage tests were conducted, five each at two different times during two successive rainy seasons (1981 and 1982); of the five cages used each time, three were "controls" having no midges introduced into them and the remaining two, experimentals. Experimental cages generally received anywhere from five to 30 cecidomyiids over a 1–3 day period, and the numbers of open flowers scored each day in all cages. Prior to initiation of these tests, all open flowers were removed from all cages and subsequently opening flowers were shielded by the bolting cloth from any possible external pollinating agents other than the confined cecidomyiids. Midges were usually introduced at different times of the day; sources of cecidomyiids included collections from open flowers and to a lesser extent from communal roosts. It was not always possible to determine the species of cecidomyiid used, although emphasis was placed on testing *Mycodiplosis* sp. 1 and *Clinodiplosis* sp. 1.

At two different dates at La Lola, I tagged the positions of several communal roost sites for adult cecidomyiids in a heavily-shaded area (the Area A of Young, 1983) of UF-29 cocoa trees to determine (1) the day-to-day changes in roosting habits and degree to which the same site is re-used over short periods of time (i.e. a succession of days), and (2) the diurnal patterns of roost formation and dissolution. I was also interested in determining which species of cecidomyiids participated in roosting behavior at La Lola, and which of these species were also visiting cocoa flowers and possibly exhibiting pollinating behavior. Several previous studies in the Neotropical Region have described the unusual phenomenon of cecidomyiids roosting communally in the silken webs of various species of spiders (Fig. 2), including both natural forest and cocoa farm habitats (e.g., Lahmann and Zuniga, 1981; Kaufmann, 1973b). As sometimes individual roosts on a given date contain more than one species of cecidomyiid (Dr. W. E. Eberhard,

Fig. 2. Communal roosting aggregate of unidentified Cecidomyiidae in the Hummingbird Hershey Farm in Belize.

per. comm.), it was necessary to collect samples of midges from roosts at various dates to estimate the degree to which roosts in this particular case were monospecific in composition. Tagged roost sites were checked almost hourly and the number of midges in them counted and recorded. Particular emphasis was given to observing roost formation and dissolution as related to dawn and dusk. Observing roosts in this manner provided the opportunity to relate diurnal activity patterns of cecidomyiids to the diurnal cycle of flower opening and anthesis in cocoa. Only at the end of observation periods were samples taken of adults in roosts for determination purposes.

Although to be summarized in detail elsewhere (A. M. Young, in preparation), an experiment of setting out sticky squares of flypaper around open cocoa flowers at both La Lola and La Tigra and checking them for trapped flying insects at various times of the day and night, provided some additional information on diurnal activity patterns of cecidomyiids in the immediate vicinity of cocoa flowers. Relevant portions of these data are mentioned in this paper. The experiments involved placing several hundred such small squares (anchored on No. 3 insect pins) each time within a few mm of open cocoa flowers on 1–5 trees at each locality. Squares were then scored as to whether they were "occupied" by insects, what kinds, and time of the day.

Cecidomyiids surveyed at Hummingbird Hershey in Belize included the collections of larvae from rotting cherelles and rearing adults from these. Information was obtained on the locations of cecidomyiid larvae in these substrates. Also, collections of animal-damaged rotting pods hanging in trees were made to determine the presence of cecidomyiid larvae (at La Lola and Hummingbird Hershey) and to rear these to adulthood.

A small sample of adult cecidomyiids was collected from cocoa flowers and preserved dry to examine with the Scanning Electron Microscope for the presence of cocoa pollen (Taylor, 1965); it is easy to match grains from flowers with those collected from insects. Laboratory analysis by R. J. Gagné also included an examination of the mouthparts of those species most consistently found in cocoa flowers. This study was done to determine if these particular species had functional mouthparts and if so, to describe these and possibly associate with the observed behavior of the midges in the flowers. While some cecidomyiids possess vestigial mouthparts as adults (e.g. Ehler, 1982), long-lived free-living forms have functional mouthparts (R. J. Gagné, pers. comm.).

RESULTS

Pollination Mechanism and Behavior.—Cecidomyiid midges, mostly *Mycodiplosis* sp. 1, *Clinodiplosis* sp. 1, *Coquillettomyia* sp., and *Aphodiplosis triangularis*, have been found between 0600 and 0700 hours, and again between 1500 and 2100 hours, exhibiting two forms of behavior associated with moving inside enclosed parts of cocoa flowers: (1) individual midges crawl along a staminode, parallel to, and adjacent to, the pistil, and oriented towards the basal ovary area of the flower, and (2) individual midges alight on a sepal, petal ligule, or exterior surface of a petal hood, and proceed to crawl inside the petal, often moving from one petal hood to the next and so on. For example, on 9 December 1982 at 0700 hours at La Lola, one female of *Clinodiplosis* sp. 1 landed at the tip of a staminode and crawled along it and rubbed against the pistil; examination of the pistil area after collecting the midge revealed a slight smear of several pollen grains. Sometimes a female remains motionless on petal ligules for several minutes to an hour beore moving. On 21 November 1981 at La Lola, one specimen (*Mycodiplosis* sp. 1) was discovered with mouthparts embedded into the distal surface tissue of a ligule at 1100 hours and was still there at 1500 hours. A male of the same species was seen crawling along a staminode at 0900 hours and with mouthparts clearly scraping against the staminode tissue, as if feeding. Another female *Clinodiplosis* sp. 1 alighted on the tip of a staminode at 0600 hours on 19 November 1981 at La Lola, stayed there for one minute, and then quickly crawled down the staminode to the ovary area of the flower; this cecidomyiid remained

Table 1. Adult cecidomyiid midge behavior in open flowers of *Theobroma cacao* as related to effective pollination.

Species	Sex	Date	Time	Locality	Description of Behavior Related to Pollination
Clinodiplosis sp. 1	female	9-XII-82	0700	La Lola	lands on tip of staminode and quickly crawls towards ovary, brushing against pistil
	female	9-XII-82	1630	La Lola	crawling in narrow space between staminodes and pistil
	female	11-XII-82	0730	La Lola	lands on floral petiole, crawls over to staminode and crawls along it and enters into inside of petal hood, exits few seconds later and enters a second petal hood
	female	12-III-82	2000	La Lola	captured while inside petal hood
Mycodiplosis sp. 1	female	11-XII-82	0730	La Lola	crawling along ligule towards petal hood opening
	female	13-XI-81	1600	La Lola	crawling around inside petal hood
	female	13-XI-81	1730	La Lola	perching on ligule and suddenly "flips" around and enters petal hood and moves around violently inside it and causes petal hood to momentarily change shape
	female	12-III-82	1700	La Lola	captured inside petal hood
	female	21-XI-81	0600	La Lola	crawling into petal hood
	female	21-XI-81	0630	La Lola	lands on outside of petal hood and crawls inside it
	female	9-XII-82	1630	La Lola	captured inside petal hood
	female	9-XII-82	1630	La Lola	captured inside petal hood
	female	9-XII-82	1645	La Lola	captured in narrow space between staminodes and pistil

on the ovary tissue for about four hours before flying off. While adult cecidomyiids are readily found resting on petal ligules, or upon dense mats of fungal growth (hyphae) covering squirrel or woodpecker-generated holes in cocoa pods (Fig. 3), of particular interest are those observations of these midges actually moving within confined spaces of the flower (Table 1). Midges hovering about cocoa flowers are sometimes captured as prey by the smaller nymphal instars of the mantid (Orthoptera) *Chaeteessa filata* (Burmeister) (Dictyoptera: Mantidae) which is abundant on branches of cocoa trees at La Lola (Fig. 3). One rainy season census (August 1983) of 70 adjacent trees at La Lola revealed that close to half (32 trees) had one individual of this mantid at 0900 hours in sunny weather, and that 20 of these individuals were nymphs and the remainder, adults (A. M. Young, unpubl. data). Various species of salticid and other spiders also capture these cecidomyiids routinely, and *Anolis* lizards, which are very abundant in Costa Rican cocoa farms, also feed upon them (A. M. Young, unpubl. obs., 1978–1983). Small dipterans sometimes comprise sizable portions of anole diets in the American tropics (e.g. Floyd and Jenssen, 1983).

Fig. 3. Various aspects of cecidomyiid biology in Central American cocoa plantations. Clockwise, beginning in upper left photo: adult cecidomyiid perched on petal hood of cocoa flower during the daytime; squirrel-generated hole in cocoa pod, and filled with fungi and rotting pod tissues, a microhabitat where cecidomyiid larvae are found; the mantid *Chaeteessa filata* on branch of cocoa tree—in earlier nymphal stages, a predator on adult cecidomyiids; adult cecidomyiid perched in hyphae of fungi on hole in cocoa pod.

While more midges are seen resting on staminodes, petal hoods, and petal ligules of cocoa flowers than seen moving in them at both La Lola and La Tigra (Tables 2 and 3), I suspect that such a paucity of direct observations of midges pollinating flowers, or at least visiting flowers in such a manner so as to possibly pollinate them, is due to (1) my inability to find and record accurately all such instances at a given time of day, and (2) the very likely fact that only relatively few species of the total cecidomyiid faunas of cocoa farms are actually visiting cocoa flowers for the purpose of feeding or gaining some other reward. In the shaded understory conditions of cocoa farms cecidomyiids in general alight on light-colored objects. While the species most abundantly seen on or inside cocoa flowers fall within the body length range of 2–4 mm, the larger *Mycodiplosis* sp. 2, with variegated wings, is commonly found alighting in groups on the bottoms of large white-plastic cups used to simulate bromeliads (see Young, 1983). Thus it is necessary to distinguish between cecidomyiids that visit cocoa flowers for some purpose other than a resting place, namely for feeding. My observations suggest that forms such as *Clinodiplosis* sp. 1, *Mycodiplosis* sp. 1, *Coquillettomyia* sp. and *A. triangularis,* are the most likely pollinators of cocoa in Costa Rica. Of these, most of the observations on actively moving cecidomyiids inside cocoa flowers are of *Clinodiplosis* sp. 1 and *Mycodiplosis* sp. 1. Interestingly, females are far more abundant on or inside cocoa flowers than males for those genera and species found in greatest frequency associated with flowers (Tables 2 and 3). Examination of freshly-open flowers on other species of *Theobroma* trees growing adjacent to cocoa at La Lola and La Tigra also suggest that cecidomyiids are attracted to these flowers (Table 4), even though there is considerable difference in size, color, and three-dimensional design of the flowers among these species (see Cuatrecasas, 1964). Young et al. (1984) and M. Strand and A. M. Young (in preparation) also found considerable differences in the types of fragrance compounds among these species, although the general positioning of floral nectaries and other possible reward-generating structures is similar among these species. For the purposes of this paper, I tentatively conclude that *Clinodiplosis* sp. 1 and *Mycodiplosis* sp. 1 are the most frequent cecidomyiids visiting cocoa flowers at La Lola and La Tigra, and are the best candidates for being effective pollinating agents. Our totally new observations of adult cecidomyiids being attracted to the flowers of *Guazuma* (Sterculiaceae) at La Tigra add indirect evidence for the existence of a generalized pattern of associaiton of these cecidomyiids with sterculiaceous flowers in the American tropics (Table 4).

A good review of the mechanism of pollination in cocoa by ceratopogonid midges is given by Bystrak and Wirth (1978) and my observations with cecidomyiids suggest a very similar pattern of association with flowers. Basically I propose that cecidomyiids such as *Clinodiplosis* sp. 1 and *Mycodiplosis* sp. 1 pick up small numbers of viable cocoa pollen grains on long caudal hairs on the abdomen and elsewhere when midges crawl around inside petal hoods in the early morning and late afternoon. Pollen grains thus removed from the petal hoods are then smeared upon the pistil when pollen-bearing midges crawl along the narrow space between staminodes and pistil. Kaufmann (1973b) and Winder (1977b) both report smear-type pollination by cecidomyiids in Africa and Brazil, respectively.

Both *Clinodiplosis* sp. 1 and *Mycodiplosis* sp. 1 have well-developed compound eyes. While the mouthparts of both species possess no specialized adaptations for flower-feeding, both have elongate functional mouthparts adapted for sucking up fluids such as nectar in flowers (R. J. Gagné, pers. comm.). Interestingly members of both genera typically possess long hairs on the legs and abdomen (R. J. Gagné,

Table 2. The abundance of adult Cecidomyiidae on/in freshly-opened *Theobroma cacao* flowers[a] for five widely separated census dates[b] for 1000 flowers examined each date[c] at Finca Experimental La Lola, near Siquirres, Limon Province, Costa Rica.

Species	No. Occupied Flowers	No. Midges Resting on Flowers[d]			No. Crawling Inside Flowers[e]			Communal Roosts[f]		
		♀♀	♂♂	T	♀♀	♂♂	T	♀♀	♂♂	T
Clinodiplosis sp. 1	17/1000	13	0	13	5	0	5	0	0	0
Clinodiplosis sp. 2[g]	0/1000	—	—		—	—		8	7	15
Clinodiplosis sp. 3	0/1000	—	—		—	—		2	1	3
Mycodiplosis sp. 1[h]	63/1000	100	16	116	1	0	1	25	27	52
Mycodiplosis sp. 2	0/1000	—	—		—	—		10	0	10
Mycodiplosis sp. 3	0/1000	—	—		—	—		10	0	10
Coquillettomyia sp.[i]	0/1000	—	—		—	—		30	9	39
Lestodiplosis sp. 2	5/1000	2	5	7	—	—		0	0	0
Aphodiplosis triangularis	19/1000	30	18	48	—	—		0	0	0
Winnertzia sp.	4/1000	2	4	6	—	—		0	0	0
Ledomyia sp.	1/1000	1	0	1	—	—		0	0	0
Bremia sp.	2/1000	1	1	2	—	—		0	0	0
Trisopsis sp.	1/1000	1	0	1	—	—		0	0	0
Chrybaneura sp.	0/1000	—	—		—	—		0	5	5
Undet. Cecidomyiidae	6/1000	3	10	13	—	—		0	0	0

Total det. species: 14

Total det. species, individuals, and sex ratio on/in flowers, resp.: 9, 194, 150:44.

Total no. occupied flowers: 112/1000

Usual range of midge number/flower: 1–3

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[a] Most censuses of flowers occurred between 0630–0900 hours and freshly-opened flowers were recognized by the horizontal orientation of the sepals.

[b] 18–23 Nov. 1981, 10–14 March 1982, 17–23 July 1982, 8–11 Dec. 1982, 12–15 March 1983.

[c] A total "pool" of approx. 1000 flowers was taken each date from usually 20–70 trees depending upon the time of the year and availability of flowers; tree varieties used were UF-677, UF-613, and Pound-7.

[d] Defined as one or more midges suspended motionless usually from staminodes, ligules, sepals or petal hoods of open flowers.

[e] Defined as a midge visibly seen crawling either between staminodes and pistil, or inside petal hood of freshly-open flower.

[f] Aggregates of several midges on spider webbing in trees; data combine one or more roosts.

[g] Tentatively named as new species *denotata* (R. J. Gagné, pers. comm.).

[h] Tentatively named as new species *ligulata* (R. J. Gagné, pers. comm.).

[i] Tentatively named as new species *obliqua* (R. J. Gagné, pers. comm.).

pers. comm.) and a preliminary SEM survey of wild-caught *Mycodiplosis* sp. 1 (N = 6 observed) revealed that one cecidomyiid had a cocoa pollen grain adhering to one caudal hair on the abdomen. While members of both genera occur worldwide, the particular species associated with cocoa flowers may have tropical distributions, and these species will soon be described by Gagné (in press).

Individual cecidomyiids approach an open cocoa flower with considerable "bobbing and weaving" flight paths around a flower. Seemingly healthy flowers are often passed by completely by cecidomyiids flying along branches in cocoa trees. The flies do not appear to "swarm" about open flowers in large numbers. But Cecidomyiidae sometimes swarm along branches in cocoa trees (i.e. 12 February 1981 at 1700 hours at La Lola) and with both sexes represented. *Winnertzia* sp. was found swarming (approx. 20 midges seen) at 1500 hours on 18 November

Table 3. The abundance of adult Cecidomyiidae on/in freshly-opened *Theobroma cacao* flowers[a] for six widely separated census dates[b] for 500–1000 flowers examined each date[c] at Finca La Tigra, near La Virgen, Heredia Province, Costa Rica.

Species	No Occupied Flowers	No Midges Resting on Flowers[d]			No. Crawling Inside Flowers[e]			Communal Roosts[f]		
		♀♀	♂♂	T	♀♀	♂♂	T	♀♀	♂♂	T
Clinodiplosis sp. 1	14/1000	23	0	23	—	—		—	—	
Mycodiplosis sp. 1[g]	18/1000	25	3	28	1	0	1	—	—	
Mycodiplosis sp. 2	3/1000	0	3	3	—	—		—	—	
Mycodiplosis sp. 4	1/500	0	1	1	—	—		—	—	
Coquillettomyia sp.[h]	2/1000	2	0	0	—	—		—	—	
Lestodiplosis sp. 1	2/1000	2	0	2	—	—		—	—	
Aphodiplosis triangularis	3/500	3	0	3	—	—		—	—	
Winnertzia sp.	1/500	1	0	1	—	—		—	—	
Ledomyia sp.	1/1000	1	0	1	—	—		—	—	
Cantarina sp.	2/1000	4	1	5	—	—		—	—	
Feltiella sp.	4/1000	3	3	6	—	—		—	—	
Undet. Cecidomyiidae	7/1000	?	?	9	—	—		—	—	

Total det. species: 11

Total det. species, individuals, and sex ratio on/in flowers, resp.: 11, 75, 64:11.

Total no. occupied flowers: 68/500–1000

Usual range of midge number/flower: 1–2

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[a] Most censuses of midges in flowers occurred between 0630–0900 hours following an initial period of determining diurnal patterns of peak abundance, and freshly-opened flowers were readily recognized by the marked horizontal orientation of the sepals (which are more vertically positioned in older flowers).

[b] 11–24 March 1979, 1–4 Nov. 1980, 4–18 Feb. 1981, 12–17 Nov. 1981, 8–13 and 27–31 July 1982, and 2–6 March 1983.

[c] A total "pool" of usually 500–1000 flowers was taken as a sample each date from usually 20–50 trees in the same area (many mixed hybrid varieties of undetermined origin) depending upon the time of year and availability of fresh flowers; because cacao flowers drop off the trees within 24–48 hours after opening under most conditions, the occupancy data given in the table are expressed in terms of 500 or 1000 flowers, i.e., a single census.

[d] Defined as one or more midges suspended motionless usually from staminodes, ligules, sepals or petal hoods of open flowers.

[e] Defined as a midge seen actively crawling either between staminodes and pistil or inside petal hood (including entering and exiting) of freshly-opened flower.

[f] In the La Tigra study as compared to the La Lola study (Table 2), little attention was given to roosts.

[g,h] See species determinations given for same footnotes in Table 2.

1981 (La Lola) along a branch in a cocoa tree. *Micromya* sp. was found swarming about 5 cm above some rotting slices or discs of banana tree trunks (Young, 1983) (La Tigra, 26 July 1981).

Freshly-opened cocoa flowers between 0530 and 0700 hours are heavily visited by cecidomyiids, and these exhibit the potential pollinating behavior described above. While some of this activity may also occur in the pre-daylight hours of the dawn period, the rather compressed daylight period of cecidomyiid activity at dawn probably precedes the formation of communal roosts (see data below). While the basis for attraction to freshly-opened flowers awaits study, when three of the five petal hoods are surgically removed from flowers, cecidomyiids are found within a few minutes resting on various exposed floral parts: on 19 November 1981 at 0800, five were found perched on exposed anthers, petal ligule on one of the remaining petal hoods, and the tip of a staminode. Although the flower was deliberately damaged, this act did not lower attractiveness of the flower to potentially pollinating insects.

The results of a preliminary experimental study involving the confining of *Mycodiplosis* sp. 1 to experimental cages on flower-laden branches of cocoa trees at La Lola provide additional evidence that cecidomyiids can be cocoa pollinators, and confirms what others have concluded for other genera and species of these midges (Kaufmann, 1973b; Winder, 1977b). On 30 July 1981 a series of 14 such cages (2 experimentals and 12 controls) were set up (see Young (1983) for view of these cages) in the Area B study site of Young (1983) using UF-29 cocoa trees. One of the two experimental trees had 95 floral buds within the caged section of the branch and the second one had 23 buds at the time the test was initiated. The control trees had a range of about 30 to 100 floral buds at this time (these are tagged trees nos. 62, 63, 66, 76, 78, 79, 80 of Young, 1984b). The two experimental cages combined received a total of 33 cecidomyiids between 1–3 August 1981. By 10 August, one cherelle was well in evidence in one of the two experimental cages and no other cages had pods. The experiment was repeated on 12 March 1982 at La Lola, but this time in the Area A study site of UF-29 cocoa described in Young (1983). This time, however, I used only one control and one experimental cage, both on the same tree (tagged tree No. 15 of Young, 1984a). The confined area of the branch covered by the control cage had 64 floral buds while the experimental cage had 51 buds. A total of 39 individuals (mixed sexes) of what I judged to be *Clinodiplosis* sp. 1 were introduced into the experimental cage between 12–14 March. By 29 March three new cherelles were evident in the experimental cage and none in the control cage. In both tests, the cages were left in place on the trees until the final census (of pods) was taken.

Abundance Patterns of Cecidomyiids in Cocoa.—Typical adult abundance patterns in open cocoa flowers are readily seen from some data collected at La Lola (Area A of UF-29 cocoa in Young 1983) during March 1982: from a total of 70 flowering trees examined almost exhaustively, and representing a total pool of about 2000 open flowers, a total of 29 adult cecidomyiids were found perched on flowers, with a range of 1–2 per "occupied" flower and with five observations of three cecidomyiids on a single flower (and all observations made 1100 to 1300 hours in hot, sunny weather). During the March 1983 dry season at Hummingbird Hershey, a total of 39 cecidomyiids were counted from a total of 28 freshly-opened flowers at 1100–1200 hours on one date; total flower abundance on these trees just exceeded 5800 at this time (5880 open flowers). But unlike La Lola, these trees also had a total of 1586 pods, mostly cherelles, from natural pollination, whereas at La Lola pod numbers were less than 200 and the result largely of hand-pollination. The Hummingbird Hershey census area was well-shaded due primarily to self-shading cocoa trees, and an adjacent section of relatively little such shade yielded a total of 9 cecidomyiids found from a total sample of 3725 open flowers on an additional 70 trees. This area had a total of 245 cherelles. Generally, adult cecidomyiids are of very low density in open cocoa flowers, as also seen by some data from La Tigra: on 3 November 1980 at 1100 hours (hot, sunny day), a total of 20 flowering cocoa trees (mixed varieties) yielded a total of 640 open flowers ($\bar{x} \pm \mathrm{SD} = 31.00 \pm 18.39$ flowers per tree for $N = 20$) and a total of 16 cecidomyiids ($\bar{x} \pm \mathrm{SD} = 0.85 \pm 0.72$ per tree) from open flowers. Total abundance of cecidomyiids, i.e. all captured flying about flowers and landing on branches and leaves at this time was N = 69 or $\bar{x} \pm SD = 3.45 \pm 1.14$, a sample that undoubtedly included many non-pollinating species. An additional census at La Lola in March 1982 yielded a total of 54 cecidomyiids (28 female & 26 male) or $\bar{x} \pm SD = 1.42 \pm 0.77$ per tree and with a range of 1–4 per flower and 25 flowers with one cecidomyiid each, 6 with 2 each, 3 with 3 each, and one flower with 4 cecidomyiids each. Another census in the clonal garden area at La Lola in August 1983 revealed that nine of 70 trees had one or more cecidomyiids on or inside open cocoa flowers, and a total of 13, with 1–2 per "occupied" flower (5 female & 8 male); most of these appeared to be *Mycodiplosis* sp. 1. At this time, flowering was very low, with a range of about 0–5 open flowers per tree (N = 70 trees) and with slightly more than 50% of the trees with no flowers at all. In all censuses of cecidomyiids on flowers, virtually every specimen found was perched on one of the following floral parts: petal hood (abaxial surface), petal ligule, sepal, or staminode. All observations of specimens actually crawling inside flowers were limited to 0600–0800 hours (most observations) and 1600–1800 hours for daylight surveys taken. Other studies (Young, 1983; Young et al., 1984) indicate that cocoa flowers generally begin opening in the late afternoon and are fully open by 0400–0500 hours at both La Lola and La Tigra (see also the data of Wellensiek, 1932). Such a pattern is consistent with the early morning daylight activity period of cecidomyiids observed in the present study (Tables 1 and 4). Yet it is not uncommon to find large numbers of these midges perching motionless on open flowers at other times of the day. Casual observation indicated that midges were at least three times as abundant in this well-shaded area (Area A of Young, 1983) as contrasted with an unshaded area (Area B) at this time (dry season). Subsequent determinations indicated that most of the midges in all of these censuses were mixes of *Mycodiplosis* sp. 1, *Clinodiplosis* sp. 1, and *Coquillettomyia* sp. Differential partitioning of adult midges between shaded and sunny cocoa habitats at La Lola during the drier months was also demonstrated by an examination of aggregates of *Clinodiplosis* sp. 2 on the undersides of large plastic cups suspended from cocoa trees in both areas (see Young 1983 for details): on 13 March 1983 at 1400 hours, a total of 6 out of 20 such cups in Area A (shade) had a total of 51 midges with 5–16 per cup, while only one of 20 cups in Area B (sunny) had one midge. A 12 March 1982 census (i.e. one year earlier) of the same areas yielded a total of 56 midges from 7 "occupied" cups in the shaded area and none in the sunny area. During the drier months at La Tigra (such as March) typically many cecidomyiids are found on open cocoa and *Guazuma* flowers between 0600-0800 hours, but that after this time there is marked decline and virtual absence of specimens at flowers until much later in the day (near dusk). Such diurnal decline patterns are less pronounced during the rainy season for cocoa flowers.

Additional data on cecidomyiid abundance in cocoa flowers are seen in Table 2. A total of 12 genera and 16 species were collected in the La Lola studies, of which nine genera and species were found visiting cocoa flowers. A total of 116 individuals of *Mycodiplosis* sp. 1 (99 female & 17 male) on flowers (Table 2) represents about 60% of the total fauna of 193 determined midges) on flowers, followed by *A. triangularis* with about 20% of the fauna on flowers (N = 53 or 28 female & 25 male), and then by *Clinodiplosis* sp. 1 (all female) at about 6% of the total sample taken (Table 2). At La Tigra the most abundant species found

Table 4. Records of adult Cecidomyiidae in freshly-opened or open flowers of *Theobroma* species other than *cacao* at Finca Experimental La Lola and Finca La Tigra in Costa Rica.[a]

Midge Species	Date	Time of Day	Sex	Tree Species	Other Comments
La Lola					
Clinodiplosis sp. 1	Feb. 1981	1600	male	*T. simiarum*	on staminode
	Mar. 1983	0800	male	*T. speciosum*	on ligule
	Mar. 1983	0700	male	*T. mammosum*	on ligule
Prodiplosis sp.	Feb. 1981	0700	1 female, 3 males	*T. simiarum*	on staminodes
Clinodiplosis sp. 4	Mar. 1983	0600	2 females, 1 male	*T. mammosum*	on staminode
Mycodiplosis sp. 1	Mar. 1983	1600	female	*T. silvestre*	on staminode
Bremia sp.	Mar. 1983	1700	female	*T. speciosum*	inside petal hood
	Mar. 1983	1700	male	*T. simiarum*	inside petal hood
Asynapta sp.	Mar. 1983	?	?	*T. mammosum*	on staminode
La Tigra					
Clinodiplosis sp. 1	Mar. 1983	1000	—	*T. mammosum*	communal roost[b] of 18 (mixed sexes)
	Mar. 1983	0700	3 females	*Guazuma* sp.[c]	landing on open flowers
Bremia sp.	Mar. 1983	1000	—	*T. bicolor*	communal roost of approx. 400 (mixed sexes)[d]

[a] Examination of flowers made opportunistically on various days and not following a particular pattern.

[b] This roost was located on spider webbing between leaf petiole and branch and about 10 cm from nearest open flowers.

[c] Also Sterculiaceae.

[d] This roost located on webbing stretching across two leaves and about 15 cm from nearest open flowers.

in cocoa flowers (and also in *Guazuma* sp. flowers) was *Clinodiplosis* sp. 1 (23 of 44 or about 50%). Eight genera and 13 species were collected from flowers at La Tigra. At La Lola all five *Clinodiplosis* sp. 1 seen moving inside floral parts of cocoa were females as well as the two *Mycodiplosis* sp. 1 (Table 4). Several genera that were not found in cocoa flowers (Table 3) at all were found forming communal roosts in cocoa habitats. Caution is exercised in interpreting these patterns as the data are small. Some species, such as *A. triangularis*, while abundant in flowers, were never found in roosts (Table 3), but *Mycodiplosis* sp. 1, while common in flowers, also constituted about 69% of all cecidomyiids found in communal roosts (Table 3). In all studies, however, relative to abundance of open flowers, cecidomyiids are relatively rare in cocoa flowers in both rainy and dry seasons in Central America (Table 5). For the three most abundant species in the La Lola samples, namely, *Mycodiplosis* sp. 1, *A. triangularis*, and *Clinodiplosis* sp. 1 (in this order), a total of 122 individuals were collected on two different "dry" season dates and 66 on three wet season dates, even though the same number of trees was covered on all dates and samples were always taken at the same times of the day. For both seasons, all census dates, these three species constitute 188/194 or

Table 5. Estimates of population density of adult Cecidomyiidae on freshly-opened flowers[a] of *Theobroma cacao* in the La Lola (Costa Rica) and Hummingbird Hershey (Belize) cocoa farms in Central America.

Census Dates	"Season"[b]	Total No. Open Flowers[c]	Range	$\bar{x} \pm$ SD	Total No. Adult Midges	$\bar{x} \pm$ SD	No Midge Occupied Flowers	Percentage (%) Flower Occupancy
				La Lola				
21-VII-82	mid-rainy	650	0–53	9.81 ± 11.20	7	0.11 ± 0.36	6	0.92%
8-XII-82	late rainy	1577	0–75	22.52 ± 19.55	19	0.27 ± 1.25	7	0.44%
14-III-83	dry	1712	0–300	24.45 ± 41.45	61	0.77 ± 2.15	31	1.82%
5-VIII-83	mid-rainy	3278	1–178	38.24 ± 47.04	30	1.50 ± 1.87	14	0.42%
				Hummingbird Hershey				
22-III-83	dry	5880	10–108	73.50 ± 48.64	39	0.53 ± 1.09	28	0.47%

[a] For each locality, all of the data on both flowers and midges were taken always from the same set of mature and healthy cocoa trees. A total of N = 70 trees were sampled each time at each locality (in the case of La Lola for the repeated censuses). At La Lola, the tree sample was almost evenly divided among the clonal varieties of UF-677, Pound-7, and UF-613 (these rows being contingent), while at Hummingbird Hershey the 70 trees were of mixed undetermined varieties. Only freshly-opened flowers were examined for midges and only midges resting on or inside definite floral parts were counted.

[b] "Season" is considered here as a relative condition of "wetter" and "drier" periods as defined by available rainfall data (Fig. 1). As such, this condition changes considerably from year to year at each locality.

[c] For 21-VII-82 census at La Lola, 153/650 or 23.5% of open flowers with horizontal sepals, i.e., flowers freshly-opened that morning (as opposed to being 1-day old flowers); similar level for 8-XII-82; for 14-III-83 the 31 flowers occupied by cecidomyiids all but 4 with horizontal sepals and 36.1% of all flowers at this time with this condition of freshness. In Belize sample about 50% of all flowers with horizontal sepals.

about 97% of all cecidomyiids collected (Table 2). For La Tigra, only rainy season data (2 dates) are available.

The experimental studies using small flypaper squares to trap flying insects within the vicinity of open cocoa flowers and away from them (Table 6) revealed very low abundance of cecidomyiids in both day and night samples at La Lola during the rainy season. While the sample size is small, there is a slight trend towards finding more specimens in "experimental" sticky squares than in the "control" squares away from flowers (Table 6). Prior to these results, a total of 48 sticky squares distributed almost randomly among 15 trees (all Pound-7) at La Lola and within one area yielded two cecidomyiids (both *Mycodiplosis* sp. 1; females) captured in the traps between 1700 and 0700 hours (dusk-to-night-to-dawn) on 16 July 1982, and the same test repeated on the following evening produced one cecidomyiid of undetermined species designation. From 27 to 31 July 1982 similar tests conducted at La Tigra provided similar results: in one patch of four cocoa trees a total of 127 squares were placed around 60 open flowers at 1700 hours (27 July) and checked at 0730 the following day. A total of 18 squares had trapped flying insects (21) including one female *Clinodiplosis* sp. 1. A second test conducted with the same trees and same number of squares and flowers yielded no cecidomyiids for the period 0800 to 1700 hours (28 July) even though 49 other flying insects were trapped during this daytime census. Tentatively these findings taken together suggest that cecidomyiids are not abundantly active

Table 6. The occurrence of Cecidomyiidae versus other flying insects in small squares of sticky flypaper adjacent open cocoa flowers (experimentals) and on bare spots on branches (controls) in an area of typically-shaded Pound-7 variety cocoa trees in a clonal garden at Finca Experimental La Lola, Costa Rica.

Date Intervals	Time Range	Tree No	No Experimental Squares	No. Flowers Used	No Control Squares (0 Flowers)	No Squares with Trapped Insects	No Cecidomyiids Trapped	Species
20 July	0630–1730	1	46	25	0	14/46	1	*Mycodiplosis* sp. 1
	(dawn–day–	2	22	20	0	5/22	2	*Mycodiplosis* sp. 1
	dusk)	3	0	0	30	3/30	0	(all females)
	Total trapped insects: 44 (all squares)							
20–21 July	1730–0630	1	46	25	0	15/46	1	*Clinodiplosis* sp. 1
	(dusk–night–		22	20	0	8/22	1	*Mycodiplosis* sp. 1
	dawn)		0	0	30	10/30		(both females)
	Total trapped insects: 40 (all squares)							
21–22 July	1730–0630	1	35	16	0	6/35	0	*Clinodiplosis* sp. 1
	(dusk–night–	2	10	6	0	5/10	2	(both females)
	dawn)	3	0	0	30	2/30	0	
		4 (new)	14	8	0	3/14	0	
	Total trapped insects: 15 (all squares)							

at cocoa flowers at any time of the day or night, assuming that the trapping method used is effective in capturing these insects, but that cecidomyiids are very likely active both at dawn and dusk at flowers.

Communal Roosts of Cecidomyiids in Cocoa.—When a total of nine different communal cecidomyiid roosts were followed in the shaded UF-29 cocoa at La Lola (Area A of Young, 1983) in November 1981, all but three roosts lasted at least five successive days in the same locations (usually in branch crotches or cherelle petiole-branch crotches) even though actual size (numbers of cecidomyiids) in each roost varies greatly from day to day. Roosts both increase and decrease in size over successive days. In one roost studied, a pattern of increase over three days was from 6 to 18 to 19, while the decline pattern of a second roost for the same period was 90 to 5 to 10. Roosting midges occupy small spider webs anchored to cocoa tree branches in shaded spots, and most roosts are within 0.1 to 3.0 m of the ground. Occasionally living spiders also occupy the webs used by roosting cecidomyiids; these include Theridiidae (possibly *Achaearenea* sp.) and *Leucauge* sp. (Araneidae). While most roosts at La Lola appear to consist of one primary species, one mixed-species roost of about 100 cecidomyiids collected at La Lola in March 1982 included 30 *Mycodiplosis* sp. 1 (15 female & 15 male), one *Mycodiplosis* sp. 2 (1 male), 10 *Coquillettomyia* sp. (8 female & 2 male), and *Feltiella* sp. (1 male). On a day to day basis, very large roosts, defined here as consisting of 100 or more midges at any one time, frequently break up into much smaller aggregates at the original roost site. As long as a web remains undamaged (by rain, wind, abrasions, etc.), midges may occupy the same web on several days. Cecidomyiids are most prevalent on roosts during daylight hours and vacate roosts at night; in clear sunny weather these frequently leave roosts by 1745 hours, as do those perching motionless on open cocoa flowers. On 20 November 1981 I witnessed the return of several cecidomyiids into a tagged roost site (web) at 0630 hours, and most roosts are formed between 0600-0700 hours each morning. Unless disturbed, the flies do not normally leave roosts in the daytime. The majority of specimens found in roosts appear to have much darker cuticles than many found on freshly-opened flowers in daylight hours, a condition suggesting that freshly-eclosed adult midges, particularly females (see Table 2), seek out cocoa flowers before entering into roost formations. On rainy, overcast days, dispersal from roosts may occur earlier in the afternoon, between 1700 and 1730 hours. Periods of heavy daytime rains do not disturb midges from roosts. During March 1982 in the shaded UF-29 cocoa habitat at La Lola, a total of 25 roosts were discovered among 50 cocoa trees, representing a total of 723 cecidomyiids (mostly *Mycodiplosis* sp. 1) with average roost size being $\bar{x} \pm \mathrm{SD} = 28.92 \pm 31.21$ for a total of 18 trees having one or more roosts; the range in numbers of specimens per roost was 1–125 for a census at 1100 hours in hot, sunny weather. In the clonal garden area at La Lola in December 1982 (late rainy season) only three roosts were found on a total of 70 cocoa trees, with 20–40 cecidomyiids per roost; specimens were also scarce on open flowers at this time. Lowest roost densities in cocoa trees occur in the rainy season at La Lola. At Hummingbird Hershey during August 1981 (rainy season) a total of five roosts were found within a 10 by 10-meter area within Field Block 18, with range in midges being 25–150 at 0900 hours and all midges being *Coquillettomyia* sp. Mortality of roosting midges is probably low, but on 20 July 1982 at La Lola one roost of 25 specimens was totally encased in hyphal growths of fungi when discovered at 0900; the roost was found following an evening period of heavy cold rains. When the webbing of a roost site is destroyed, sometimes new webbing appears in the same spot a day or so later, and new webs are sometimes recolonized by midges. Earwigs scattering along branches in cocoa trees at La Lola (A. M. Young, in preparation) occasionally fall into webs with roosting cecidomyiids, and these quickly disperse in response to such disturbances. By following diurnal patterns of roost formation and dissolution, it was determined that roosting in cocoa cecidomyiids is a daytime behavior, and that they are active principally at dusk, night, and dawn (Table 7). Roosting cecidomyiids are not disturbed by actively hunting insect predators such as *Anolis* lizards and salticid spiders. The flies are most vulnerable to these predators when hovering above branches or landing on branches, leaves, and flowers. The exploitation of spider webs in cocoa trees may function to protect cecidomyiids from such predators at times of the day when these insects are largely inactive.

Cecidomyiid Midge Life Cycle Substrates.—Cocoa trees with branches covered with epiphytic mosses generally have many adult cecidomyiids flying about them during the early daylight morning hours. Most cocoa-associated cecidomyiids most likely breed close to the ground, colonizing various kinds of rotting organic materials for completion of the life cycle. Small areas within cocoa farms that consistently have high numbers of cherelles are also sites of sustained high adult population densities of cecidomyiids and ceratopogonids (A. M. Young, field obs. 1978–1983). At Hummingbird Hershey, a total of six large cocoa pods in various stages of rotting, and with large woodpecker-generated holes in them, yielded a total of 158 cecidomyiid larvae, with a range of 6-60, and for a total sample of 20 damaged pods (all but 4 150–180 mm long) examined (of which six had midge

Table 7. Comparative abundance of cecidomyiid midges (mostly *Mycodiplosis* sp. 1) in communal roosts[a] between day and night in one section of cocoa plantation[b] in Finca Experimental La Lola, near Siquirres, Limon Province, Costa Rica, during two different rainy season census periods.

		0700 to 1700 hrs ("Day")		1800 to 0600 hrs ("Night")	
Day	No. Roosts Present	Range in Roost Size	Max No. Midges Seen in Roosts Day	Range in Roost Size	Max No. Midges Seen in Roosts Day
		18–22 November 1981 ("late rainy")			
1	5	2–6	26	0	—
2	9	2–110	131	0–10	10
3	9	2–18	47	0	—
4	9	1–22	73	0–16	16
5	9	0–34	34	0	—
Total midge "observations":[c] 341					
$\bar{x}$ ± SD (N = 5 days): 68.20 ± 54.85					
		16–22 July 1982 ("mid-rainy")			
1	5	10–45	109	0	—
2	7	1–20	67	0	—
3	14	2–150	517	0	—
4	15	2–60	217	0	—
5	15	1–88	251	0	135
6	17	7–51	322	0	—
7	17	2–53	293	0	—
Total midge "observations":[c] 1776					
$\bar{x}$ ± SD (N = 7 days): 253.71 ± 148.70					

[a] Roosts were discovered and positions tagged with small, yellow plastic tags (numbered); most roosts in spider webbing draped between branches or pods and branches in cocoa trees.

[b] Well-shaded "habitat" of UF-29 cocoa—the "Area A" of Young (1983).

[c] Defined as the total number of midges obtained by summing the "maximum number seen" figures in the table.

larvae), the average abundance was $\bar{x}$ ± SD = 7.85 ± 17.52 midges per pod (23–24 March 1983 census). Within a given pod having larvae, larvae are distributed in a patchy fashion. Larvae occur in both moist and dry exocarp as well as on moist rotting seeds inside pods. Shaded areas of cocoa have many rotting cherelles and tend to have more roosts of cecidomyiids than exposed areas. Pockets of several larvae frequently occur inside pods. At Hummingbird Hershey in March 1983, I witnessed several instances of female cecidomyiids perched on rotting pods in cocoa trees, and with the terminal tips of swollen abdomens (perhaps filled with mature eggs) probing the pod surface as if determining an egg-placement site. Larvae clustered in pockets in pods may reflect a clustered egg-laying habit in cecidomyiids. A hanging pod at La Lola in March 1982 and having a large squirrel-generated hole in it was blanketed with the hyphae of various fungi (*Fusarium*, *Phytophthora*, and *Thielaviopsis* sp.) and several adult cecidomyiids (*Clinodiplosis* sp. 1 and several undetermined ones as well) having swollen abdomens were perched in the fungal growth (Fig. 3). When the pod was collected and opened, many larvae of *Clinodiplosis* sp. 1 were found inside, within the rotting tissues exposed by the wound in the pod wall. Prior to collecting, adults on the fungus remained there for several hours, and adults were also present the next day as well. *Clinodiplosis* larvae make audible clicking sounds and jump several centimeters when disturbed. Various genera and species of cecidomyiids dwelling in cocoa farms in Central America undergo their life cycles in a range of rotting organic debris (Table 8). Samples of epiphytic moss from cocoa trees brought into the laboratory (Milwaukee) exhibit a gradual day-to-day emergence of *Mycodiplosis* sp. 1 adults: a sample collected in November 1981 at La Tigra generated 3 adults on 28 December 1981, and one each on 7, 8, 11 and 12 January 1982, and with all emergences occurring 0700–1000 hours under laboratory conditions. Both *Mycodiplosis* and *Clinodiplosis* species are known to be fungus-feeders in the larval stages and none are predatory or gall-makers (R. J. Gagné, pers. comm.). Cocoa farm habitats appear to be suitable for breeding in cecidomyiids, some of which may be cocoa pollinators (Table 8).

DISCUSSION

Other studies have indicated that some Cecidomyiidae are pollinating agents of cocoa in both the New and Old World humid tropics (Kaufmann, 1973b; Winder, 1977b, 1978a), although the general conclusion has been that these midges are only incidental or fortuitous cocoa pollinators (e.g. Entwistle, 1972; Winder, 1978a). The present findings indicate that a few species of cecidomyiids, such as *Clinodiplosis* sp. 1 and *Mycodiplosis* sp. 1, are natural pollinators of cocoa in Central America, and several species also visit the flowers of other *Theobroma* species. The observed mechanism of pollination of cocoa by cecidomyiids in Costa Rica did not appear to include the "wing vibration" syndrome of several specimens in one flower as observed by Kaufmann (1973b) in Ghana. Rather, pollination appeared to be largely limited to the movements of individual cecidomyiids through enclosed reproductive floral parts in the present study.

In general the mode of cocoa pollination by cecidomyiids in Costa Rica matches well the typical pollination system involving ceratopogonid midges (e.g., see the review in Entwistle (1972) and in Bystrak and Wirth (1978) with these notable differences: (1) cecidomiids tend to carry fewer pollen grains than ceratopogonids (as also noted by Winder, 1977b), (2) cecidomyiids are mostly active in cocoa flowers at dawn, dusk, and at night while ceratopogonids are generally most active in the later daylight hours of the morning (e.g. Fontanilla-Barroga, 1962; Soria et al., 1980), and (3) cecidomyiids exhibit apparent feeding behavior at the fleshy petal ligules in areas filled with stomate-type nectaries (see Young et al., 1984) whereas this floral part is largely ignored by ceratopogonids; such feeding in cecidomyiids generally precedes the movement of midges into the enclosed reproductive parts of the cocoa flower, and might therefore be a prerequisite to actual pollination by cecidomyiids. Decazy et al. (1980) found many cocoa pollen grains adhering to the cuticle of cecidomyiids in South Cameroon, and determined that these midges often fly up to 35 meters and can therefore serve as cross-pollinating agents. Winder (1977b) also noted pollen grains in the cuticle of cecidomyiids in Brazil and Privat (1979) describes the movement of cecidomyiids in the petal hoods of cocoa flowers in Costa Rica. The question of whether or not this interaction is fortuitous awaits further study, given the general conclusion that dipterans are generalist floral visitors (e.g. Percival, 1965; Faegri and Pijl, 1971; Kevan and Baker, 1983). Yet some field studies indicate a more specialized role of some dipterans as pollinators (e.g. Baumann, 1978; Vogel, 1978; Mesler et

Table 8. Rearing records for Cecidomyiidae in some Central American cocoa farms.

Species	Locality	Rearing Conditions
Mycodiplosis sp. 1	La Tigra (Costa Rica)	10 from larvae on moss on trunk of tree in forest adjacent to cocoa; July–August, November 1981
	La Lola (Costa Rica)	1 from larva in experiment rotting disc (slice) of banana tree trunk (Young, 1983), March 1983
Mycodiplosis sp. 2	La Tigra (Costa Rica)	4 from larvae in ground-cover rotting cocoa leaf litter; July 1982
Clinodiplosis sp. 1	La Tigra (Costa Rica)	9 from larvae in arboreal plastic cup (artificial bromeliad) filled with rotting cocoa leaves (Young, 1982) and from moss on trunk of tree in forest adjacent to cocoa; Dec. 1978, Nov. 1981 and March 1983
	La Lola (Costa Rica)	30 larvae in squirrel-generated wound in ripe cocoa pod in tree (with pod hole covered with hyphae of various fungi); March 1982
	Hummingbird Hershey (Belize)	8 larvae just beneath dry exocarp layer of hanging cocoa pod destroyed by black pod rot; March 1983
Clinodiplosis sp. 3	La Lola (Costa Rica)	1 from larva in arboreal plastic cup (artificial bromeliad) filled with rotting cocoa leaves (Young, 1983); February 1981
Coquillettomyia sp.	La Lola (Costa Rica)	1 from larva in arboreal plastic cup (artificial bromeliad) filled with rotting cocoa leaves (Young 1983); August 1981
Micromyia sp.	La Lola (Costa Rica)	2 from larvae in experimental rotting discs (slices) of banana tree trunk (Young, 1983); July 1981
	La Tigra (Costa Rica)	1 from larva in arboreal plastic cup (artificial bromeliad) filled with rotting cocoa leaves; December 1978
Ledomyia sp.	La Tigra (Costa Rica)	1 from larva in ground-cover rotting cocoa leaf litter and 2 from larvae in arboreal plastic cup (artificial bromeliad) filled with rotting cocoa leaves; Dec. 1978 and March 1979
Lestodiplosis sp.	La Tigra (Costa Rica)	1 from larva in ground-cover rotting cocoa leaf litter; March 1979
Porricondylia sp.	La Tigra (Costa Rica)	2 from larvae in ground-cover rotting cocoa leaf-litter; December 1978
Camptomyia sp.	Hummingbird Hershey (Belize)	12 larvae in both wetter and drier portions of exocarp galleries in 3 arboreal rotting cocoa pods; March 1983
Resseliella sp.	Hummingbird Hershey (Belize)	10 larvae inside woodpecker-generated gouge or hole in arboreal cocoa pod in early stages of rotting cycle; March 1983
Undet. Cecidomyiidi	La Lola (Costa Rica)	5 larvae in squirrel-generated wound in ripe cocoa pod in tree (with pod hole covered with hyphae of various fungi); March 1982

al., 1980). The presence of functional elongate mouthparts and exceptionally long hairs on the legs and abdomen of *Clinodiplosis* and *Mycodiplosis*, and the observed apparent feeding by these midges on petal ligules and other floral parts involved in the reproductive biology of cocoa, point to a specialized association with flowers. Both Kaufmann (1973b) and Winder (1977b) observed cecidomyiids inside petal hoods of cocoa flowers in Ghana and Brazil, respectively, and related this behavior to pollination. Other genera of these midges formed the basis of their studies. Patterns of feeding on nectar and pollen by some Diptera may vary within a group of closely related species and may be expressed in terms of divergence in mouthpart structure (e.g. Gilbert, 1981). Although there exist some extensive records of life cycle associations in Neotropical Cecidomyiidae (Gagné, 1968, 1977), a pollination association with cocoa has not been emphasized in great detail (with the exceptions of Kaufmann, 1973b and Winder, 1977b). The observed heavily skewed abundance of female midges in cocoa flowers suggests a possible feeding association somehow linked to the reproductive physiology of these midges. But Kaufmann (1973b) found a 1:1 sex ratio in *Parallelodiplosis triangularis* (Cecidomyiidae) in cocoa flowers in Ghana, and the females were sexually mature. Pollen-feeding by female *Heliconius* butterflies is an adaptation for acquiring some amino acids essential for egg development (Gilbert, 1972). Female cecidomyiids in cocoa farms may seek out flowers for pollen or nectar, and then proceed to breed in nearby microhabitats such as epiphytic mosses and rotting cocoa pods still on the trees. In some studies of mosquitoes, there are good correlations in females between breeding sites and feeding sites from the previous evening (e.g. Kay, 1983). While Baker et al. (1953) noted associations of cecidomyiids with predaceous larval stages feeding on mealybugs associated with cocoa and other *Theobroma* in Brazil, free-living non-predaceous forms such as species found as adults in cocoa flowers may have larval stages associated with these trees in a different way: larvae are found in the rotting tissues of either animal-damaged or diseased pods still on the trees. *Toxomyia*, a genus evolutionarily close to *Mycodiplosis*, has larval stages associated with rust spores on leaves in the West Indies (Parnell, 1969). Unlike the association of other cecidomyiids with the flowers of grasses in the American tropics (Soderstrom and Calderón, 1971), larval stages of cocoa-pollinating cecidomyiids have not been found in the flowers. Kaufmann (1937b) in her Ghana studies has reported larvae of cocoa-associated cecidomyiids in flowers.

There is an abundant data base indicating that small-bodied midges such as cecidomyiids are largely limited in activity to moist forest habitats or to times of the day and evening when ambient conditions are moist and cool (e.g. Fisher and Teetes, 1982; Barnes, 1930; Summers, 1975; Shazli and Mostafa, 1980; Brewer, 1981; Vanhara, 1981; Brown and McGavin, 1982; Charlwood et al., 1982; Lumsden, 1952; Willmer, 1982). My data indicate a strongly crepuscular and nocturnal activity pattern of cocoa-pollinating cecidomyiids, as determined from surveys of midges in cocoa flowers, and by observing roosting habits in some species. Kaufmann (1973b) noted similar diurnal activity patterns for cocoa-associated cecidomyiids in Ghanian cocoa farms, and at least one tropical study indicates that *Toxomyia* (a genus close to *Mycodiplosis*) adults emerge in the late afternoon and early evening from their pupae (Parnell, 1969). Lucas (1981) reported cecidomyiids laden with cocoa pollen grains being collected at or before 0700 hours in cocoa farms in the Ivory Coast, and Decazy et al. (1980), using radio-isotopes as midge markers, determined two peaks of cecidomyiid activity in cocoa plantations in South Cameroon as 0730–0930 and 1630–1830 hours. In general cocoa flowers begin to open in the late afternoon, and gradually open all night and are fully open by 0500 hours (e.g. Wellensiek, 1932; Sampayan, 1966; Gorrez, 1962; Soetardi, 1950). Although Sampayan (1966) concludes that anther dehiscence in cocoa flowers peaks between 0600-1000 hours and stigma receptivity to pollen between 1000–1300 hours in the Philippines, similar data from Costa Rica (La Lola) indicates pollen-release throughout most of the day and night, and greatest fertilization of flowers in the early and mid-morning hours (Young et al., 1984). Given these data and the observed activity patterns of cecidomyiids in the Costa Rican studies, I propose, tentatively, that these midges pick up viable cocoa pollen grains during their dusk and evening activity periods, and deposit pollen on stigmas and pistils primarily in the dawn hours (e.g. 0530–0700 hours). Thus cocoa flowers behaviorally function as males during most of the day and evening following anthesis, and as females in the dawn hours, even though the flowers are morphologically and physiologically hemaphroditic (e.g. Walker, 1959). Differential rates of sexual maturation in male and female floral parts in relation to pollinator behavior have been noted in other plant species exhibiting synchronized flowering (e.g. Philbrick, 1983; Essig, 1971; Gibbs et al., 1977).

The habit of some cocoa flower cecidomyiids forming roosting aggregates in spider webs on cocoa trees may assist in the concentration of midges near floral rewards. Although such roosts in the present study were found to contain about equal numbers of male and female midges, Kaufmann (1973b) noted twice as many females as males in Ghanian cecidomyiids in cocoa. As in the present study, Kaufmann (1973b) also noted dissolution of roosts in the evening and the formation of roosts in the daylight hours. Although not yet determined, roosting behavior in cecidomyiids may function primarily to conceal midges from predators that forage on the trunks and branches of cocoa trees (see also Lahmann and Zuniga, 1981) as they apparently have little or no function in mating behavior (Sivinski and Stowe, 1980). As in the present study, Kaufmann (1973b) too noted that midges often roost in spider-occupied webs, suggesting little threat of predation from these animals. By far, the greatest densities of midge predators in cocoa trees are seen in *Anolis* lizards and the mantid *Chaeteessa filata*. Dipterans are known to be a major component of the diet in *Anolis* (e.g. Floyd and Jenssen, 1983), and the high densities of these lizards in cocoa habitats like La Lola (see Andrews, 1979) suggests that considerable selection pressure is operating for effective predator defense behavior in small-bodied flying insects in the same habitats. Aggregative behavior has been long known to be one form of protection against predators in invertebrate animals (Allee and Rosenthal, 1949 and several included references). The observation that the same sites (webs) tend to be reused over several successive days suggests a social organization associated with roosting cecidomyiid species in cocoa habitats. Roosting in these midges, with daily recruitment of new individuals in some instances, may represent a form of "local enhancement" to advertise optimal resources within the cocoa habitat (e.g. Ward and Zahari, 1973). Because reproductive effort (i.e. numbers of eggs deposited in the environment per unit area) in forest-dwelling dipterans can be relatively high (e.g. Fallis and Snow, 1983), predators may selectively forage on numerically-abundant species such as cecidomyiids. The high turnover in organic rotting materials in cocoa farms very likely promotes the maintenance of cecidomyiid breeding populations, unlike closed laboratory systems in which enforced migrations can sometimes occur in response to contamination arising from high population densities, as shown for some fungus-dwelling Sciaridae (Binns, 1980). Preferential egg-laying behavior in cecidomyiids may allow midges to exploit a range of different microhabitats, both terrestrial and arboreal, as a means of resource partitioning as shown for other dipterans in the tropics (e.g. Siefert, 1980; Siefert and Barrera, 1981; Gagné, 1968, 1977; Carpenter, 1983; Winder, 1978b and many included references). A major component of the evolutionary association of Cecidomyiidae with cocoa trees may include the exploitation of arboreal breeding microhabitats routinely found in *T. cacao* populations in the American tropics, namely, rotting holes in cocoa pods made by animals such as squirrels and woodpeckers, and epiphytic mosses.

Various studies have shown that cocoa-pollinating Ceratopogonidae exhibit wide fluctuations in population structure correlating well with seasonal patterns of rainfall (e.g. Soria and Abreu, 1976). While the drier months of the year at Costa Rican cocoa-growing localities such as La Tigra and La Lola tend to be times of reduced levels of flowering in cocoa trees (e.g. Young, 1982, 1983, 1984b) the preliminary data on abundance of adult cecidomyiids given in the present paper suggest an increase in abundance during the drier months. These data were not gathered in such a way so as to distinguish between greater abundance being an artifact of sampling, i.e. in which areas of cocoa sampled in the dry season tended to have greater accumulations of midges, or an actual indication of greater absolute abundance in populations at these times. But Kaufmann (1973b) determined that cecidomyiids were more abundant in cocoa flowers during the dry season in Ghana. If the observed high densities of these midges during the drier periods is a real biological effect and not an artifact of small sample size, and if it represents a concentration of these insects into moist pockets of cocoa, there is expected to be an increased dispersion of the populations during the rainy months. Flowering tends to be greater in the wetter months at the Costa Rican localities studied (Young, 1984b) and there will be a greater floral reward for pollinators over larger areas of cocoa habitats. Because the egg-to-adult developmental time in some free-living tropical cecidomyiids is only about ten days (e.g. Parnell, 1969), many overlapping generations can occur each year. During the drier months, these midges may exploit dry substrates as breeding sites as shown by the discovery of larvae in relatively dry exocarp of cocoa pods in the dry season at Hummingbird Hershey. Particularly during the drier months, small-bodied Diptera may accumulate in the more shaded areas of cocoa farms in response to thermal and moisture stress, and shaded areas of cocoa habitats tend to have a greater diversity of Diptera than sunny habitats (Bigger, 1981; Gibbs and Leston, 1970; Young, 1983). Seasonally-related changes in the spatial distribution and abundance of moist or wet microhabitats used by Cecidomyiidae and other Diptera in the tropics result in changes in the availability of adult insects in breeding populations (e.g. McLachlan and Cantrell, 1980). Levels of natural pollination in cocoa are determined in part by the ways in which seasonal changes in rainfall influence population cycles in natural pollinators (De la Cruz and Soria, 1973). Times of the year in which flowering is highest and synchronous within a population of a tropical tree species are also times of greatest abundance of pollinators at flowers, since more pollinators are attracted to more intense floral displays (e.g. Augspurger, 1981).

Although it was determined, by light microscopy, that cocoa flowers possess nectary-like structures on specific floral parts (Stejskal, 1969), recent studies using scanning electron microscopy reveal stomate-type nectaries on petal ligules and on the inner surfaces of petal hoods in these flowers (Young et al., 1984). These nectaries have diameters suitable to accommodate the sucking mouthparts of cecidomyiids such as *Clinodiplosis* sp. 1, *Mycodiplosis* sp. 1, *Coquillettomyia* sp., and *Aphodiplosis triangularis.* The surface of the floral ovary is blanketed with peg-like glandular structures (Stejskal, 1969; Young et al., 1984) of unknown function, but perhaps an additional component of the "pollinator reward syndrome" of *Theobroma* flowers (Young et al., 1984). Cecidomyiids and ceratopogonids, as well as wild bees (Young et al., 1984), may visit cocoa flowers and those of other *Theobroma* for both pollen and nectar as floral rewards. A fragrance-producing ring of glandular structures located between the sepals and petals of *Theobroma* flowers, and greatly reduced in faintly-scented cocoa flowers (Young et al., 1984), may constitute the mechanism by which floral visitors are attracted to flowers. Once inside petal hoods, cecidomyiids often follow the pigmented "nectar guides" leading towards the basal area of the flower, and they are perhaps also following a fragrance being produced by the basal glandular ring, albeit faint in cocoa. Similar behavior, resulting in pollination, has been noted for certain species of fungus gnats associated with *Asarum* (Vogel, 1978).

Elsewhere (Young et al., 1984) the hypothesis is advanced that the basic floral design in *Theobroma* may have originally evolved as a bee-pollination system as most species of the genus have colorful flowers with strong pleasant fragrances, two conditions reduced in *T. cacao.* It is suggested that *T. cacao* which thrives well in cool, moist shaded forest understories, even in its natural state (Allen, 1981), has evolutionarily replaced bees with Diptera as frequent natural pollinators (Young et al., 1984). While some wild bees, such as *Trigona jaty* (Hymenoptera: Apoidea: Meliponinae) may not directly pollinate cocoa flowers (Soria, 1975; Young, 1981), such heavy-bodied insects may sufficiently jostle pollen loose from anther sacs to facilitate eventual contact with small midges crawling through petal hoods. Pollen grains frequently lodge on the inner surface of petal hoods, adjacent to the anthers they enclose (Young et al., 1984). In the closely related genus *Herrania,* pollen grains adhering to the side of petal hoods are picked up by phorid flies, the natural pollinators (Young, 1984c). Still other kinds of small-bodied wild bees may directly pollinate cocoa flowers (e.g. Kaufmann, 1975c). In Costa Rica, wild bees tend to forage primarily on cocoa flowers in the sunlit upper portions of cocoa trees, while midges (cecidomyiids and ceratopogonids) are more commonly encountered on shaded, lower branches (A. M. Young, unpubl. data). In some plant species, both dipterans and bees jointly contribute to the overall reproductive success in populations (e.g. Motten et al., 1981). When bee-pollinated plant species occur in cool, moist environments, generalized or specialist flies tend to replace bees as routine pollinating agents (e.g. Levesque and Burger, 1982; Anderson and Beare, 1983). In the American tropics, some tree species such as *Hevea* possess specialized associations between flowers and their midge pollinators (Steiner, 1983), and it is sometimes necessary to view a plant species as having both "major" and "minor" sets of pollinators, often belonging to very different taxa (Lewis and Zenger, 1983). Wild bees and midges (Ceratopogonidae and Cecidomyiidae) may comprise such a constellation of pollinator sets in *Theobroma* and other Sterculiaceae.

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LITERATURE CITED

Allee, W. C. and G. M. Rosenthal, Jr. 1949. Group survival value for *Philodina roseola*, a rotifer. Ecology 30: 395–397.

Allen, J. B. 1981. Collecting wild cocoa at its centre of diversity. Proc. 8th Int. Cocoa Res. Conf., Cartegena, Colombia, 655–662.

Alvim, P. de T. 1977. Cacao, pp. 279–313. *In* P. de T. Alvim and T. T. Kozlowski, eds., Ecophysiology of tropical crops. New York: Academic Press.

Amponsah, J. D. 1975. Studies in natural pollination of cocoa in Ghana. Acta Horticult. 49: 223–229.

Anderson, R. C. and M. H. Beare. 1983. Breeding system and pollination ecology of *Trientalis borealis* (Primulaceae). Am. J. Bot. 70: 408–415.

Andrews, R. M. 1979. Evolution of life histories: a comparison of *Anolis* lizards from matched island and mainland habitats. Breviora, Museum of Comp. Zool., Harvard, No. 454.

Augspurger, C. K. 1981. Reproductive synchrony of a tropical shrub: experimental studies on effects of pollinators and seed predators on *Hybanthus prunifolius* (Violaceae). Ecology 62: 775–788.

Baker, R. E. D., F. W. Cope, P. C. Holliday, B. G. Bartley, and D. J. Taylor. 1953. The Anglo-Colombian cacao collecting expedition. Report on Cacao Research (Governmental), St. Augustine, Trinidad, B.W.I. 133–154.

Barnes, H. F. 1930. On some factors governing the emergence of gall midges (Cecidomyiidae: Diptera). Proc. Zool. Soc. London 1: 381–393.

Baumann, E. 1978. Rennfliegen (Diptera: Phoridae) als Blütenbesucher. Kritische Sicht. der Literatur. Flora 167: 301–314.

Bigger, M. 1981. Observations on the insect fauna of shaded and unshaded Amelonado cocoa. Bull. Entomol. Res. 71: 107–119.

Billes, D. J. 1941. Pollination of *Theobroma cacao* L. in Trinidad, B.W.I. Trop. Agric. 18: 151–156.

Binns, E. S. 1980. Field and laboratory observations on the substrates of the mushroom fungus gnat *Lycoriella auripila* (Diptera: Sciaridae). Ann. Appl. Biol. 96: 143–152.

Brewer, J. M. 1981. The influence of light on circadian emergence patterns of *Monarthropalpus buxi* (Diptera, Cecidomyiidae). Acta Entomol. Bohemoslov. 78: 152–161.

Brown, V. K. and G. C. McGavin. 1982. The biology of some mine and gall forming Diptera on bracken, *Pteridium aquilinum* (L.) Kuehn. J. Nat. Hist. 16: 511–518.

Bystrak, P. G. and W. W. Wirth. 1978. The North American species of *Forcipomyia*, subgenus *Euprojoannisia* (Diptera: Ceratopogonidae). U.S. Dept. Agric. Tech. Bull. No. 1591.

Carpenter, S. R. 1983. Resource limitation of larval treehole mosquitoes subsisting on Beech detritus. Ecology 64: 219–223.

Charlwood, J. D., J. Lopes, and P. C. Whalley. 1982. Light intensity measurement and the biting behaviour of some sylvatic mosquitoes of the Amazon Basin (Diptera: Culicidae). Acta Amazon. 12: 61–64.

Chiang, H. C. 1968. Ecology of insect swarms. V. Movement of individual midges *Anarete pritchardi*, within a swarm. Ann. Entomol. Soc. Am. 61: 584–587.

Cope, F. W. 1939. Agents of pollination in cacao. Cacao Res. 1939: 13–19.

Cuatrecasas, J. 1964. Cacao and its allies—a taxonomic revision of the genus *Theobroma*. Contrib. U.S. Nat. Mus. 35: 379–614.

Decazy, B., F. Massaux, C. Tchiendju, and C. Misse. 1980. Use of radioisotopes (32P) in the study of pollinating agents of the cacao tree in the ecological conditions of South Cameroon. Proc. 8th Int. Cocoa Res. Conf., Douala, Cameroon.

De La Cruz, J. and S. de J. Soria. 1973. Estudio de fluctuaciones de polinizacion del cacao por las mosquitas *Forcipomyia* spp. (Diptera, Ceratopogonidae), en Palmira, Valle, Colombia. Acta Agronom. 23: 1–17.

Dessart, P. 1961. Contribution a l'étude des Ceratopogonidae (Diptera). Bull. Agric. Congo Belge 52: 525–540.

Edwards, D. F. 1973. Pollination studies on Upper Amazon cocoa clones in Ghana in relation to the production of hybrid seed. J. Hort. Sci. 48: 247–259.

Ehler, L. E. 1982. Ecology of *Rhopalomyia californica* Felt (Diptera: Cecidomyiidae) and its parasites in an urban environment. Hilgardia 50: 1–32.

Entwistle, P. F. 1972. Pests of cocoa. London: Longmans.

Essig, F. B. 1971. Observations on pollination in *Bactris*. Principes 15: 20–24.

Faegri, K. and L. van der Pijl. 1971. Principles of pollination ecology. New York: Pergamon Press.

Fallis, S. P. and K. R. Snow. 1983. Distribution of the eggs of *Aedes punctor* (Diptera: Culicidae). Ecol. Entomol. 8: 139–144.

Fisher, R. W. and G. L. Teetes. 1982. Effect of moisture on sorghum midge (Diptera: Cecidomyiidae) emergence. Env. Entomol. 11: 946–948.

Floyd, H. B. and T. A. Jenssen. 1983. Food habits of the Jamaican lizard *Anolis opalinus*: resource partitioning and seasonal effects examined. Copeia 1983: 319–331.

Fontanilla-Barroga, S. 1962. A progress report on the study of insects associated with pollination of *Theobroma cacao* with special emphasis on midges. Philippine J. Agric. 27: 147–159.

Gagné, R. J. 1968. A catalogue of the Diptera of the Americas south of the United States. 23. Family Cecidomyiidae. Dept. Zool. Secret. Agric. Sao Paulo, Brazil 23: 1–62.

———. 1977. The Cecidomyiidae (Diptera) associated with *Chromolaena odorata* (L.) K.&R. (Compositae) in the Neotropical Region. Brenesia 12/13: 113–131.

———. 1984. Five new species of neotropical Cecidomyiidae (Diptera) associated with cacao flowers, killing the buds of Clusiaceae, or preying on mites. Brenesia 22: 123–138.

Gibbs, D. G. and D. Leston. 1970. Insect phenology in a forest cocoa-farm locality in West Africa. J. Appl. Ecol. 7: 519–548.

Gibbs, P. E., J. Semir, and N. Diniz da Cruz. 1977. Floral biology of *Talauma ovata* St. Hil. (Magnoliaceae). Cienc. Cult. 29: 1436–1441.

Gilbert, L. E. 1972. Pollen feeding and reproductive biology of *Heliconius* butterflies. Proc. Nat. Acad. Sci., U.S.A. 69: 1403–1407.

Gilbert, F. S. 1981. Foraging ecology of hoverflies: morphology of the mouthparts in relation to feeding on nectar and pollen in some common urban species. Ecol. Entomol. 6: 245–262.

Glendenning, D. R. 1962. Natural pollination of cacao. Nature 193: 1305.

Gnanaratnam, J. K. 1954. Pollination mechanism of the cacao flower. Trop. Agric. 31: 98–104.

Gorrez, J. 1962. The flower biology, morphology, and pollinating and crossing habits of cacao. Philippine Agric. 46: 288–302.

Hernandez, J. 1965. Insect pollination of cacao (*Theobroma cacao* L.) in Costa Rica. Doct. Dissert., Univ. of Wisconsin, Madison.

Hutcheon, W. V. 1981. Physiological studies on cocoa (*Theobroma cacao* L.) in Ghana. Doct. Dissert., Univ. of Aberdeen, Scotland.

Jones, G. A. 1912. The structure and pollination of the cacao flower. West Indian Bull. 12: 347–350.

Kaufmann, T. 1973a. Behavioural ecology of a cocoa pollinator *Forcipomyia inornatipennis* (Diptera: Ceratopogonidae) in Ghana. J. Kansas Entomol. Soc. 47: 541–548.

———. 1973b. Preliminary observations on cecidomyiid midge and its role as a cocoa pollinator in Ghana. Ghana J. Agric. Sci. 6: 1093–1098.

———. 1974. Pollinators of *Theobroma cacao* in Ghana. Proc. 4th Int. Cocoa Res. Conf., West Africa.

———. 1975a. Cocoa pollination by males of *Forcipomyia squamipennis* (Diptera: Ceratopogonidae) in Ghana. Trop. Agric. 52: 71–74.

———. 1975b. Biology and behaviour of cocoa pollinating Ceratopogonidae in Ghana. Env. Entomol. 4: 347–351.

———. 1975c. An efficient, new cocoa pollinator, *Lasioglossum* sp. (Hymenoptera: Halictidae) in Ghana, West Africa. Turrialba 25: 90–91.

Kay, B. H. 1983. Collection of resting adult mosquitoes at Kowanyaince, Northern Queensland and Charlesville, South-Western Queensland. J. Aust. Entomol. Soc. 22: 19–24.

Kevan, P. and H. G. Baker. 1983. Insects as flower visitors and pollinators. Ann. Rev. Entomol. 28: 407–453.

Lahmann, E. J. and C. Ma. Zuniga. 1981. Use of spider threads as resting places by tropical insects. J. Arachnol. 9: 339–341.

Leston, D. 1969. Phenology of cocoa and some associated insects in Ghana. Proc. 3rd Int. Cocoa Res. Conf., Accra 197–204.

Levesque, C. M. and J. F. Burger. 1982. Insects (Diptera, Hymenoptera) associated with *Minuartia groenlandica* (Caryophyllaceae) on Mount Washington, New Hampshire, U.S.A., and their possible role as pollinators. Arct. Alp. Res. 14: 117–124.

Lewis, W. H. and V. E. Zenger. 1983. Breeding systems and fecundity in the American Ginseng, *Panax quinquefolium* (Araliaceae). Am. J. Bot. 70: 466–468.

Lucas, P. 1981. Étude des conditions de pollinisation du cacaoyer au Togo. Café Cacao Thé 25: 113–120.

Lumsden, W. H. R. 1952. The crepuscular biting activity of insects in the forest canopy at Bwamba, Uganda. A study in relation to the Sylvan epidemiology of yellow fever. Bull. Entomol. Res. 42: 721–760.

Mamaev, B. M. 1975. Evolution of gall forming insects—gall midges. Leeds: The British Library, Maney Ltd.

McLachlan, A. J. and M. A. Cantrell. 1980. Survival strategies in tropical rain pools. Oecologia 47: 344–351.

Mesler, M. R., J. D. Ackerman, and K. L. Lu. 1980. The effectiveness of fungus gnats as pollinators. Am. J. Bot. 67: 564–567.

Mogal, B. H., A. R. Mali, S. G. Rajput, and K. L. Pawar. 1979. Emergence of sorghum midge (*Contarinia sorghicola* Coq.) from diapausing larvae. J. Maharashtra Agric. Univ. 4: 323.

Motten, A. F., D. R. Campbell, D. E. Alexander, and H. L. Miller. 1981. Pollination effectiveness of specialist and generalist visitors to a North Carolina population of *Claytonia virginica*. Ecology 62: 1278–1287.

Myers, J. G. 1930. Notes on wild cacao in Surinam and British Guiana. Kew. Bull. 1930: 1–10.

Parnell, J. R. 1969. The biology and morphology of all stages of *Toxomyia fungicola* Felt (Diptera: Cecidomyiidae) in Jamaica. Proc. R. Entomol. Soc. London (A) 44: 113–122.

Percival, M. 1965. Floral biology. London: Pergamon Press.

Petralia, R. S., A. L. Wuensche, G. L. Teetes, and A. A. Sorenson. 1979. External morphology of the mouthparts of larvae of sorghum midge, *Contarinia sorghicola*. Ann. Entomol. Soc. Am. 72: 850–855.

Philbrick, C. T. 1983. Contributions to the reproductive biology of *Panax trifolium* L. (Araliaceae). Rhodora 85: 97–113.

Posnette, A. F. 1942. Natural pollination of cocoa, *Theobroma leiocarpa* Bern. on the Gold Coast. II. Trop. Agric. 19: 188–191.

———. 1944. Pollination of cacao in Trinidad. Trop. Agric. 21: 115–118.

Privat, F. 1979. Les Bromeliacees, lieu de développement de quelques insectes pollinisateurs des fleurs de cacao. Brenesia 16: 197–212.

Sampayan, T. S. 1966. Flower biology, fruiting habit and compatibility relationship in cacao. Philippine J. Plant Indust. 31: 193–201.

Saunders, L. G. 1959. Methods for studying *Forcipomyia* midges, with special reference to cacao-pollinating species (Diptera, Ceratopogonidae). Can. J. Zool. 37: 33–51.

Shazli, A. and T. M. Mostafa. 1980. Frequency of *Thomasiniana oleisuga* Targ. (Dipt., Cecidomyiidae) and its parasites and predators in Amman, Jordan. Z. Angew. Entomol. 89: 269–277.

Siefert, R. P. 1980. Mosquito fauna of *Heliconia aurea*. J. Anim. Ecol. 49: 687–697.

Siefert, R. P. and R. Barrera. 1981. Cohort studies on mosquito (Diptera: Culicidae) larvae living in water-filled floral bracts of *Heliconia aurea* (Zingiberales: Musaceae). Ecol. Entomol. 6: 191–197.

Sivinski, J. and M. Stowe. 1980. A kleptoparasitic cecidomyiid and other flies associated with spiders. Psyche 87: 337–348.

Soderstrom, T. R. and C. E. Calderón. 1971. Insect pollination in tropical rain forest grasses. Biotropica 3: 1–16.

Soetardi, R. G. 1950. De Betekenis van Insecten Bij Bestuiving van *Theobroma cacao* L. Arch. Koffiecult. Indonesie 17: 1–31.

Soria, S. de J. 1975. O papel das abelhas sem ferrão (Meliponinae) na polinizacão do cacaueiro na América tropical. Rev. Theobr. (Brasil) 5: 12–20.

Soria, S. de J. and J. M. Abreu. 1976. Dinâmica populacional de *Forcipomyia* spp. (Diptera, Ceratopogonidae) na Bahia, Brasil. 1. Fluctuação estacional dos polinizadores do cacaueiro relacionada com chuva e balanco de agua (Thornthwaite). Rev. Theobr. (Brasil) 6: 47–54.

Soria, S. de J., W. W. Wirth, and R. K. Chapman. 1980. Insect pollination of cacao in Costa Rica. 1. Preliminary list of the ceratopogonid midges collected from flowers. Rev. Theobr. (Brasil) 10: 61–68.

Soria, S. de J., R. K. Chapman, J. K. Knoke. 1981. Cacao pollination in Costa Rica. 2. Breeding sites of ceratopogonid (Diptera, Nematocera) midges. Rev. Theobr. (Brasil) 11: 119–123.

Steiner, K. E. 1983. Pollination of *Mabea occidentalis* (Euphorbiaceae) in Panama. Syst. Bot. 8: 105–117.

Stejskal, M. 1969. Nectar y aroma de las flores del cacao. Oriente Agropeuc. 1: 75–92.

Summers, C. G. 1975. Daily adult emergence in the sorghum midge, *Contarinia sorghicola*. Env. Entomol. 4: 495–498.

Taylor, A. S. 1965. Studies in the pollen morphology of *Theobroma* and *Herrania*. Cacao 10: 1–9.

Van Der Knapp, W. P. 1955. Observations on the pollination of cacao flowers. Rep. 14th Int. Hort. Congr. 2: 1287–1293.

Vanhara, J. 1981. Lowland forest Diptera (Brachycera, Cyclorrhapha). Acta Sci. Nat. Acad. Sci. Bohemoslov. Brno. 15: 1–32.

Vello, F. and W. S. Magalhaes. 1971. Studies on the role of the cacarema ant (*Azteca chartifex spiriti* Forel) on the pollination of cacao in Bahia. Rev. Theobr. (Brasil) 1: 29–42.

Vogel, S. 1978. Pilzmückenblumen als Pilzmimeten. Flora 167: 329–366; 367–398.

Walker, C. 1959. Notes on the botany of cocoa. Agric. J. Fiji 29: 56–61.

Ward, P. and A. Zahari. 1973. The importance of certain assemblages of birds as "information centres" for food-finding. Ibis 1973: 517–537.

Wellensiek, S. J. 1932. Flower-biological observations with cocoa. (translat. from Dutch). Arch. Koffeekult 6: 87–101.

Willmer, P. G. 1982. Hygrothermal determinants of insect activity patterns: the Diptera of water-lily leaves. Ecol. Entomol. 7: 221–231.

Winder, J. A. 1972. Cacao pollination: Microdiptera of cacao plantations and some of their breeding places. Bull. Entomol. Res. 61: 651–655.

———. 1977a. Some organic substrates which serve as insect breeding sites in Bahian cocoa plantations. Rev. Brasil. Biol. 37: 351–356.

———. 1977b. Field observations on Ceratopogonidae and other Diptera: Nematocera associated with cocoa flowers in Brazil. Bull. Entomol. Res. 67: 57–63.

———. 1978a. Cocoa flower Diptera: their identity, pollinating activity and breeding sites. PANS 24: 5–18.

———. 1978b. The role of non-dipteran insects in the pollination of cocoa in Brazil. Bull. Entomol. Res. 68: 559–574.

Winder, J. A. and P. Silva. 1975. Current research on insect pollination of cacao in Bahia. Proc. 4th Int. Cocoa Res. Conf., Trinidad & Tobago, 553–565.

Wirth, W. W. and W. T. Waugh. 1976. Five new Neotropical *Dasyhelea* midges (Diptera: Ceratopogonidae) associated with culture of cocoa. Stud. Entomol. 19: 223–236.

Young, A. M. 1981. The ineffectiveness of the stingless bee, *Trigona jaty* (Hymenoptera: Apidae: Meliponinae) as a pollinator of cocoa (*Theobroma cacao* L.). J. Appl. Ecol. 18: 149–155.

———. 1982. Effects of shade cover and availability of midge breeding sites on pollinating midge populations and fruit set in two cocoa farms. J. Appl. Ecol. 19: 47–63.

———. 1983. Seasonal differences in abundance and distribution of cocoa-pollinating midges in relation to flowering and fruit set between shaded and sunny habitats of the La Lola Cocoa Farm in Costa Rica. J. Appl. Ecol. 20: 801–831.

———. 1984a. Mechanism of pollination by Phoridae (Diptera) in some *Herrania* species (Sterculiaceae) in Costa Rica. Proc. Entomol. Soc. Wash. 86: 503–518.

———. 1984b. Flowering and fruit-setting patterns of cocoa trees (*Theobroma cacao* L.) (Sterculiaceae) at three localities in Costa Rica. Turrialba 34: 129–142.

Young, A. M., M. Schaller, and M. Strand. 1984. Floral nectaries and trichomes in relation to pollination in some species of *Theobroma* and *Herrania* (Sterculiaceae). Am. J. Bot. 71: 466–480.

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MAYACNEPHIA FORTUNENSIS (DIPTERA: SIMULIIDAE), A NEW BLACK FLY SPECIES FROM PANAMA

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Abstract.—The larva, pupa, male and female of *Mayacnephia fortunensis,* new species, are described and illustrated. This report extends the distribution of the genus from the western United States, Mexico and Guatemala, southward to include Panama.

Field studies related to a black fly pest problem at the Fortuna Hydroelectric Project, Chiriqui Province, Panama, revealed 10 simuliid species (Petersen et al., 1983). Nine of these belong to the genus *Simulium*; the tenth is described here as a new species of the genus *Mayacnephia* Wygodzinsky and Coscarón (1973). Nine species of *Mayacnephia* have been described, ranging from western U.S.A. south to the highlands of Mexico and Guatemala. The species described below represents the first member of this genus reported from Panama. Terminology follows Peterson (1981).

Mayacnephia fortunensis Petersen, New Species

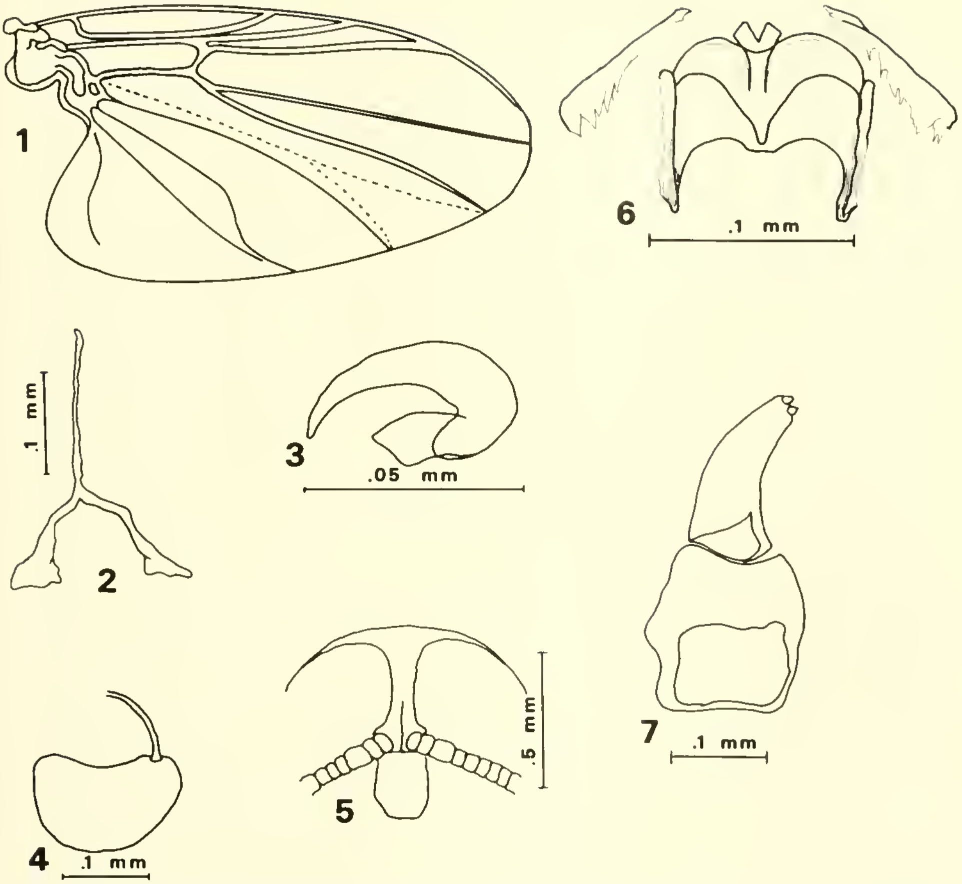
Figs. 1–14

Female.—Wing length 3.2 mm.

Head: Dichoptic; frontal angle 50–55° (Fig. 5). Antenna about 0.7 mm long; scape and pedicel light brown; flagellum brown with nine flagellomeres. Palpus dark brown. Sensory vesicle larger than in male, elongate with neck distad of vesicle midline. Frons and clypeus brown, with white pruinosity, irregularly clothed with yellow and black hairs. Postocciput brown, densely clothed with yellow hairs. Distal cornua of cibarium slender, sharp-pointed, heavily sclerotized at ends, median distal space hyaline and smooth.

Thorax: Scutum dark brown, densely covered with yellow hairs; prescutellar region with a few long fine black hairs. Postpronotum and proepisternum with yellow hairs. Scutellum light brown, with long black hairs and short yellow hairs. Postnotum glabrous, with gray pruinosity. Pleural sclerites glabrous, with gray pruinosity. Wings, 3.2 mm long and 1.5–1.6 mm wide; Sc sparsely pilose ventrally; R_1 pilose dorsally with spines along distal third; R_s completely pilose; CuA_2 and A_1 arcuate; basal cell present; A_2 ending before wing margin (Fig. 1). Legs brown except for tarsi which are light brown; calcipala well-developed, pedisulcus absent. Claws with large, blunt, subquadrate, basal tooth (Fig. 3).

Terminalia: Spermatheca somewhat kidney shaped, sclerotized, with at most



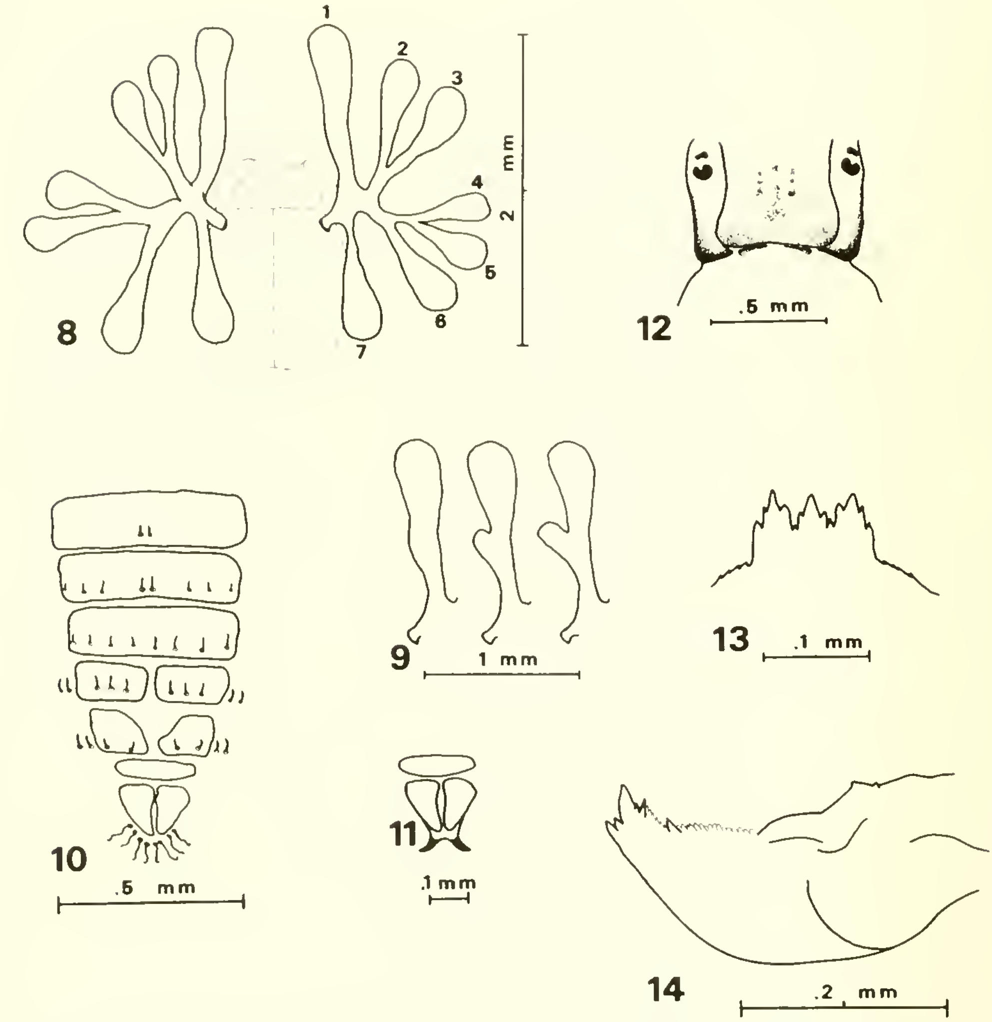
Figs. 1–7. *Mayacnephia fortunensis.* Figs. 1–5, Female. 1, Wing. 2, Genital fork. 3, Claw. 4, Spermatheca. 5, Portion of head showing frons and clypeus. Figs. 6–7, Male. 6, Ventral plate, median sclerite and paramere, ventral view. 7, Gonostylus, ventral view.

a slight membranous area at junction with spermathecal duct, without internal spicules; spermathecal duct not sclerotized (Fig. 4). Genital fork without lateral, anteriorly directed apodemes (Fig. 2).

Male.—General body color dark brown. Length: body, 2.1 mm (dry pinned specimens), 2.3 mm (alcohol preserved specimens); wing, 2.5 mm.

Head: Holoptic; frons and clypeus brown with silvery pruinosity; clypeus with pale yellowish to brownish hairs. Antenna with scape, pedicel, and base of 1st flagellomere dull yellow, rest of flagellomeres light brown. Palpus dark brown. Sensory vesicle globular and smaller than in female.

Thorax: Scutum dark brown, with short yellow hairs distributed evenly over entire surface, with long black hairs near scutellum, pleural sclerites glabrous, with grayish pruinosity. Scutellum light brown, with long black hairs and short yellow hairs, ventral portion with faint silvery pruinosity. Halter light brown. First abdominal tergite dark brown, with very long yellow hairs appearing brown-



Figs. 8–14. *Mayacnephia fortunensis.* Figs. 8–11, Pupa. 8, Respiratory filaments. 9, Variation in respiratory filament number 1. 10, Chaetotaxy of abdominal sternites. 11, Terminal abdominal hooks. Figs. 12–14, Larva. 12, Posterior portion of head capsule showing head spot pattern and cervical sclerites. 13, Hypostoma. 14, Mandible, inner lateral aspect.

ish at base. Tergites dark brown, distal borders appearing light brown in pinned specimens. Legs brown, except for tarsi which are light brown; hind basitarsus strongly expanded laterally, calcipala broadly rounded.

Terminalia: Gonostylus with 2 apical spines (Fig. 7). Ventral plate with distal margin deeply incised medially; ventral lip setose, moderately long, narrowing to a point distally. Basal arms short and slender in ventral aspect. Median sclerite Y-shaped, arms recurving inwardly; stem longer than arms. Paramere bladelike, without denticles. Serrated edges of paramere arms in Fig. 6 indicate torn surfaces of points of attachment to basal plates that in turn join basal arms of ventral plate.

Pupa.—Cocoon roughly pocket-shaped, loosely woven, without collar or rim. Cephalopterothecal length 2.1–2.5 mm. Respiratory organ with 7 thick tubular branches originating from 4 primary trunks (Fig. 8); branch 1 pleomorphic; sometimes with a boss on the mesal surface, which in 5 out of 72 pupae examined was enlarged as a thumb-like process (Fig. 9). Head and portions of thorax with small rounded platelets in an irregular pattern. Head with 2 + 2 single frontal trichomes and 1 + 1 single facial trichomes; thorax with 5 + 5 single dorsal trichomes. Pattern of ventral abdominal setae and hooks as in Fig. 10; posterior margins of tergites II, III and IV with 4 + 4 anteriorly projecting hooks; tergites VII–IX each with small posteriorly directed spines. Sternite VI with 3 + 3 hooks; sternite VII with 2 + 2 hooks accompanied by 2 + 2 hooks in pleural membrane; all hooks simple; posterior sternites with 8–10 irregularly formed, long hook-like setae. Abdominal sternites VI and VII divided longitudinally along middle by membranous, striate area. Dorsal terminal hooks well developed (Fig. 11).

Larva.—General body color dull creamy yellow with gray-green to dark brownish mottling, intensity varying from faint to dark. Length, about 7.5 mm; width of last larval instar head capsule 0.75 mm. Cephalic apotome pale, with a positive head pattern as in Fig. 12. First antennal segment as long as second. Postgenal cleft shallow. Cervical sclerites large, separated from upper ends of postocciput (Fig. 12). Hypostoma with 13 teeth in 3 groups, 4-5-4 (Fig. 13). Mandibles with two outer teeth, one large apical tooth and numerous mandibular serrations (Fig. 14).

Diagnosis.—The chaetotaxy of the pupal abdomen and the morphology of the pupal respiratory organ separate *M. fortunensis* from all other species of *Mayacnephia* described. *M. fortunensis* most closely resembles *M. grenieri* and *M. aguirrei* sharing with these species 3 + 3 spines on sternite VI and 2 + 2 spines on sternite VII, but differing from these species in the branching pattern of the respiratory organ, being 7-branched in *M. fortunensis*, 4-branched in *M. grenieri* and 2-branched in *M. aguirrei*.

Types.—Holotype ♂ (pinned, with pupal exuviae) PANAMA, Chiriqui Province, Los Planes de Hornito, 26 August 1980, J. L. Petersen. Allotype ♀ with pupal exuviae dissected and mounted in Euparal. Holotype and allotype deposited in US National Museum of Natural History, Washington, D.C. Paratypes: 9 ♂♂, 2 ♀♀, 5 pupae, 30 larvae, same data as holotype, deposited in the US National Museum of Natural History, Washington, D.C., the American Museum of Natural History, New York, and Gorgas Memorial Laboratory, Panama.

Biology.—All specimens have come from 3 temporary streams that traverse Los Planes de Hornito, 8°38′N, 82°13′W, Chiriqui Province, Republic of Panama. The streams were less than 1 m wide. Collecting sites were at about 1000 m elevation on a wooded slope of about 20–25° and heavily shaded by forest trees. Larval and pupal substrates were roots, green leaves, blades of grass, dead leaves, and rocks in the stream bed. Water temperatures were 19–20°C.

Etymology.—Latin: "of Fortuna," for Cerro Fortuna, elev. 1495 m, prominent landmark near type locality.

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LITERATURE CITED

Petersen, J. L., A. J. Adames, and L. De León. 1983. Bionomics and control of black flies (Diptera: Simuliidae) at the Fortuna Hydroelectric Project, Panama. J. Med. Entomol. 20: 399–408.

Peterson, B. V. 1981. Simuliidae, pp. 355–391. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera. Vol. 1, Research Branch Agriculture Canada, Monograph No. 27, pp. 674.

Wygodzinsky, P. and S. Coscarón. 1973. A review of the Mesoamerican and South American black flies of the tribe Prosimuliini (Simuliinae, Simuliidae). Bull. Am. Mus. of Nat. Hist. 151: 129–200.

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SEASONAL HISTORY, HOST PLANTS, AND NYMPHAL DESCRIPTIONS OF *ORTHOCEPHALUS CORIACEUS*, A PLANT BUG PEST OF HERB GARDEN COMPOSITES (HEMIPTERA: MIRIDAE)

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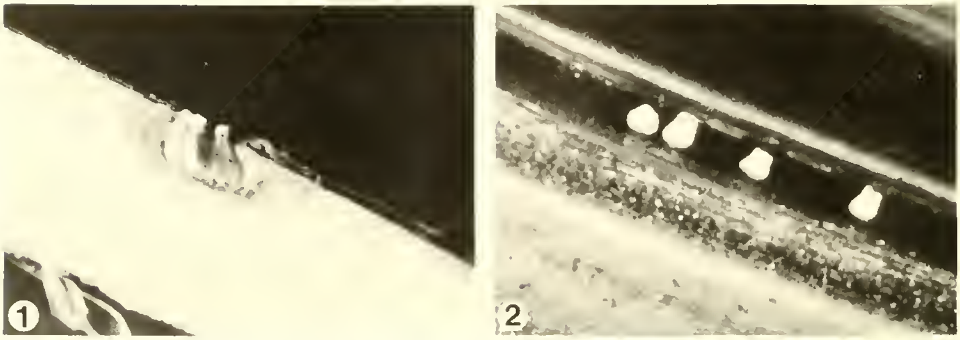
Abstract.—The plant bug *Orthocephalus coriaceus* (F.), common throughout most of Europe and known from northern Africa, was first recorded from the New World (Maine) in 1917. The known North American distribution is given, with Ohio and Virginia listed as new state records. Seasonal history of this univoltine mirid is summarized for a population studied in southcentral Pennsylvania on mugwort, *Artemisia vulgaris* L., during 1983. A list of host plants observed in the eastern United States, all members of the Asteraceae, is provided, and foliar damage to herb garden composites is described. All nymphal stages are described; the fifth instar is illustrated.

Orthocephalus coriaceus was described by Fabricius (1776). Even though Thomson (1871) and Reuter (1888) established *O. mutabilis* (Fallén) as a junior synonym of *coriaceus*, the former name was used in much of the European and North American literature until Carvalho's (1955) confirmation of the synonymy. This mirid of the orthotyline tribe Halticini is widely distributed in Europe and is known from northern Africa (Carvalho, 1958). According to Kullenberg (1944) and Southwood and Leston (1959), it typically is found in dry, open, sandy areas where it feeds on various composites and occasionally on plants of the Lamiaceae (= Labiatae) and Rubiaceae. In Sweden, Kullenberg found that yarrow, *Achillea millefolium* L., and tansy, *Tanacetum vulgare* L., are favored hosts. *O. coriaceus* attacks stems and leaves, especially the veins, of its hosts; adults have been observed to feed on inflorescences of grasses. Eggs are inserted in host stems, with furrows of the middle and lower portions usually selected as oviposition sites. Overwintering occurs in the egg stage, and adults begin to appear in mid- to late June; adults are present until late July or early August. Males and females may be either macropterous or brachypterous (Kullenberg, 1944; Southwood and Leston, 1959).

Knight (1917) first reported *O. coriaceus* from North America based on specimens from wild daisies at Orono, Maine. In recording it from oxeye daisy, *Chrysanthemum leucanthemum* L., at Ithaca, New York, Knight (1918) suggested that this species had been accidentally introduced with "egg-infested plant stems used for packing or in hay." In Maine, Stear (1923) noted that *O. coriaceus* injured *C. leucanthemum*, the "plants being undersized and poorly developed." Other



Figs. 1–2. Eggs of *Orthocephalus coriaceus* in stem of chicory. 1, Split stem showing inserted eggs. 2, Opercula protruding from stem surface.

North American records for this mirid are Pennsylvania (Knight, 1941), Connecticut (Slater, 1974), Ontario (Reid et al., 1976), West Virginia (Wheeler et al., 1983), and Quebec (Larochelle, 1984). The following are new records based on specimens in the insect collections of the Pennsylvania Department of Agriculture (PDA) and U.S. National Museum of Natural History (USNM). OHIO: Wayne Co., Wooster, 15 May 1953, R. W. Rings (USNM); VIRGINIA: Highland Co., near McDowell, 15 July 1984, A. G. Wheeler, Jr. (PDA).

Except for the note on injury to oxeye daisy (Stear, 1923), the habits of *O. coriaceus* in North America are unknown. In this paper the seasonal history, hosts, and damage to herb garden plants are recorded. The nymphal stages are described, and the fifth-instar nymph is illustrated.

METHODS AND STUDY SITES

The plants used by *O. coriaceus* for development ("breeding hosts") or injured by adults were observed during 1982–83 in several herb and flower gardens on the Cornell University campus at Ithaca, New York, and in an herb garden at the Morris Arboretum, Philadelphia, Pennsylvania. A few additional records are based on specimens submitted by a nursery inspector of the Pennsylvania Department of Agriculture. Host plants of *O. coriaceus* in ruderal sites (roadside plantings, railroad right-of-ways, vacant lots, waste areas) are based on personal collecting in the eastern United States during 1974–83. Seasonality was determined by sampling a population associated with mugwort, *Artemisia vulgaris* L. (Asteraceae = Compositae), at Harrisburg, Pennsylvania, in 1983. Plants were observed every few days beginning in late April to detect the appearance of first-instar nymphs. Once the overwintered eggs had hatched (28 April), sweep net collections were made until early June at 7- to 10-day intervals from the nearly pure colony of mugwort (about 20 m^2). After sweeping, the net bag was emptied into a small tray, and the first 10 individuals observed (or all individuals if <10 were found) were placed in 70% alcohol for sorting to stage in the laboratory. When fifth instars appeared in the samples (late May), a supplemental collection was taken 3 days later to check for the appearance of adults. Observations continued until late June when only one adult was collected after extensive sweeping of mugwort. Additional

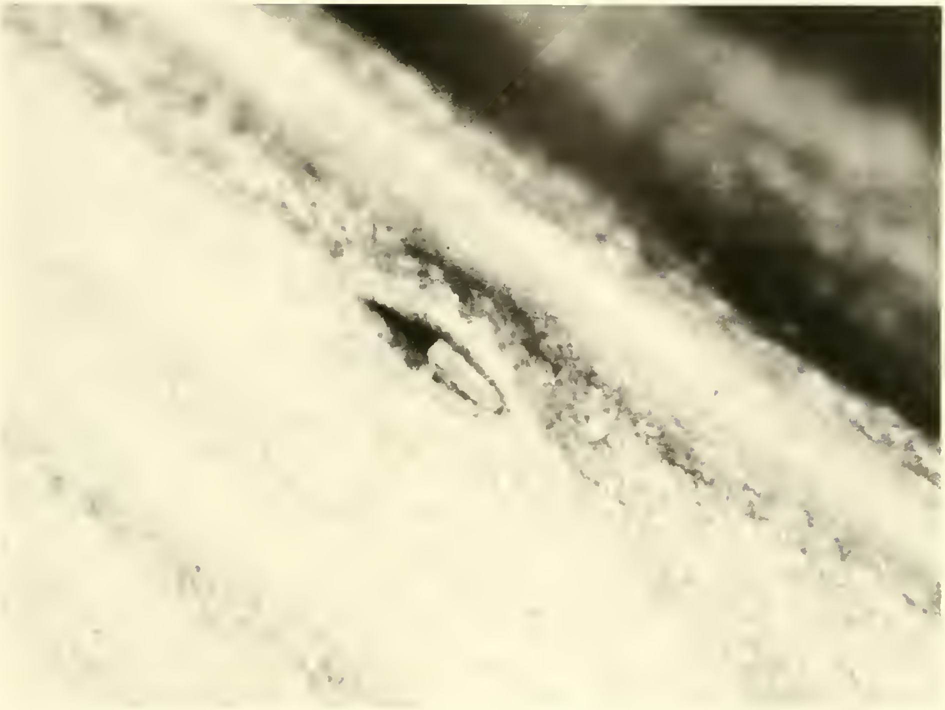


Fig. 3. Egg of *Orthocephalus coriaceus*. Note the operculum flush with or slightly below surface of chicory stem and visible within oviposition wound.

seasonal history data were obtained in 1983 from a population of *O. coriaceus* developing on various composites at the Morris Arboretum.

BIOLOGY

Seasonal history.—Eggs of *O. coriaceus* overwinter in stems of various composites. On chicory and oxeye daisy they are deposited singly or in groups of 2–6 (Fig. 1). The operculum may be exposed so that the white eggs are conspicuous during field observations (Fig. 2), or the operculum may be flush with or slightly below the stem surface (Fig. 3). Eggs inserted deep into stems may be detected by a surrounding dark necrotic area, although in some cases no oviposition scar is apparent.

At the Harrisburg site eggs began to hatch between 26 and 28 April in 1983 (Fig. 4); at the same site in 1974 they had hatched by 23 April. One week later (5 May 1983) second- and third-instar nymphs were present, but third instars are indicated (dotted line in Fig. 4) as appearing somewhat later than second instars. At Philadelphia on 4 May a sample of 10 nymphs indicated a similar development of populations: 1 first-instar nymph, 4 second instars, and 5 third instars. Fourth instars appeared in the Harrisburg sample of 13 May; fifth instars, by 23 May. Although the 31 May sample consisted only of fifth instars, a few adults also were observed on the plants, having appeared since 26 May. At Harrisburg adults of this univoltine species disappeared by late June. Males, which appear a few days

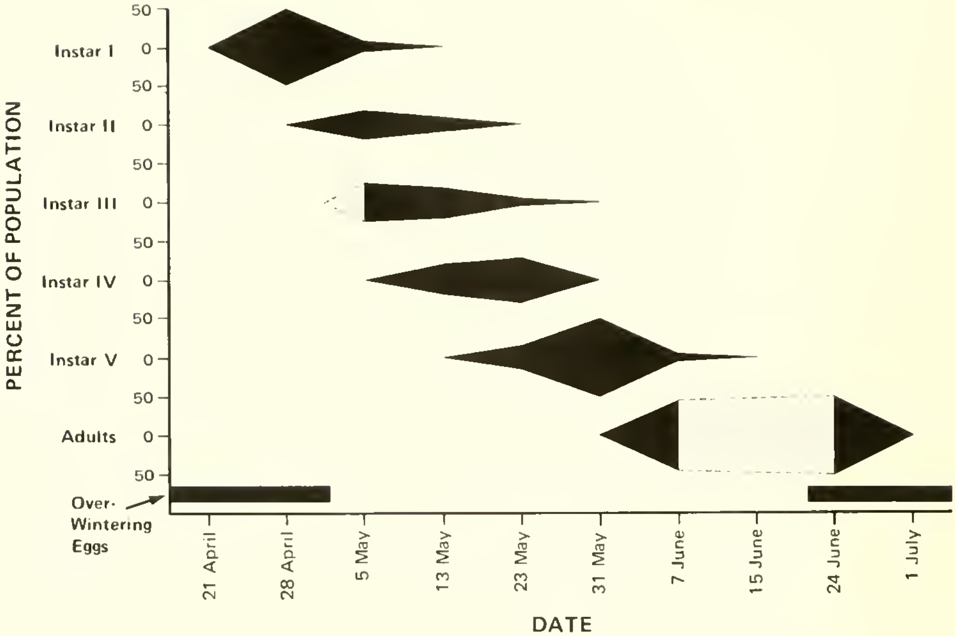


Fig. 4. Seasonal history of *Orthocephalus coriaceus* on mugwort at Harrisburg, Pennsylvania, 1983. Dotted lines indicate extrapolated data.

before females, tend to die somewhat earlier than females so that late-season collections consisted mainly of females.

Host plants and damage.—In this study all hosts of *O. coriaceus* were composites: either widely naturalized Old World members of the flora of eastern North America or exotic Eurasian taxa planted in herb and flower gardens. The most common hosts in ruderal sites were chicory and oxeye daisy (Table 1). Heavily infested chicory plants were conspicuous by their chlorotic foliage, the irregular blotches ranging from yellow to pinkish or reddish. Spotted knapweed, *Centaurea maculosa* Lam., which occurs frequently on dry roadside slopes in Pennsylvania, also was a common host. In New York large populations were observed on tansy growing along a road and a railroad right-of-way. All but one collection in herb gardens was made from plants of the composite tribe Anthemideae. Often damaged by the feeding of *O. coriaceus* were feverfew, Shasta daisy, and other *Chrysanthemum* spp.; *Achillea* and *Artemisia* spp.; and tansy. Injury consisted of chlorotic areas on foliage, which later became unsightly brown blotches (Fig. 5). Black spots of excrement contributed to the unaesthetic appearance of infested leaves.

DESCRIPTIONS

Kullenberg (1943) described and figured the egg of *O. coriaceus.* A brief description of the fifth-instar nymph was given by Butler (1923). In the nymphal descriptions that follow all measurements are in millimeters.

Table 1. Host plants of *Orthocephalus coriaceus* in eastern United States, 1974–83.

Taxa	Common Name	No. of collections: Herb Gardens	No. of collections: Ruderal Sites
Asteraceae			
Tribe Anthemideae			
Achillea decolorans Schrad. in Willd.		1	—[1]
A. filipendulina Lam. × *clypetiolata* Sibth & Sm. 'Coronation Gold'		1	—
A. millefolium L.	yarrow	1	1
A. millefolium 'Rosea'		3	—
A. 'Moonshine'		1	—
A. tanacetifolia All.		1	—
Anthemis tinctoria L.	golden marguerite	1	—
A. tinctoria 'Kelwayi'	hardy marguerite	1	—
Artemisia abrotanum L.	southernwood	3	—
A. abrotanum 'Lemon Scented'		1	—
A. glanduligera Krasch ex Poljakov		1	—
A. pontica L.	Roman wormwood	1	—
A. vulgaris L.	mugwort	—	2
Chrysanthemum balsamita L.	costmary	1	—
C. 'Chiquita'		1	—
C. cinerariifolium (Trevir.) Vis.	pyrethrum	1	—
C. leucanthemum L.	oxeye daisy	—	7
C. parthenium (L.) Bernh.	feverfew	2	—
C. × *superbum* Bergmans ex J. Ingram	Shasta daisy	1	—
Tanacetum vulgare L.	tansy	6	2
T. vulgare var. *crispum* DC.		2	—
Tribe Cynareae			
Centaurea maculosa Lam.	spotted knapweed	—	4
Tribe Cichorieae			
Cichorium intybus L.	chicory	1	7

[1] Not collected.

Fifth instar (in alcohol, n = 5) (Figs. 6–7).—Length, 3.52–4.08, $\bar{x} = 3.81$. Body stout, elongate-oval, general coloration black; head, pronotum, and wing pads shining black to fuscous, with antennae, head beneath, and abdomen more brown; Y-shaped epicranial suture and thoracic midline pale. Head declivent, tapering anteriorly, with numerous black bristlelike setae mostly in front of epicranial suture, eyes prominent, touching and extending laterally beyond anterior pronotal angles; length, 0.48–0.68; width, 1.12–1.36; interocular space, 0.60–0.76. Antennae with suberect black bristlelike setae, segment I subclavate, II gradually thickened to apex, III–IV filiform; lengths, segment I, 0.32–0.40; II, 0.90–1.00; III, 0.74–0.88; IV, 0.50–0.56. Labium stout, extending to intermediate coxae; lengths, segment I, 0.32–0.40; II, 0.30–0.40; III, 0.10–0.20; IV, 0.16–0.30. Pronotum trapeziform, with stout black bristlelike setae mainly along anterior and lateral margins, wing pads extending to 5th abdominal segment, with scattered erect and suberect bristlelike setae; length, 0.52–0.64; width, 1.25–1.36. Abdomen with numerous suberect setae laterally and dorsally, scent gland opening between ter-

Fig. 5. Injury to foliage of *Chrysanthemum* sp. from feeding of *Orthocephalus coriaceus*.

gites III–IV, tergites with row of prominent shiny black blotches along midline, decreasing in size posteriorly to penultimate segment, last segment entirely black. Legs clothed with stout bristlelike setae, coxae largely pale, femora brown, tibiae and claws fuscous to black. Ventral surface brown, with thoracic pleura shiny black, abdominal spiracular openings surrounded by shiny fuscous area. Genital segment in female with 2 large quadrate fuscous plates, the posterior one divided mesally; male with one large undivided fuscous plate.

Fourth instar (in alcohol, n = 5).—Similar to 5th instar in form and color; wing pads extending to abdominal tergite II. Length, 2.72–3.00, $\bar{x} = 2.84$. Head, length, 0.34–0.46; width, 0.90–0.98; interocular space, 0.54–0.58. Protergal length, 0.40–0.46; humeral width, 0.82–0.96. Antennal segment lengths, I, 0.16–0.24; II, 0.50–0.60; III, 0.50–0.54; IV, 0.38–0.48. Labial segment lengths, I, 0.24–0.28; II, 0.20–0.26; III, 0.12–0.18; IV, 0.18–0.22.

Third instar (in alcohol, n = 5).—Similar to 4th instar; forewing pads extending to middle of metanotum. Length, 1.44–1.96, $\bar{x} = 1.73$. Head, length, 0.24–0.30; width, 0.72–0.78; interocular space, 0.42–0.48. Protergal length, 0.46–0.52; humeral width, 0.62–0.72. Antennal segment lengths, I, 0.16–0.20; II, 0.30–0.36; III, 0.34–0.38; IV, 0.32–0.36. Labial segment lengths, I, 0.16–0.20; II, 0.16–0.20; III, 0.10–0.14; IV, 0.14–0.16.

Second instar (in alcohol, n = 5).—Similar in form and color to preceding instar. Length, 1.42–1.54, $\bar{x} = 1.48$. Head, length, 0.20–0.26; width, 0.58; interocular space, 0.34–0.42. Protergal length, 0.22–0.26; humeral width, 0.50–0.54. Antennal segment lengths, I, 0.12–0.14; II, 0.22–0.26; III, 0.24–0.26; IV, 0.28–0.32. Labial segment lengths, I, 0.14–0.18, II, 0.14–0.18; III, 0.10–0.16; IV, 0.12–0.14.

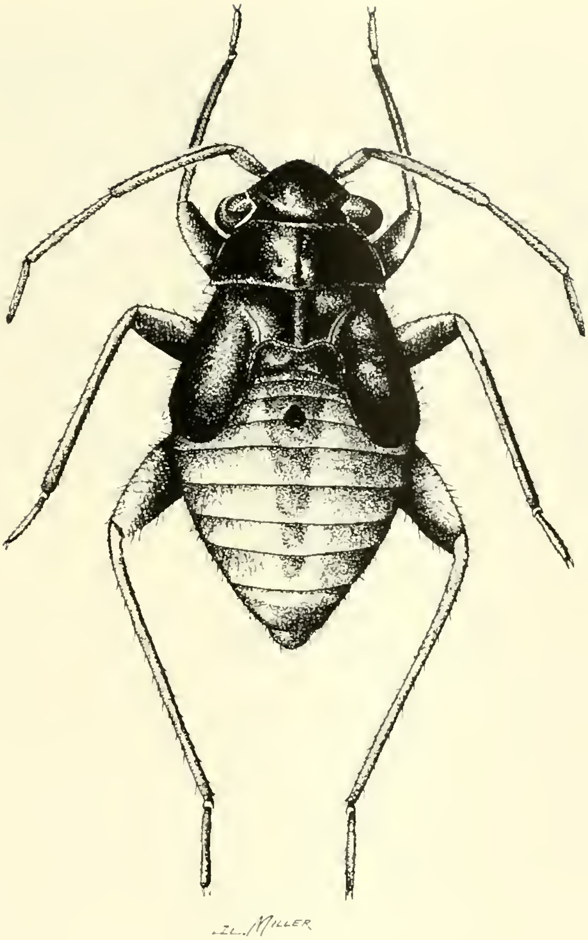
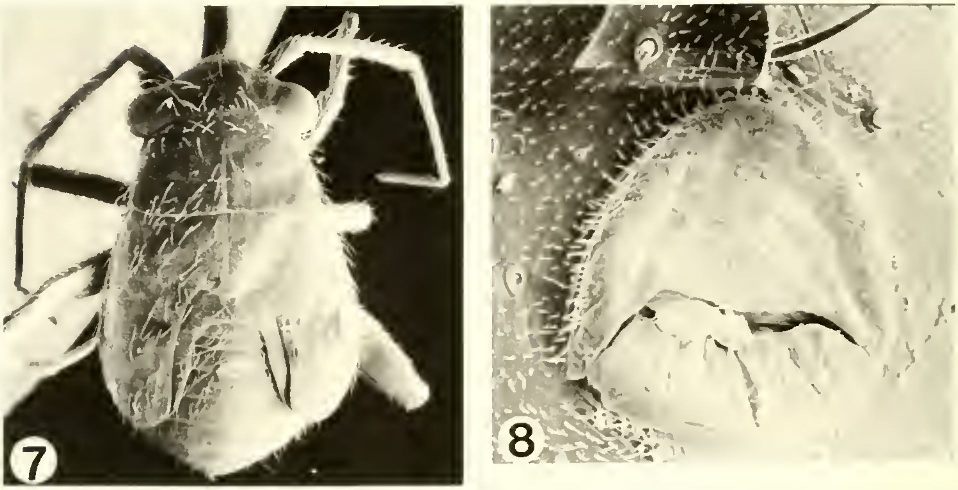


Fig. 6. *Orthocephalus coriaceus*, fifth-instar nymph.

First instar (in alcohol, n = 5).—More elongate than 2nd instar; reddish brown, antennae and legs yellow to tan except fuscous tarsi and claws, nota darker, with extent of dark sclerotized area decreasing from pro- to metanotum, small dark area at middle of abdominal tergites I–II and surrounding scent gland opening. Length, 0.92–1.20, $\bar{x} = 1.01$. Head, length, 0.16–0.20; width, 0.42–0.44; interocular space, 0.28–0.30. Protergal length, 0.16–0.26; humeral width, 0.34–0.40. Antennal segment lengths, I, 0.08–0.12; II, 0.14–0.18; III, 0.14–0.18; IV, 0.24–0.26. Labial segment lengths, I, 0.10–0.14; II, 0.12–0.14; III, 0.08–0.16; IV, 0.10–0.14.

Remarks.—Although not included in the generic key to fifth-instar Miridae of Wisconsin (Akingbohungbe et al., 1973), the only such key available for the North American fauna, *Orthocephalus coriaceus* will run to couplet 24 with the halticine genus *Slaterocoris*. At the sample site at Harrisburg, nymphs of *Slaterocoris stygicus* (Say) were taken on mugwort, but they may be distinguished from those of *O. coriaceus* by being more shining black and broadly oval, lacking bristlelike setae, having testaceous antennae and legs, and having a simple scent gland open-



Figs. 7–8. Micrographs of *Orthocephalus coriaceus*, fifth-instar nymph. 7, Habitus (28 ×). 8, Dorsal abdominal scent gland opening (406 ×).

ing without a tendency toward secondary doubling and with no sclerotized bar above (type 1 of Akingbohungbe, 1974).

The type of abdominal scent gland opening observed in *O. coriaceus* (Fig. 8) deserves comment. Although it is closest to Akingbohungbe's (1974) type 2 (same as type 1 but lacking a sclerotized bar above), there is a semicircular sclerotized area above that appears unlike any of the dorsal abdominal gland openings described and illustrated by Akingbohungbe et al. (1973) or Akingbohungbe (1974). These studies remain the most comprehensive available, but a survey of the world mirid fauna can be expected to reveal additional types of gland openings.

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LITERATURE CITED

Akingbohungbe, A. E. 1974. Nymphal characters and higher classification analysis in the Miridae (Hemiptera:Heteroptera) with a subfamily key based on the nymphs. Can. Entomol. 106: 687–694.

Akingbohungbe, A. E., J. L. Libby, and R. D. Shenefelt. 1973. Nymphs of Wisconsin Miridae (Hemiptera:Heteroptera). Univ. Wisc.-Madison, Coll. Agric. Life Sci. R-2561. 25 pp.

Butler, E. A. 1923. A biology of the British Hemiptera-Heteroptera. H. F. & G. Witherby, London. 682 pp.

Carvalho, J. C. M. 1955. Analecta Miridologica: Einige nomenklatorische Berichtigungen für die paläarktische Fauna. Beitr. Entomol. 5: 333–336.

———. 1958. Catalogue of the Miridae of the world. Part III. Subfamily Orthotylinae. Arq. Mus. Nac., Rio de Janeiro. 161 pp.

Fabricius, J. C. 1776. Genera insectorum eorumque characteres naturales secundum numerum, figuram, situm et proportionem omnium partium oris adjecta mantissa specierum nuper detectarum. Chilonii. 14 + 310 pp.

Knight, H. H. 1917. Records of European Miridae occurring in North America. (Hemiptera, Miridae). Can. Entomol. 49: 248–252.

———. 1918. Interesting new species of Miridae from the United States, with a note on *Orthocephalus mutabilis* (Fallen) (Hemip. Miridae). Bull. Brooklyn Entomol. Soc. 13: 111–116.

———. 1941. The plant bugs, or Miridae, of Illinois. Ill. Nat. Hist. Surv. Bull. 22: 1–234.

Kullenberg, B. 1943. Die Eier der schwedischen Capsiden (Rhynchota) II. Arkiv Zool. 34A: 1–8.

———. 1944. Studien über die Biologie der Capsiden. Zool. Bidr. Uppsala 23: 1–522.

Larochelle, A. 1984. Les punaises terrestres (Hemipteres:Géocorises) du Quebec. Fabreries, Suppl. 3. 513 pp.

Reid, D. G., C. C. Loan, and R. Harmsen. 1976. The mirid (Hemiptera) fauna of *Solidago canadensis* (Asteracea) in south-eastern Ontario. Can. Entomol. 108: 561–567.

Reuter, O. M. 1888. Revisio synonymica Heteropterorum palaearcticorum quae descripserunt auctores vetusitiores (Linnaeus, 1758-Latreille, 1806). Acta Soc. Sci. Fenn. 15:1, pp. 243–313.

Slater, J. A. 1974. A preliminary analysis of the derivation of the Heteroptera fauna of the northeastern United States with special reference to the fauna of Connecticut. Mem. Conn. Entomol. Soc., 1974. pp. 145–213.

Southwood, T. R. E. and D. Leston. 1959. Land and water bugs of the British Isles. Frederick Warne, London. 436 pp.

Stear, J. R. 1923. *Orthocephalus mutabilis* Fall. (Hemip., Miridae). Bull. Brooklyn Entomol. Soc. 18: 62.

Thomson, C. G. 1871. Ofversigt af de i Sverige funna arter af gruppen Capsina. Opusc. Entomol. 4: 410–452.

Wheeler, A. G., Jr., T. J. Henry, and T. L. Mason, Jr. 1983. An annotated list of the Miridae of West Virginia (Hemiptera-Heteroptera). Trans. Am. Entomol. Soc. 109: 127–159.

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87(1), 1985, pp. 94–97

A KEY TO NYMPHS OF FOUR SPECIES OF THE GENUS *PODISUS* (HEMIPTERA: PENTATOMIDAE) OF NORTHEASTERN NORTH AMERICA

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Abstract.—A simple key based on color characters is provided for nymphs of *Podisus maculiventris* (Say), *P. modestus* (Dallas), *P. placidus* Uhler, and *P. serieventris* Uhler.

Five species of the genus *Podisus* occur in northeastern North America. Of these, four species (*P. maculiventris* (Say), *P. modestus* (Dallas), *P. placidus* Uhler, and *P. serieventris* Uhler) are commonly collected (e.g., Kirkland, 1898; Tostowaryk, 1971; Morris, 1972; Evans, 1982, 1983). The fifth species, *P. fretus* Olsen, is an especially large (adult length: 12.5–14 mm) and seemingly rare member of the genus that has been reported sporadically from Maine to Florida and west to Indiana and Michigan (McPherson, 1982). Because they are predators that often attack economic pests, these insects are of considerable interest to many entomologists. At present, however, reporting of these insects' habits is hampered by inability to identify nymphs encountered in the field. Therefore I have developed the following simple key for nymphs of all but *P. fretus* (with which I am unfamiliar). Adults are well treated by several published keys (e.g. Torre-Bueno, 1939; Furth, 1974; McPherson, 1982), and a key to eggs of these four species is given by Coppel and Jones (1962).

Because nymphs of the four species are essentially indistinguishable in structural characters, the key given below is based on differences in color pattern among the species. These differences are readily apparent in freshly collected or frozen material. The colors fade slowly when specimens are stored in alcohol, but fading can largely be prevented if specimens preserved in alcohol are kept refrigerated.

The key is based on nymphs that I reared from eggs laid by adults collected near Ithaca, New York. Voucher specimens of adults of the four species have been placed in the Cornell University Insect Collection under Lot 1086. Extensive collections and subsequent rearings of *Podisus* nymphs have proved the key to be reliable. Detailed descriptions of the nymphs of three of the species are available elsewhere: *P. serieventris* (Prebble, 1933), *P. maculiventris* (DeCoursey and Esselbaugh, 1962), and *P. placidus* (Oetting and Yonke, 1971).

The terms used in the key are identified for a fourth instar nymph of *Podisus* in Fig. 1. One can confirm that an unidentified nymph belongs to the Pentatomidae by using the key provided by Herring and Ashlock (1971). One must know also that indeed the specimen belongs to the genus *Podisus* before using the key given

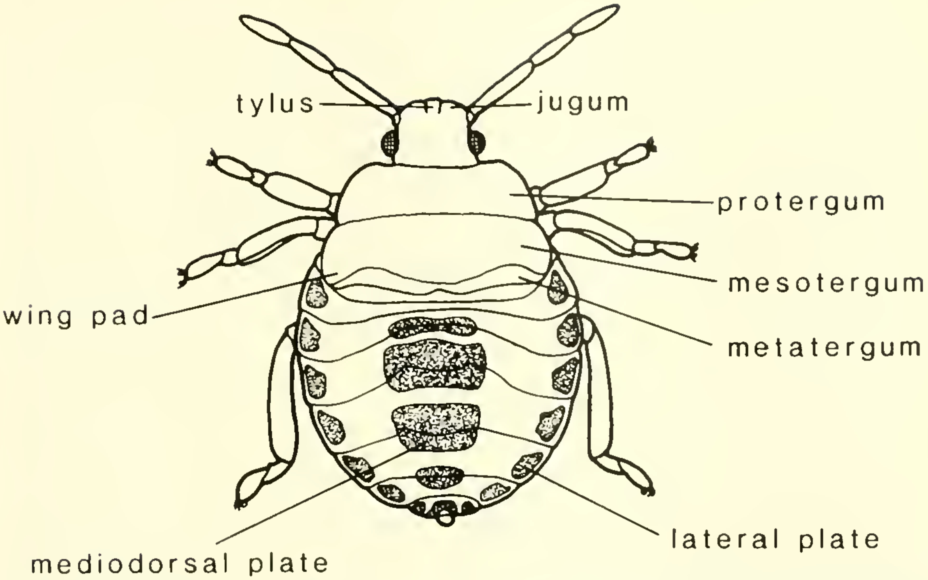

Fig. 1. Fourth-instar nymph of *Podisus* labeled with characters mentioned in text and in keys. The figure is redrawn from Oetting and Yonke (1971); this source should be consulted for more detailed illustrations of all five nymphal instars of *Podisus*.

below; of help here is the generic key for nymphs by DeCoursey and Allen (1968). One can determine quickly whether a specimen belongs in the subfamily Asopinae (which includes the genus *Podisus*) by examining the beak (rostrum). As noted by DeCoursey and Allen (1968: 144; see their Figs. 1 and 2), the first segment of the rostrum in the predatory Asopinae is "stout, free, (with) only the base imbedded between the bucculae" whereas the first segment of the rostrum in phytophagous Pentatomidae (i.e. other subfamilies) is "slender, imbedded between the bucculae." Unlike the beak of plant-feeding stink bugs, the broad sword-like beak of *Podisus* and other asopines can be extended fully forward (thus facilitating feeding on prey). DeCoursey and Allen (1968) further note that nymphs of the genus *Podisus* can be distinguished from other asopines in the eastern United States in that they are not metallic in color (vs. *Euthyrhynchus*), they lack a spine or tubercle on the fore femora (vs. *Stiretrus* and *Perillus*), and they have juga approximately equal in length to the tylus (vs. *Apateticus*).

Use of the key also requires that the investigator know which instar is at hand. Good descriptions of the different instars of Pentatomidae appear in DeCoursey and Esselbaugh (1962), and excellent illustrations of *P. placidus* in particular appear in Oetting and Yonke (1971). A simple key for identifying instars is presented below.

KEY TO INSTARS FOR *PODISUS* NYMPHS

1. Posterior margin on mesotergum laterally without wing pads 2
– Posterior margin of mesotergum laterally with wing pads reaching to or beyond posterior margin of metatergum 4

2. Dorsal surface impunctate. Length 1–2 mm .... first instar
– Dorsal surface with fine punctures. Length 2–5 mm 3
3. Posterior margin of mesotergum medially not bulging over base of metatergum. Length 2–3 mm .... second instar
– Posterior margin of mesotergum medially bulging over base of metatergum. Length 3.5–5 mm .... third instar
4. Wing pads extending to but not beyond posterior margin of metatergum. Length 5–7 mm .... fourth instar
– Wing pads extending beyond posterior margin of metatergum. Length 7.5–9.5 mm .... fifth instar

Key to First- and Second-Instar Nymphs of *Podisus*

(No differences are apparent to distinguish the red and black first-instar nymphs of *P. maculiventris, P. modestus,* and *P. placidus*).

1. Dorsum of abdomen predominantly white with thin *red* transverse lines extending from black mediodorsal plates to black lateral plates . . *serieventris*
– Dorsum of abdomen predominantly red .... 2 (second instar only)
2. Dorsum of abdomen entirely red except for black mediodorsal and lateral plates (and sometimes white between black mediodorsal plates) .... *maculiventris*
– Dorsum of abdomen with some white as well as red and black 3
3. Dorsum of abdomen predominantly red but with some distinct thin white lines outlining black lateral plates .... *placidus*
– Dorsum of abdomen primarily red but with *creamy-white* patches to each side of anterior mediodorsal plate immediately posterior to black thoracic metatergum .... *modestus*

Key to Third-Instar Nymphs of *Podisus*

1. Dorsum of abdomen white with red transverse lines extending from black mediodorsal plates to black lateral plates and with distinct *yellow-orange* patches on each side anteriorly (immediately posterior to black thoracic metatergum) .... *maculiventris*
– Dorsum of abdomen without yellow-orange patches anteriorly 2
2. Dorsum of abdomen as above *except* that patches immediately posterior to black thoracic metatergum are *creamy-white* .... *modestus*
– Dorsum of abdomen *without* distinctly colored patches immediately posterior to black thoracic metatergum 3
3. Dorsum of abdomen white with *thin* red transverse lines extending from black mediodorsal plates to black lateral plates; dorsum of thorax *without* white lateral margins but often with 2–3 pairs of large clear zones surrounded by black .... *serieventris*
– Dorsum of abdomen white with *thick* red lines that fuse to varying degrees with each other (generally imparting a distinctly reddish appearance to the abdomen in contrast to appearance of *P. serieventris*); dorsum of thorax completely black except for white lateral margins that may be present on protergum and mesotergum .... *placidus*

KEY TO FOURTH- AND FIFTH-INSTAR NYMPHS OF *PODISUS*

1. Protergum and mesotergum (sometimes only protergum in fourth instar) of black thorax with distinct white lateral margins . . . . *placidus*
– Thorax without white lateral margins 2
2. Dorsum of abdomen with much brown and with *creamy-white* patches (partially obscured by wing pads in fifth instar) to each side anteriorly (immediately posterior to black thoracic metatergum) . . . . *modestus*
– Dorsum of abdomen not as above 3
3. Dorsum of abdomen with *yellow-orange* patches (partially obscured by wing pads in fifth instar) to each side anteriorly (immediately posterior to black thoracic metatergum) . . . . *maculiventris*
– Dorsum of abdomen entirely black, red, and white (i.e. *without* yellow-orange or creamy-white patches) . . . . *serieventris*

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LITERATURE CITED

Coppel, H. C., and P. A. Jones. 1962. Bionomics of *Podisus* spp. associated wth the introduced pine sawfly, *Diprion similis* (Htg.), in Wisconsin. Trans. Wis. Acad. Sci. Arts Lett. 51: 31–56.

DeCoursey, R. M., and R. C. Allen. 1968. A generic key to the nymphs of the Pentatomidae of the eastern United States (Hemiptera: Heteroptera). Univ. Conn. Occas. Pap. (Biol. Sci. Ser.) 1: 141–151.

DeCoursey, R. M., and C. O. Esselbaugh. 1962. Descriptions of the nymphal stages of some North American Pentatomidae (Hemiptera-Heteroptera). Ann. Entomol. Soc. Am. 55: 323–342.

Evans, E. W. 1982. Timing of reproduction by predatory stink bugs (Hemiptera: Pentatomidae): patterns and consequences for a generalist and a specialist. Ecology 63: 147–158.

———. 1983. Niche relations of predatory stink bugs (*Podisus* spp., Pentatomidae) attacking tent caterpillars (*Malacosoma americanum*, Lasiocampidae). Am. Midl. Nat. 109: 316–323.

Furth, D. G. 1974. The stink bugs of Ohio (Hemiptera: Pentatomidae). Bull. Ohio Biol. Surv. N. S. 5: 1–60.

Herring, J. L., and P. D. Ashlock. 1971. A key to nymphs of the families of Hemiptera (Heteroptera) of America north of Mexico. Fla. Entomol. 54: 207–212.

Kirkland, A. H. 1898. The species of *Podisus* occurring in the United States. Rep. Mass. State Board Agric. on Gypsy Moths. Appendix: 112–138.

McPherson, J. E. 1982. The Pentatomoidea (Hemiptera) of northeastern North America with emphasis on the fauna of Illinois. Southern Illinois Univ. Press, Carbondale, Illinois.

Morris, R. F. 1972. Predation by insects and spiders inhabiting colonial webs of *Hyphantria cunea*. Can. Entomol. 104: 1197–1207.

Oetting, R. D., and T. R. Yonke. 1971. Immature stages and biology of *Podisus placidus* and *Stiretrus fimbriatus* (Hemiptera: Pentatomidae). Can. Entomol. 103: 1506–1515.

Prebble, M. L. 1933. The biology of *Podisus serieventris* Uhler, in Cape Breton, Nova Scotia. Can. J. Res. 9: 1–30.

Torre-Bueno, J. R. de la. 1939. A synopsis of the Hemiptera-Heteroptera of America north of Mexico. Entomol. Am. N. S. 19: 141–310.

Tostowaryk, W. 1971. Life history and behavior of *Podisus modestus* (Hemiptera: Pentatomidae) in boreal forest in Quebec. Can. Entomol. 103: 662–674.

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THE NEW WORLD GENUS *PARACRIAS* ASHMEAD (HYMENOPTERA: EULOPHIDAE)

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Abstract.—The species of the New World genus *Paracrias* Ashmead (Hymenoptera: Eulophidae) are revised. Three previously described species are recognized and 3 new species, ***strii, guatemalensis,*** and ***beus,*** are described and illustrated. *Emersonopsis* Girault (1917) is here regarded as a synonym of *Paracrias*. A key to the species is included.

The subfamily Entedontinae (Eulophidae) contains a number of genera of economic importance (e.g. *Pediobius* and *Horismenus*). However, few of these genera have been recently revised and their relationships to one another are poorly understood. *Paracrias* is closely related to both of the genera mentioned above and the known host relationships of the group indicate that these species may also be of potential economic importance.

Methods

Terminology for surface sculpturing follows Harris (1979). Measurements and ratios were made with a Wild stereomicroscope and eyepiece reticle. The measurements are in microns unless specified otherwise. Lengths and widths of antennal segments and wings were made at their widest and longest points. Gaster, as used here, refers to that portion of the abdomen posterior to the petiole.

Genus *Paracrias* Ashmead

Paracrias Ashmead, 1904. Type-species: *Paracrias laticeps* Ashmead. Orig. desig.

Euplectrentedon Girault, 1917b. Type-species: *Euplectrentedon mirus* Girault. Orig. desig.

Emersonopsis Girault, 1917a. Type-species: *Entedon arizonensis* Ashmead. Orig. desig. New Synonymy.

Paracrias was described by Ashmead for a single species, *P. laticeps*, from Brazil. Later, Peck (1951) synonymized the monotypic genus *Euplectrentedon* Girault with *Paracrias*, which increased the number of species in the genus to two. Brèthes (1923) described *P. phytomyzae*, which was later transferred to *Euparacrias* by DeSantis (1955). *Emersonopsis* has been separated from *Paracrias* by recent authors (e.g. Burks, 1979), but neither genus has been critically revised. The only character difference that I have been able to find between these genera is that females of *Emersonopsis* have 2 funicle segments and a 3-segmented club, while species of *Paracrias* have a 3-segmented funicle and a 2-segmented club. There is very little difference between these two conditions and it is often difficult to distinguish a third funicle from the first club segment. As a result, I have proposed the above synonomy.

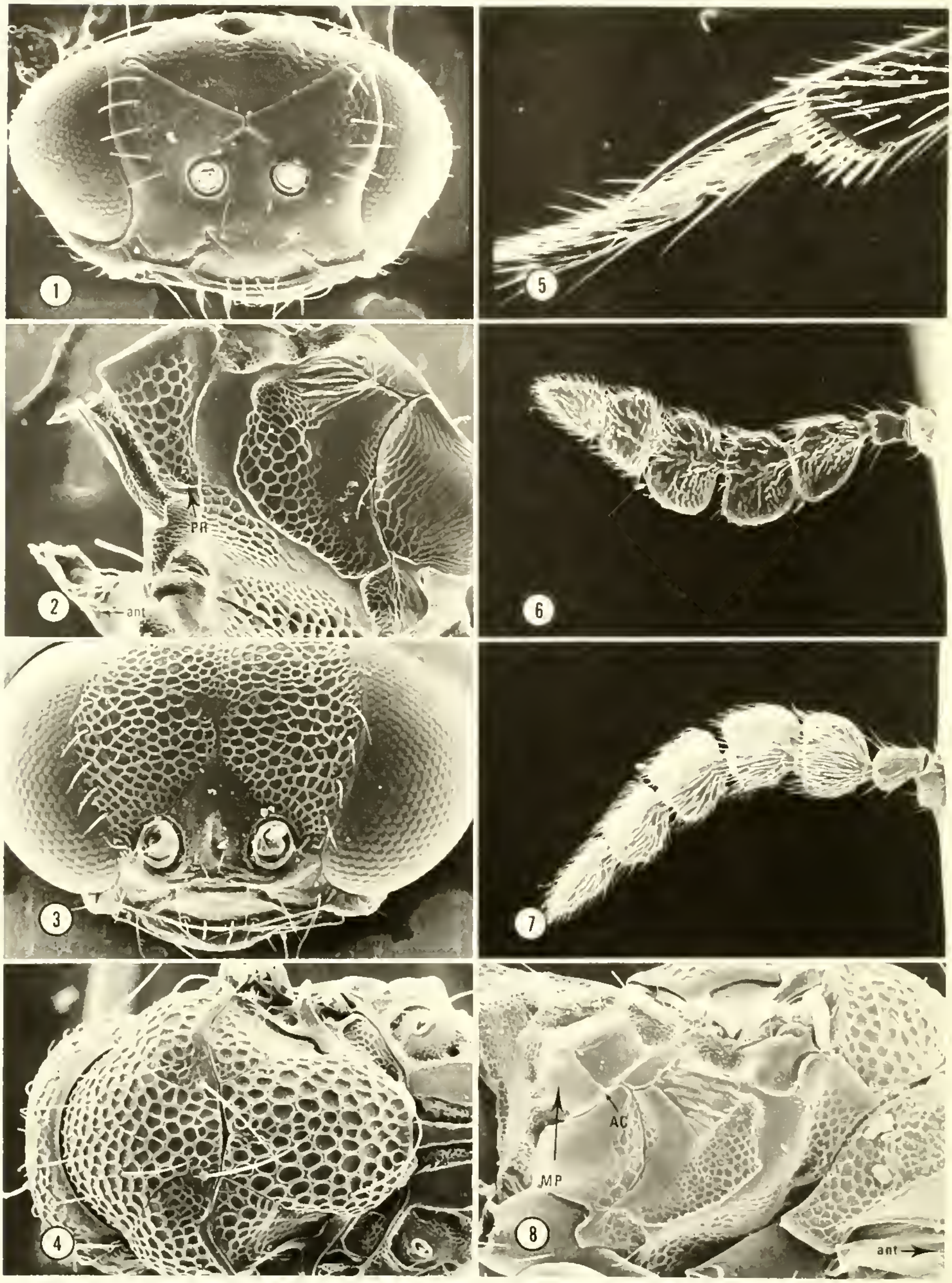
This genus is placed in the subfamily Entedontinae (sensu Burks, 1979). Genera in this subfamily are most easily recognized by the presence of a single pair of scutellar setae. Other eulophids have two or more pairs of scutellar setae.

Paracrias can be separated from other genera of entedontine eulophids by the following characters: head and thorax well sclerotized, not collapsed when dried; scutum and scutellum alveolate (Fig. 4); scrobal grooves united below Y-shaped facial groove (Fig. 1); mandibles with single large tooth (Fig. 14) and smaller second tooth; pronotum without transverse carina; propodeum with sublateral raised smooth area, area around spiracle recessed (Fig. 4); metapleural protuberance with anterolateral carina (Fig. 8); scutellum without median groove (Fig. 4).

Paracrias is considered to be most closely related to *Horismenus* Walker, *Psephenivorus* Burks, and *Edovum* Grissell. These genera possess the same basic Propodeal pattern (Figs. 9, 11, 16), the presence of an anterolateral carina on the metapleural protuberance (carina absent in other genera), and the Y-shaped facial grooves (a character seen in several other related entedontines), and distance between the insertion point of the mid and hindcoxae is much greater than in other genera. Another distinctive feature uniting these genera is the presence of a deep canal-like groove anteriorly on the prepectus (Fig. 2). This groove is concealed by the hind edge of the pronotum. Thus the groove can be seen only in dissected specimens. Ventrally, this may continue as a ridge, which is concealed by the posterior edge of the prosternum and propleura. However, at least some species of *Horismenus* lack the ventral ridge, and in others the canal is interrupted for part of its length. In some of the species of *Paracrias*, the hindtibial spur is enlarged, and subequal or slightly longer than the first tarsomere (Fig. 5), and the setae of the tibial comb are flattened and blunted. However, the degree of development of these tibial spur characters seems to vary continuously and does not appear to be reliable at the generic level.

Paracrias is most easily separated from *Horismenus, Psephenivorus* and related genera by the absence of median or lateral scutellar grooves (present at least anteriorly in most other genera), and the presence of mandibles with a single large tooth and a second much reduced tooth (mandibles with 2 or 3 subequal teeth in others).

The monophyly of *Paracrias* has been difficult to establish, in part, because the generic limits of its closest allies have not been critically assessed. Based on outgroup comparison, many of the thoracic structural differences between *Paracrias* and related genera can only be interpreted as symplesiomorphies in *Paracrias*. Nevertheless, the following features may be used as putative synapomorphies: 1) the clypeus is clearly set off by carinae, sutures, and/or marked differences in sculpturing (in related genera, this area can usually only be distinguished with difficulty if at all, however, this character state is plesiomorphic for the Chalcidoidea as a whole and its value is therefore questionable); 2) there is no transverse pronotal carina (this is present in the other genera, but other entedontine genera also lack a transverse pronotal carina and the value of this character remains in doubt); 3) the mandibles have a single large tooth, with a small second tooth dorsally (other genera have 2 or 3-dentate mandibles and the teeth are about



Figs. 1–8. Scanning electron micrographs of *Paracrias*. 1, Head of *P. mirus*. 2, Thorax of *P. guatemalensis* (lateral view). 3–4, Head and thorax of *P. strii*. 5, Hindtibial spur of *P. mirus*. 6–7, Male antenna of *P. strii*. 8, Thorax of *P. strii* (lateral view) (pr = prepectus; ant = anterior; mp = metapleural protuberance; ac = anterior carina).

equal in size); and 4) the marginal vein is short, being only about equal to the submarginal (related genera have the marginal longer than the submarginal, often twice as long).

Very little is known about the biology of species of *Paracrias*. The two species with known hosts are both parasites of seed infesting weevil larvae (Coleoptera: Curculionidae).

KEY TO NEW WORLD SPECIES OF *PARACRIAS*.

1. Fore and midfemora black or dark metallic blue; occiput sharply margined (Fig. 10) 4
– Fore and midfemora light brown or yellow, at least at tips; occiput rounded 2
2. Facial grooves indicated only by slight changes in sculpturing (Fig. 3); area between toruli swollen; tibiae brown or metallic black medially; male funicles flattened (Figs. 6, 7) .... *P. strii* Schauff new species
– Facial grooves distinct (Figs. 1, 14, 19); area between toruli flattened or only slightly raised; tibiae concolorous brown or yellow; male funicles cylindrical 3
3. Tibiae yellow; areas directly above and below toruli smooth (Fig. 1); prepectus smooth or only weakly sculptured .... *P. mirus* (Girault)
– Tibiae brown; areas directly above and below toruli alveolate (Fig. 14); prepectus alveolate medially (Fig. 15) .... *P. guatemalensis* Schauff new species
4. Propodeal dorsum alveolate medially (Fig. 13); funicle 3-segmented in females; gastral tergum 1 without hair tuft at petiolar insertion .... *P. laticeps* Ashmead
– Propodeal dorsum with smooth raised median plate (Fig. 17); funicle 2-segmented (Fig. 21) in females; gastral tergum 1 with tuft of hairs at petiolar insertion (Fig. 24) 5
5. Hindcoxa with numerous small silver setae dorsally; scutellum sculpture fading medially; female petiole 2× longer than wide, laterally with small tuft of setae (Fig. 24); wing membrane asetose under proximal section of marginal vein (Fig. 23) .... *P. beus* Schauff new species
– Hindcoxae bare dorsally; scutellum uniformly alevolate; female petiole quadrate, barely as long as wide, laterally without setal tuft; wing membrane uniformly setose under proximal section of marginal vein (as in Fig. 22) .... *P. arizonensis* (Ashmead)

Paracrias laticeps **Ashmead**

Paracrias laticeps Ashmead, 1904: 510.

This species is known only from the types. The lectotype is largely intact, with only pieces of the legs and apical segment of the antennae missing. The paralectotype is missing both antennae and pieces of the wings.

Diagnosis.—This species shares the sharply margined occiput with *P. beus* and *P. arizonensis* (Fig. 10). However, both of the latter species have 2-segmented funicles in the female (3-segmented in *P. laticeps*) and the propodeum has a raised smooth plate medially (Fig. 17) (propodeum evenly alveolate medially in *P. la-*

Figs. 9–16. Scanning electron micrographs of *Paracrias.* 9, Propodeum of *P. strii.* 10, Head and thorax of *P. arizonensis.* 11–12, Propodeum and thorax of *P. guatemalensis.* 13, Propodeum of *P. laticeps.* 14–15, Head and lateral thorax of *P. guatemalensis.* 16, Propodeum of *P. mirus* (ant = anterior; pet = petiole).

ticeps, (Fig. 13)). In addition, the modified hair tufts laterad of the petiolar insertion to the gaster are absent in *P. laticeps* (present in *P. beus* and *P. arizonensis*).

Hosts.—Unknown.

Distribution.—Known only from Brazil.

Types.—Lectotype ♀ (present designation): August, Chapada dos Guimaraes, Brazil H. H. Smith collector. USNM type no. 8096. Paralectotype ♀ with same data, except collected in September.

***Paracrias mirus* (Girault)**

Euplectrentedon mirus Girault, 1917b: 3.

Girault's original description does not mention how many specimens he saw. Only a single female is present in the USNM and type records in Girault's handwriting indicate only one specimen. This specimen is labelled as the type and the label data corresponds with that given in the description. This specimen has had the head removed and mounted on a slide. As with many of Girault's types, the head has been partly smashed, but some details are still discernable. A separate coverslip contains pieces of one antenna and an intact hindleg. The rest of the body of the type was found to have been knocked off its point and most of the mid and hindlegs are missing (some small pieces of each are still imbedded on the original point) as is one forewing and one hindwing. The body has been remounted on a new point, above the original point.

Diagnosis.—This species is unique in having entirely yellow legs (femora and/or tibiae light brown to black in other species). It shares a rounded occiput with *P. strii* and *P. guatemalensis*. *P. strii* has weak facial grooves and a distinct swelling between the toruli (Fig. 3) (grooves well defined and area between toruli more or less flat in *P. mirus* and *P. guatemalensis* (as in Fig. 1). The prepectus is evenly alveolate in *P. guatemalensis* (prepectus smooth in *P. mirus*).

Variation.—Body length varies from 2.6 mm for the largest females to 2.2 mm for smaller males. The thorax and abdomen of the type are considerably darker and less metallic green than the other specimens, although the head does appear metallic. The type also has the sculpturing of the upper frons descending to the top of the facial grooves, while in the other specimens there is a small smooth area directly above the Y.

Hosts.—Reared from *Lignyodes bischoffi* (Blatchley) on green ash, *Fraxinus pennsylvanicus* Marsh; also reared from the seeds of *Fraxinus oregona* Nutt.

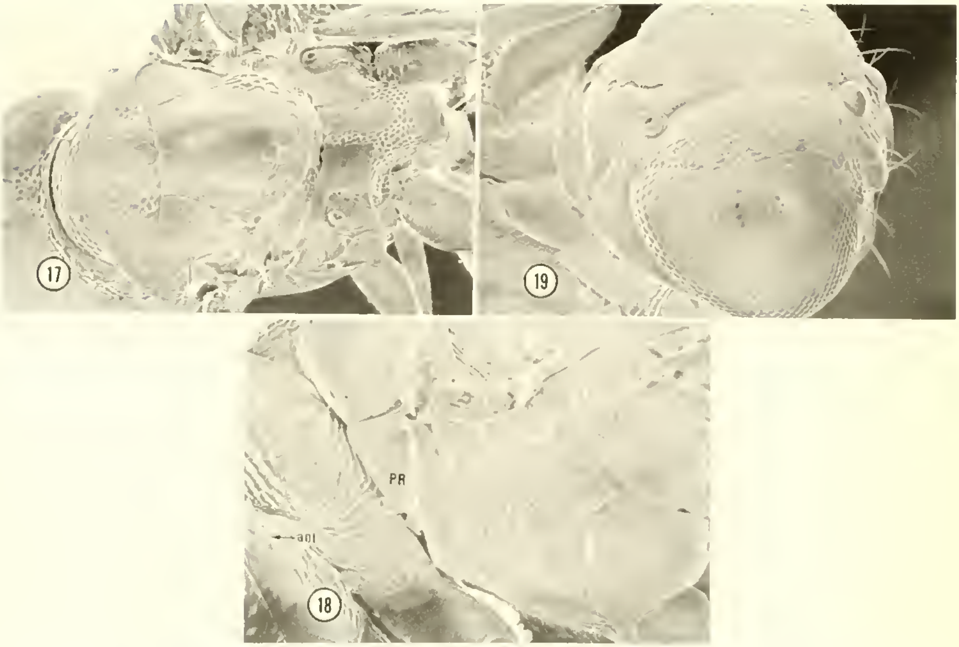
Distribution.—New York, Iowa, Minnesota, and Oregon.

Types.—Holotype ♀, USNM type no. 20437, on point, with data: "Ames, Iowa., 7-31-95, Exp. Sta."

Other specimens examined.—One ♂ and 1 ♀, Syracuse, New York, 3/15/1951 and 4/27/1957, respectively, both reared from ash. One ♀ and 9 ♂ from Ashland, Oregon, April, May and June, 1918 and 1 ♂ 10/2/1916. Reared from *Fraxinus oregona*. Seven ♀ Minnesota, Lac Qui Parle Co., 5 Aug., 1983, reared from *Lignyodes bischoffi* on ash tree by P. Hanson.

***Paracrias strii* Schauff, NEW SPECIES**

Holotype ♀.—Length 3.2 mm. Color as follows: scape, tips of femora, tibiae, and tarsi yellow; femora medially and tips of tarsi light brown; funicle, fore and



Figs. 17–19. Scanning electron micrographs of *Paracrias beus*. 17, Dorsal thorax. 18, Lateral thorax. 19, Head (pr = prepectus; ant = anterior).

midcoxae dark brown; head, thorax, hindcoxae, and gaster dark metallic green to black or blue; scutum and scutellum tinged with bronze; head width : height 1000: 680, eye margins converging ventrally; frons as in Fig. 3, facial grooves weak, only indicated medially at fork; area between toruli swollen, with a distinct shelf-like carina extending across face below toruli; clypeus smooth, bordered laterally by carinae; malar sulcus present; occiput rounded, minutely alveolate, sculpture fading slightly laterally and dorsally, laterally with small carina extending from the oral cavity parallel to the eye margin and meeting genal carina; antennal length ratio (Fig. 20) (scape, pedicel, F1, F2, F3, club) 378:99:207:135:117:180; thorax as in Figs. 4, 8; exposed prepectus uniformly foveate-reticulate, except dorsal and postero-dorsal margin smooth; scutellum and axillae alveolate; mesosternum interrupted in posterior quarter by lateral carinae which converge, but do not meet, forming a small shelf anterior to the midcoxae, with few scattered setae posteriorly; metapleural protuberance with carina running dorsally from the midpoint (Fig. 8); propodeum (Fig. 9) with median, smooth, raised area which projects forward, bisecting metanotum; sunken spiracular area alveolate, fading to coriaceous medially, spiracular opening elliptic; petiole only slightly longer than wide, rugose to lightly alveolate, with two lateral longitudinal carinae, without lateral setal tuft; gaster ovate elliptic, about 1.5 × as long as wide (viewed dorsally), with scattered minute punctures laterally, antero-dorsal margin of tergum 1 without modified setal patch, posterior margin straight; terga laterally with 1 or 2 setae, last 3 terga with 2 or 3 dorsal setae, ovipositor sheaths and sterna smooth; ratio of lengths of femur : tibia : tarsus as follows: foreleg 540:540:360; midleg 630:675:495; hindleg 720:720:531 (hindtarsomeres 162:117:99:153); hindtibial spur length subequal to hindtarsomere 1, inner surface of hindcoxae with 4–6 long setae; forewing length:width 2160:830, ratio submarginal : marginal : stigmal 855:765:40, membrane evenly setose under proximal section of marginal vein (Fig. 22).

Allotype.—Generally similar to the ♀, except the following: funicle segments flattened (Figs. 6, 7), ratio length : width F1–F4 180:135; 180:135:189:135; 162:135, outer surface light brown, inner surface metallic copper. Sensilla nearly absent on inner surface, evenly scattered on outer surface; gaster about as long as wide, first tergum covering ¾ of surface.

Variation.—Coloration varies slightly between males and females. In females the face is metallic green, the thorax is largely metallic green dorsally and laterally, becoming bronze colored medially, while the occipital region of the head, pronotum, lateral thorax, and gaster are dark blue to black. Males often have the face darker green or dark violet, the dorsal thorax very dark blue or greenish and nearly black medially. In addition, the size of the median brown area on the tibiae varies slightly and is often smaller and lighter in the males. Sculpturing is quite uniform. However, there is minor variation in the size of the reticulations on the thoracic dorsum, particularly at the posterior margin of the scutum and the antero-medial margin of the scutellum.

Diagnosis.—This species is most easily distinguished by the weak facial grooves (Fig. 3) (grooves well defined in other species (as in Fig. 1)) and the swelling between the toruli (area flat or barely raised in other species). In addition, the propodeum bisects the metanotum medially (Fig. 9), while in other species it either does not reach the metanotum (Fig. 16) or reaches but does not bisect it (Fig. 12).

Hosts.—Unknown.

Distribution.—Known only from Panama.

Types.—Holotype ♀ on point with data: Barro Colorado Island, Canal Zone, X-1937, Ficus fruit, J. A. S. Zetek, no. 4421, lot no. 39-11659. Five ♀ and 10 ♂ paratypes with same data. Deposited in USNM, type no. 101168. Paratypes deposited in British Museum (Natural History) and Canadian National Collection.

Etymology.—This species is named after the Smithsonian Tropical Research Institute on Barro Colorado Island, commonly known by its acronym STRI.

***Paracrias guatemalensis* Schauff, New Species**

Holotype ♀.—Length approximately 4.2 mm; color: scape, tarsi light yellowish brown; funicle, femora, tibiae brown; head, thorax, gaster, coxae dark blue-green to black; scutal dorsum, scutellum tinged with bronze; ratio of head width : height 1044:810, eye margins parallel ventrally; frons as in Fig. 14, facial grooves well defined; toruli slightly sunken, without shelflike carina below; clypeus smooth, bordered laterally by weak carinae; malar space with carina running from edge of oral cavity to genae; occiput rounded, minutely alveolate, sculpture fading slightly at lateral and dorsal edge, laterally with small carina running from above oral cavity parellel to the eye margin and meeting malar carina; antennal length ratio (scape, pedicel, F1, F2, F3, club) 540:144:216:153:135:225; thorax and propodeum as in Figs. 12, 15; exposed prepectus foveate-alveolate, except dorsal and postero-dorsal margin; scutellum and axillae evenly alveolate; mesosternum interrupted in posterior quarter by two lateral carinae which converge but do not meet, forming a small shelf anterior to the midcoxae, with few scattered setae posteriorly; metapleural protuberance with carina running dorsally from midpoint; propodeum (Fig. 11) with median smooth area which does not bisect metanotum; sunken spiracular area on propodeum alveolate changing to coriaceous medially, spiracle elliptic; petiole about 1.5× as long as wide, smooth, with single small lateral longitudinal carina, without lateral setal tuft; gaster elongate elliptic, about 3× as long as wide (viewed dorsally), smooth, first tergum without antero-dorsal setal clump, posterior margin straight; terga laterally with 3–4 setae, last 3 with 2–4 dorsal setae, ovipositor sheaths and apical sterna weakly imbricate; ratio of lengths of femur : tibia : tarsus as follows: foreleg 630:630:450; midleg 756:810:594; hindleg 936:990:648 (225:135:108:180); hindtibial spur length subequal to first hindtarsus; inner surface of hindcoxae with 6–7 long setae; forewing length : width 2790:1080, ratio submarginal : marginal : stigmal 820:1026:54, membrane evenly setose under proximal section of marginal vein (as in Fig. 22).

Allotype.—Generally similar to the ♀, except the following; scape dark brown, antennal ratio beginning with scape 360:135:198:126:126:126:180.

Variation.—Size ranges from 2.4 mm for males to 4.2 mm for females. Color on the dorsal thorax varies slightly, with the bronze tinge of the scutum and scutellum occasionally subdued and more greenish or blackish laterally, the mesopleuron is occasionally tinged with purple rather than black. The hindtibial spur of the holotype is uniformly yellowish, but some of the paratypes have the apical tip colored brown. Very little structural difference was noted in the specimens available for study. The dorsal mesepisternum in some females is more heavily strigate than in others, and the length of tergum 2 varies from about as long as wide to a narrow transverse band several times wider than long (this is probably largely an artifact of drying). Males have the area laterad of the clypeus more heavily sculptured than the females, two male paratypes show a slight rugosity medially on the clypeus.

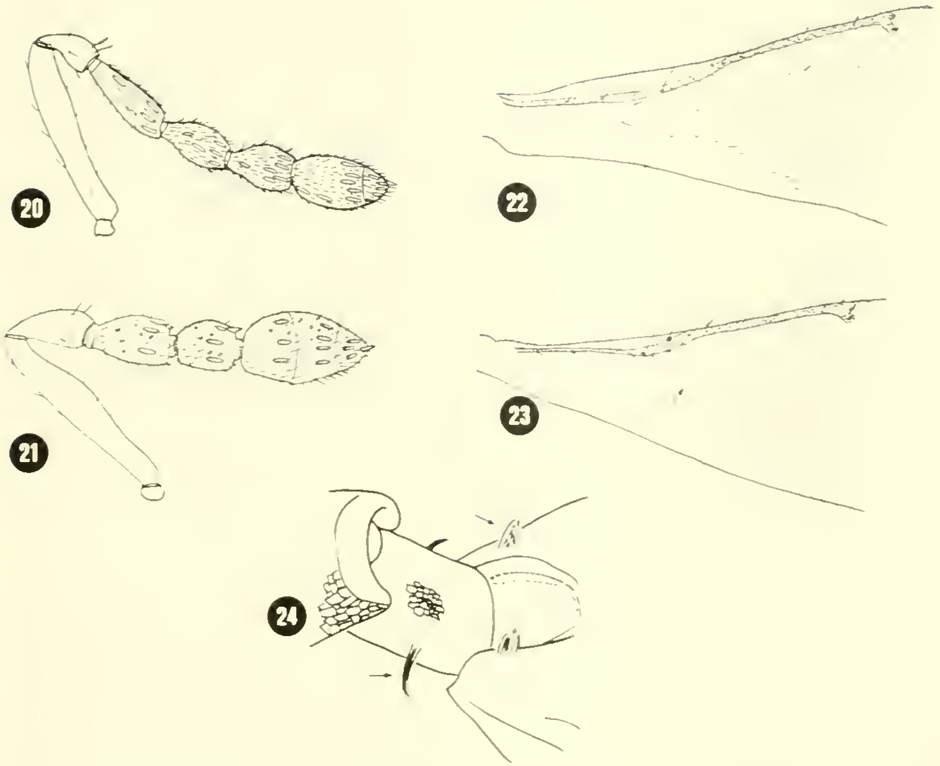
Diagnosis.—This species is most easily confused with *P. strii*, both of which have the mesosternum interrupted posteriorly by carinae which form a small shelf anterior to the midcoxae. They also have a dorsal carina on the metapleural protuberance (Fig. 8). The two species can be separated by the following: facial grooves (Fig. 14) well defined in *P. guatemalensis* (grooves weak in *P. strii* (Fig. 3); area between toruli nearly flat (area swollen in *P. strii*); petiole smooth dorsally (petiole rugose in *P. strii*). This species keys out near *P. mirus*, but the color of the tibiae (yellow in *P. mirus*, brown in *P. guatemalensis*) and the sculpturing of the prepectus (smooth in *P. mirus*, alveolate in *P. guatemalensis* (Fig. 15)) are diagnostic.

Host.—*Conotrachelus perseae* Barber (Curculionidae).

Distribution.—Guatemala.

Types.—Holotype ♀ on point with data: "Guatemala City, coll. Popenoe, Feb., 1918. Iss. at Wash., D.C. by H. S. Baker, FHB 23172, ex. larva of *Conotrachelus* n.sp. (*perseae*)." Paratypes: 17 ♀ and 6 ♂, same data as holotype, except some specify that the parasites were reared from avocado seeds. Deposited in USNM, type no. 101169. Paratypes also deposited in British Museum (Natural History) and Canadian National Collection.

Etymology.—This species is named for the type locality.



Figs. 20–24. 20–21, Female antennae. 20. *P. striı.* 21. *P. beus.* 22–23. Forewings. 22. *P. striı.* 23. *P. beus.* 24. Propodeum and anterior gaster of *P. beus.*

Paracrias beus Schauff, New Species

Holotype ♀.—Length approximately 2.2 mm. Color: first 3 tarsomeres, femoral apices and tibial bases white; rest of body, legs, and antennae dark metallic blue black to black; ratio of head width : height 1440:1116, eye margins converging ventrally; frons as in Fig. 19, facial grooves well defined, toruli slightly sunken, area between and below toruli swollen slightly; clypeus smooth, raised medially, bordered laterally by sulcus; malar space without carina; occiput sharply margined, alveolate, sculpture fading medially and laterally at eye margins, laterally without a carina; antennal ratio (Fig. 23) (scape, pedicel, F1, F2, club) 288:99:117:99:162; thorax and propodeum as in Figs. 17, 18; exposed prepectus smooth; scutellum with alveolate sculpture which fades medially, axillae smooth; mesosternum not interrupted by carina, sloping evenly to midcoxae, with numerous white setae medially and posteriorly; metapleural protuberance without dorsal longitudinal carina; propodeum (Fig. 17) with median smooth area not bisecting metanotum; sunken spiracular area of propodeum weakly coriaceous, spiracle elliptic; petiole 2× as long as wide, minutely alveolate, without lateral carinae, with lateral hair tuft (Fig. 24); gaster ovate elliptic, about 1.5× as long as wide (viewed dorsally), smooth; first tergum extending slightly less than ½ length of gaster dorsally, with modified setal patch antero-dorsally, subequal to tergum 2, posterior edge sinuate, ventrally expanded and extending ⅔ length of gaster; terga laterally with 2–3 setae, last 3 with 4–6 dorsal setae; ovipositor sheaths and sterna minutely alveolate; ratio of lengths of femur : tibia : tarsus as follows: foreleg 360:378:270; midleg 387:450:360; hindleg 486:504:306 (73:63:63:108); hindtibial spur slightly shorter than tarsomere 1; inner, dorsal, and ventral surfaces of hindcoxa with numerous silvery setae; ratio of forewing length : width 810:630, ratio submarginal : marginal : stigmal 495:545:27, membrane devoid of setae under proximal ½ of marginal vein (Fig. 23).

Diagnosis.—This is the only known species in which the sculpturing fades out medially on the scutellum (Fig. 17) (scutellum evenly alveolate in other species). In addition, *P. beus* has a modified setal tuft (Fig. 24) projecting laterally from the sides of the petiole (tuft absent in other species), and the dorsal and inner lateral surfaces of the hindcoxa are covered with numerous short silvery setae (other species with only 4–8 long setae laterally on the hindcoxae). Finally, the wing membrane beneath the proximal section of the marginal vein is without setae (Fig. 23) in *P. beus*, while in the other species this area is evenly covered with setae (as in Fig. 22).

Hosts.—Unknown.

Distribution.—Known only from Surinam.

Types.—Holotype ♀ on point with data: "Surinam, Foengoe Island; Voltzberg Nat. Res. San.; Feb. 1982. James Carpenter. Pan trap." Deposited in the Canadian National Collection, type no. 18013. This specimen was collected among second growth vegetation at 90 m in Raleigh Vallen-Voltzberg Natuurreservaat.

Etymology.—The species epithet is a euphonious arbitrary combination of letters.

***Paracrias arizonensis* (Ashmead), New Combination**

Entedon arizonensis Ashmead, 1888a: 103.
Entedon cupreicollis Ashmead, 1888b: viii.

This species was described from a single female collected in Arizona. Later, Girault (1924) synonymized *E. cupreicollis* with *E. arizonensis*. I have examined the type of *Cupreicollis* and concur with this synonymy. Specimens in the USNM indicate that this species may be quite widespread in Western United States and occurs in two color forms. Specimens collected in May, June, and July are nearly uniformly metallic green, while specimens collected in July, August, and September are black. I have been unable to find any additional morphological differences that would indicate that the two color forms represent separate species.

Diagnosis.—This species can be distinguished by the following characters: fore and midfemora black or dark metallic blue, occiput sharply margined (Fig. 10) (also present in *P. beus* and *P. laticeps*; femora brown or yellow and occiput rounded in other species); propodeum with smooth median area (as in Fig. 9) (uniformly alveolate in *P. laticeps* (Fig. 13)); funicle 2-segmented (3-segmented in *P. laticeps*); petiole quadrate, without lateral setal tuft (petiole 2× as long as wide and with lateral tuft in *P. beus* (Fig. 24)).

Hosts.—Unknown.

Distribution.—Alberta, Idaho, Utah, Oregon, Colorado, Arizona, and New Mexico.

Types.—Holotype ♀ on point, USNM type no. 13145. Wings and antennae mounted separately on slide.

ACKNOWLEDGMENTS

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LITERATURE CITED

Ashmead, W. H. 1888a. Descriptions of some new North American Chalcididae. Can. Entomol. 20: 101–107.

———. 1888b. Descriptions of some unknown parasitic Hymenoptera in the collection of the Kansas State Agricultural College, received from Prof. E. A. Popenoe. Bull. Kans. St. Agr. Coll. Exp. Sta. appendix i–viii.

———. 1904. Classification of the Chalcid-Flies. Mem. Carnegie Mus. 1(4): 551 pp.

Brèthes, J. 1923. Sur un Diptère mineur des feuilles de *Salvia splendens* et deux Hyménoptères, ses parasites. Rev. Zool. Agric. Appl., Bord. 6: 1–6.

Burks, B. D. 1979. Family Eulophidae. *In* Krombein et al., eds., Catalog of Hymenoptera in America North of Mexico. Smithsonian Inst. Press. Vol. 1. 1198 pp.

DeSantis, L. 1955. Los Insectos de Las Islas Juan Fernandez. Rev. Chil. Entomol. 4: 167–198.

Girault, A. A. 1917a. Two new genera of North American Entedontinae (Chalcid-Flies). Can. Entomol. 49: 110–111.

———. 1917b. Speciosissima Genera Nova Eulophidarum. Privately Published. 4 pp.

———. 1924. The North American species of *Emersonopsis*, *Amestocharis*, *Euderus*, and *Neomphalomyia*. (Hymenoptera: Chalcididae). Ins. Ins. Mens. 12: 93–95.

Harris, R. 1979. A glossary of surface sculpturing. Occasional papers in Entomology no. 28. California State Department of Food and Agriculture, Sacramento, CA.

Peck, O. 1951. Superfamily Chalcidoidea. *In* Muesebeck, Krombein, and Townes, eds., Hymenoptera of America North of Mexico. U.S. Dept. Agric., Agr. Monog. 2. 1420 pp.

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 110–115

THE INTERTIDAL ZONATION OF *THALASSOTRECHUS BARBARAE* (HORN) (COLEOPTERA: CARABIDAE)

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Abstract.—In central California, crevices occupied by larvae and pupae of *Thalassotrechus barbarae* were distributed in the upper intertidal zone between Highest Lower High Water (1.53 m) and Lowest Lower High Water (0.87 m). Adults were collected from crevices ranging in height from just below Highest Higher High Water (1.89 m) to just below Mean Lower High Water (1.1 m), but their nightly activities outside the crevices extended from just below the splash zone (2.89 m) down to Mean Higher Low Water (0.72 m).

Carabid beetles are found in a great variety of terrestrial habitats but some are adapted for living in a narrow band or zone within the wider intertidal boundaries on rocky shores, sand beaches or tidal mudflats. Intertidal zonation is characteristic of all life on seacoasts and a vast literature exists on the zones occupied by the more conspicuous sedentary organisms such as barnacles, mussels, limpets and marine algae. However, little is known about zonation of intertidal insects and most of the records are qualitative. Concerning carabid beetles, for instance, Johns (1974) reported finding specimens of *Kenodactylus audouini* (Guérin) ". . . just above the mean tide level" in the Auckland Islands, and Evans (1968) recorded *Tachys* sp. from "crevices at the upper level of the barnacle-algae zone" in western Mexico. Riedl (1963) lists the habitat of *Pogonus luridipennis* Germar and *P. gracilis* DeJean simply as intertidal. In a more quantitative study, Glynne-Williams and Hobart (1952) found individuals of the European intertidal carabid *Aepopsis* (= *Aepus*) *robini* Laboulbène widely distributed at about the mean tide level.

Thalassotrechus barbarae (Horn) is the only pogonine carabid species inhabiting rocky shores on the Pacific coast of North America. Members of this flightless species are distributed from Point St. George near Crescent City in northern California to Bahia Magdalena, Baja California, Mexico (Evans, 1977). This is in a region of mixed tides (Doty, 1957); variations in tidal height take place twice a day, but successive high tides and successive low tides are quite different in height (Fig. 1). Along this coastline beetles live in rocky shore habitats in protected bays such as San Francisco Bay and Bahia Magdalena or on semiprotected exposed coasts such as Carmel Bay and Pismo Beach.

All stages occur in rock crevices in the upper intertidal zone though adults emerge at night when tidal conditions permit and walk over nearby rock and sand surfaces (Evans, 1976). Mating as well as feeding takes place at these times. Rock

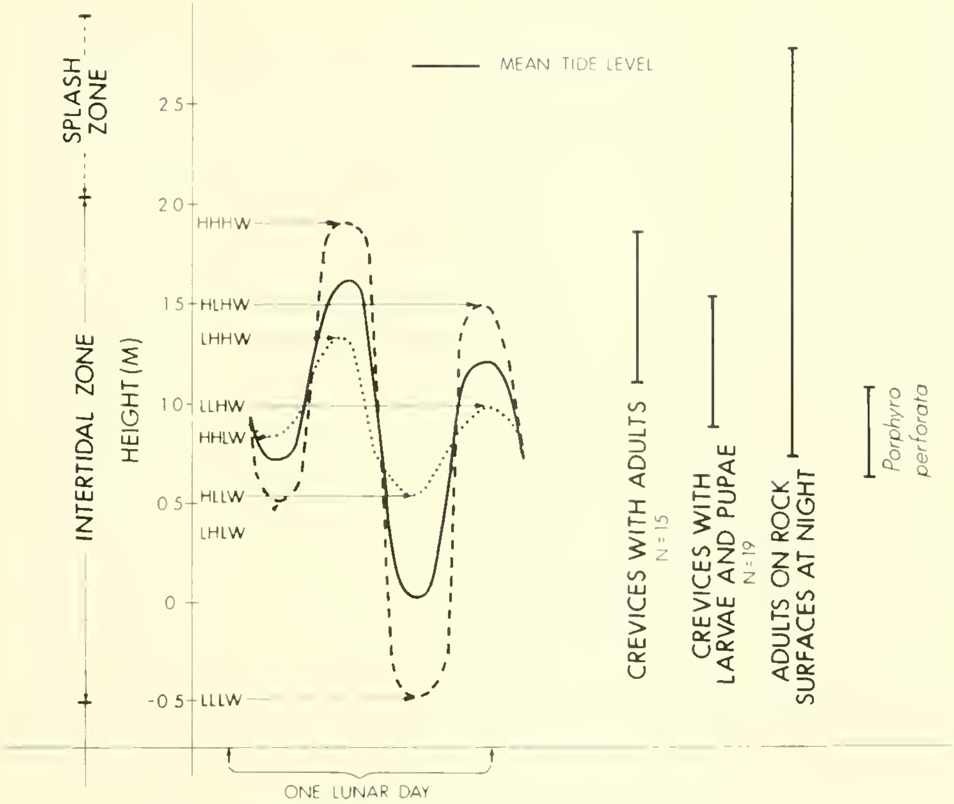

Fig. 1. Ranges of heights of crevices in the intertidal zone at Pacific Grove, California, occupied by adults, larvae and pupae of *Thalassotrechus barbarae*; the range of nocturnally active adults outside crevices; and the range of heights of the alga, *Porphyra perforata*. Algal data from Smith (1969) and tidal diagram modified from Doty (1957). H, L, and W = High, Low and Water with suffixes -est and -er appended to the first two words of each four word set respectively.

crevices form a distinct habitat in the marine littoral (Glynne-Williams and Hobart, 1952; Richoux, 1972) with a characteristic fauna that consists partly of marine and partly of terrestrially-derived constituents, such as insects (Glynne-Williams and Hobart, 1952; Kensler, 1965). Crevices shelter inhabitants from extremes of temperature and humidity and from wave action. Sediments trapped in crevices serve as a substrate for the resident organisms as well as a filter of plankton and organic detritus brought in by tides.

The objectives of this study were twofold. As part of another study on adaptations of *T. barbarae* to the chemical milieu of the crevice habitat the vertical range of heights of crevices occupied by larvae and adults was needed to relate chemical composition of crevice sediments to tidal influences. Secondly, as part of another project on mechanisms of habitat selection in the Carabidae (Evans, 1983) I required information on the vertical distances travelled by adults to help explain how they find their way back to crevices at dawn or at flood tide after their nocturnal perambulations.

METHODS

The study area was a rocky shore in Spanish Bay near Pacific Grove, Monterey County, California with a mean tidal amplitude of 1.07 m. Height and times of tides were obtained from the *Tide Tables* 1973 and 1974 published by the United States Department of Commerce, National Oceanic and Atmospheric Administration. Zonation of larvae, pupae and adults of *T. barbarae* was determined in the following manner: during the day rock crevices were selected randomly and opened with a geological hammer. The heights of crevices occupied by any stage were measured in relation to a nearby benchmark of the California State Lands Commission Survey with a Brunton pocket level. Quantitative assessment of numbers of individuals in each crevice or of mean heights of occupied crevices was not attempted because of considerable variation in sizes of individual crevices, differences in degree of exposure of the crevices to wave action, and differences in slope and aspect of the crevice-bearing rock. (Also, since sampling of this generally rare species requires destruction of numerous crevice habitats and their occupants, extensive sampling was neither possible nor desirable in the environmentally protected shoreline areas of central California).

During low tide periods at night, heights of foraging or mating adults were also recorded to obtain the vertical range at which these activities take place.

Frequencies of emersion/immersion cycles of different intertidal heights in the study area were calculated with the use of computer-generated tables of hourly tidal heights, based on the graphical method given on p. 186 of the 1974 *Tide Tables*, for March and July (periods of both spring and neap tides) for San Francisco, California with appropriate adjustments made for time and height differences for Pacific Grove. The range of tidal height during these periods was grouped into 17 classes, each 0.14 m wide and, using the midpoint for each class, the hourly height tables were scanned for the number of times the tide rose above and fell below these midpoints during all the tidal cycles of the two months.

RESULTS AND DISCUSSION

As expected, crevices occupied by adults, and by larvae and pupae of *T. barbarae* are distributed in narrow bands on intertidal rocks of central California (Fig. 1). At night, active adults range in a wider band that corresponds roughly to the upper half of the intertidal zone. Also shown in this figure is the zonation of *Porphyra perforata* Agardh (Rhodophyta; Bangiaceae) (Smith, 1969), a red alga that is generally a reliable indicator of *T. barbarae* populations in the region where the distribution of these organisms overlap (essentially the entire Californian coastline); this yellowish-green, leafy alga is also the host plant of *Tethymyia aptena* Wirth (Diptera: Chironomidae) larvae that are eaten by *T. barbarae* adults (Evans, 1980).

Crevices occupied by adults, larvae and pupae were distributed in the upper regions of the intertidal zone corresponding approximately to the mean high tide level. Adults were collected from 15 crevices that ranged in height from 1.10 m (just below Mean Lower High Water) to 1.89 m which is just below Highest Higher High Water. Foraging and mating activities outside the crevices took place over a range extending from 0.72 m (Mean Higher Low Water) to just below the upper limits of the splash zone. Of 19 crevices with larvae and pupae, the highest at 1.53 m (approximately Highest Lower High Water) overlapped part of the

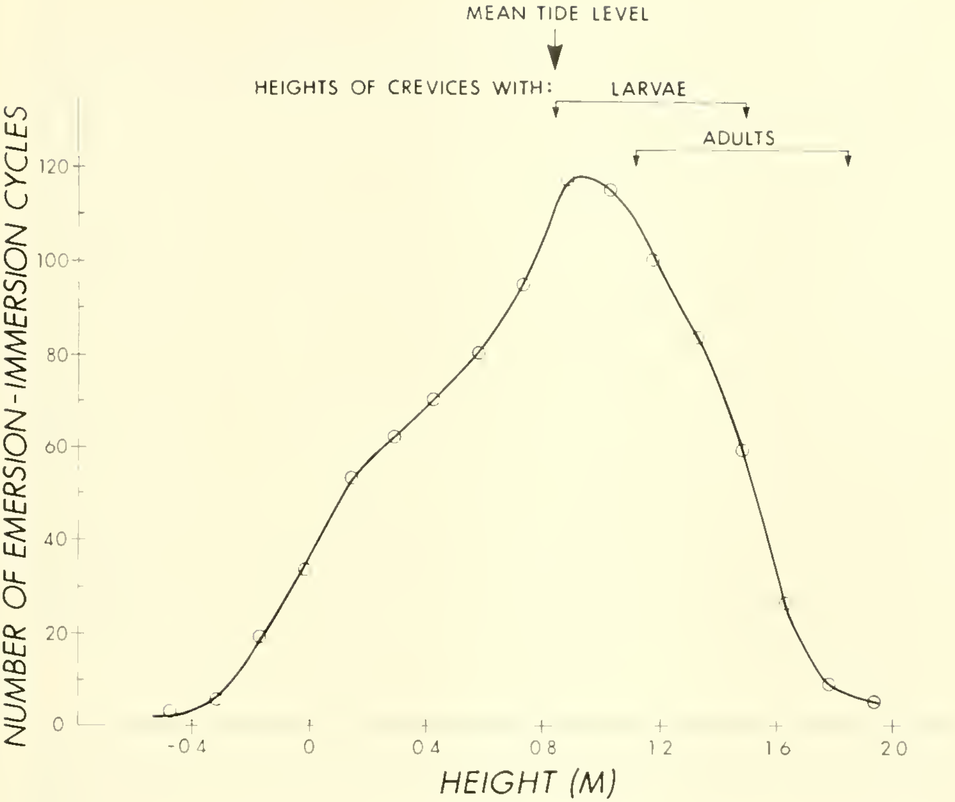

Fig. 2. Number of immersion and emersion cycles for different heights of the intertidal zone at Pacific Grove, California, for March and July, 1974 in relation to intertidal zonation of adults and larvae of *Thalassotrechus barbarae.*

adult range. Larvae and adults were collected together sometimes but since adults were not found in crevices below 1.10 m, females presumably enter such crevices for oviposition as part of their nocturnal activities while higher crevices serve as daytime retreats. Height differences between crevices with larvae and those with adults are probably real because the heavily sclerotized adults appear to be more resistant to water loss and are thus able to tolerate the drier conditions of the higher crevices. However, there is a lower height limit for the larvae below which they would be exposed to excessive periods of immersion. This limit corresponds to 0.87 m (Lowest Lower High Water), a level that is one of several "critical tide levels" (Doty, 1946) in California where changes in dominant species occur due to abrupt differences in duration of immersion or emersion over a period of time. At a level just below 0.87 m the duration of immersion increases two to three times so that crevices in this region are much wetter than those above this limit and are probably unsuitable for an essentially terrestrial insect such as *T. barbarae.*

The difference in ranges of heights of crevices with larvae and those with adults also reflects differences in trophic niches between these stages. Adults are free to scavenge or prey over a height range of more than 1.5 m in the upper intertidal zone whereas larvae are restricted to allochthonous planktonic material brought in when tides are high enough to wash the crevices. Larvae would thus benefit by occupying crevices at heights subjected to the greatest frequency of immersion/emersion cycles since influx of tidal water into crevices followed by draining is necessary for filtration of their planktonic food. The frequency of these wetting and drying cycles for classes of heights in the intertidal zone for Monterey County is shown in Fig. 2. Larvae occupy crevices at heights exposed to the maximum number of these cycles and consequently to the maximum amount of filtered food per unit time.

The restriction of individuals of a species within sharply-defined habitat boundaries is common to all intertidal insects; they have just not been recorded anywhere else. When dispersal occurs, it is along the shoreline (Leech, 1971) and even some of the forms inhabiting the upper beaches or rocks do not stray above the splash zone. *T. barbarae* is no exception to this generalization. Since adults are apterous, extensive sand beaches must act as barriers to them so dispersal may only occur when individuals fall or get washed into the water and are accidentally transported to suitable rocky shore habitats elsewhere.

Like other halophilic remnants of the once widespread and dominant pogonines *T. barbarae* survived displacement by competing forms, such as bembidiines (G. E. Ball, pers. comm.), because it was adapted to a very specialized habitat. A major adaptation had to be to the tidal regime which is inextricably involved in food supply, timing of activities and zonation of this species.

ACKNOWLEDGMENTS

I wish to thank my wife Joan and children Christopher and Claire for assistance in the field. My thanks are also extended to C. S. Pittendrigh and C. P. Abbott for use of the facilities at Hopkins Marine Station of Stanford University and to J. S. Scott for drafting the figures. This research was supported by grant A-1409 from the National Sciences and Engineering Council of Canada.

LITERATURE CITED

Doty, M. S. 1946. Critical tide factors that are correlated with the vertical distribution of marine algae and other organisms along the Pacific coast. Ecology 27: 315–328.

———. 1957. Rocky intertidal surfaces, pp. 535–585. *In* Hedgpeth, J. W., ed., Treatise on marine ecology and paleoecology. Geol. Soc. Am. Mem. 67, Vol. 1.

Evans, W. G. 1968. Some intertidal insects from western Mexico. Pan-Pac. Entomol. 44: 236–241.

———. 1976. Circadian and circatidal locomotory rhythms in the intertidal beetle *Thalassotrechus barbarae* (Horn), Carabidae. J. Exp. Mar. Biol. Ecol. 22: 79–90.

———. 1977. Geographic variation, distribution and taxonomic status of the intertidal insect *Thalassotrechus barbarae* (Horn) (Coleoptera, Carabidae). Quaest. Entomol. 13: 83–90.

———. 1980. Insecta, Chilopoda, and Arachnida: Insects and allies, pp. 641–658. *In* Morris, R. H., D. P. Abbott, and E. C. Haderlie, Intertidal invertebrates of California. Stanford University Press.

———. 1983. Habitat selection in the Carabidae. Coleop. Bull. 37(2): 164–167.

Glynne-Williams, J. and J. Hobart. 1952. Studies on the crevice fauna of a selected shore in Anglesey. Proc. R. Soc. Lond. 122: 797–825.

Johns, P. M. 1974. Southern New Zealand, Patagonian and Falkland Island Carabidae. Arthropoda of the Subantarctic Islands of New Zealand. (1) Coleoptera, Carabidae. J. R. Soc. N. Z. 4: 283–302.

Kensler, C. B. 1965. The Mediterranean crevice habitat. Vie Milieu 15: 947–977.

Leech, H. B. 1971. Nearctic records of flights of *Cafius* and some related beetles at the seashore (Coleoptera: Staphylinidae and Hydrophilidae). Wasmann J. Biol. 29: 65–70.

Riedl, R. 1963. Fauna und Flora der Adria. Verlag Paul Parey. Hamburg and Berlin.

Smith, G. M. 1969. Marine algae of the Monterey Pensinula, California. 2nd ed. Stanford University Press.

Richoux, P. 1972. Ecologie et ethologie de la faune des fissures intertidales de la Région malouine. Bull. Lab. Marit. Dinard 1: 145–206.

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 116–134

DESCRIPTIONS OF NEW NEARCTIC CECIDOMYIIDAE (DIPTERA) THAT LIVE IN XYLEM VESSELS OF FRESH-CUT WOOD, AND A REVIEW OF *LEDOMYIA* (S.STR.)

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Abstract.—The six species discovered during a study of cecidomyiids associated with xylem vessels in fresh-cut wood are described here as new to science. These are: *Xylodiplosis* ***longistylus,*** the first record of this genus in North America; the monotypic ***Trogodiplosis flexuosa,*** especially notable for its sexually dimorphic adult mouthparts; *Ledomyia* ***emilyae,*** *L.* ***mira,*** and *L.* ***parva***; and *Trichopteromyia* ***denticauda,*** the second species known for the genus. ***Trogodiplosis*** is a new genus erected to contain *T. flexuosa. Ledomyia* (sensu stricto) is redefined and reviewed and a key is given to the seven Nearctic species.

A guild of cecidomyiids that lives in xylem vessels of fresh cut or newly fallen wood was recently discovered by Emily A. Rock of the Department of Biology, University of Akron, Ohio. The biology of these species is treated in a companion paper directly following this one (Rock and Jackson, 1985). The guild comprises at least four genera in three separate tribes or supertribes of Cecidomyiidae. In North America it consists of the six new species that were discovered by Rock and at least six other species implicated from indirect evidence. The new species of *Xylodiplosis* is the first record of that genus in North America; the new monotypic genus, *Trogodiplosis,* is erected for the only known cecidomyiid with sexually dimorphic mouthparts; the three new species of *Ledomyia,* a genus not previously known to be associated with xylem vessels, serve as a pretext to define the generic limits of that genus and to present a key to the North American species; and the new species of *Trichopteromyia* is the only known congener of a species that has a worldwide distribution and has also been reared from wood.

Xylodiplosis Kieffer (Cecidomyiinae: Supertribe Cecidomyiidi)

The new species of *Xylodiplosis* described here represents the first record of the genus for North America. Three European species were listed under *Xylodiplosis* in Kieffer (1913): *praecox* (Winnertz), *nigritarsis* (Zetterstedt), and *aestivalis* Kieffer. All three are poorly known, the types of two are presumed lost, at least one may not be properly referred to the genus, and no comprehensive systematic study has been made on these species. This may be why no specific identification has been given in recent studies that have referred only to a "*Xylodiplosis* sp." (Barnes, 1951; Möhn, 1955; Mamaev and Krivosheina, 1965).

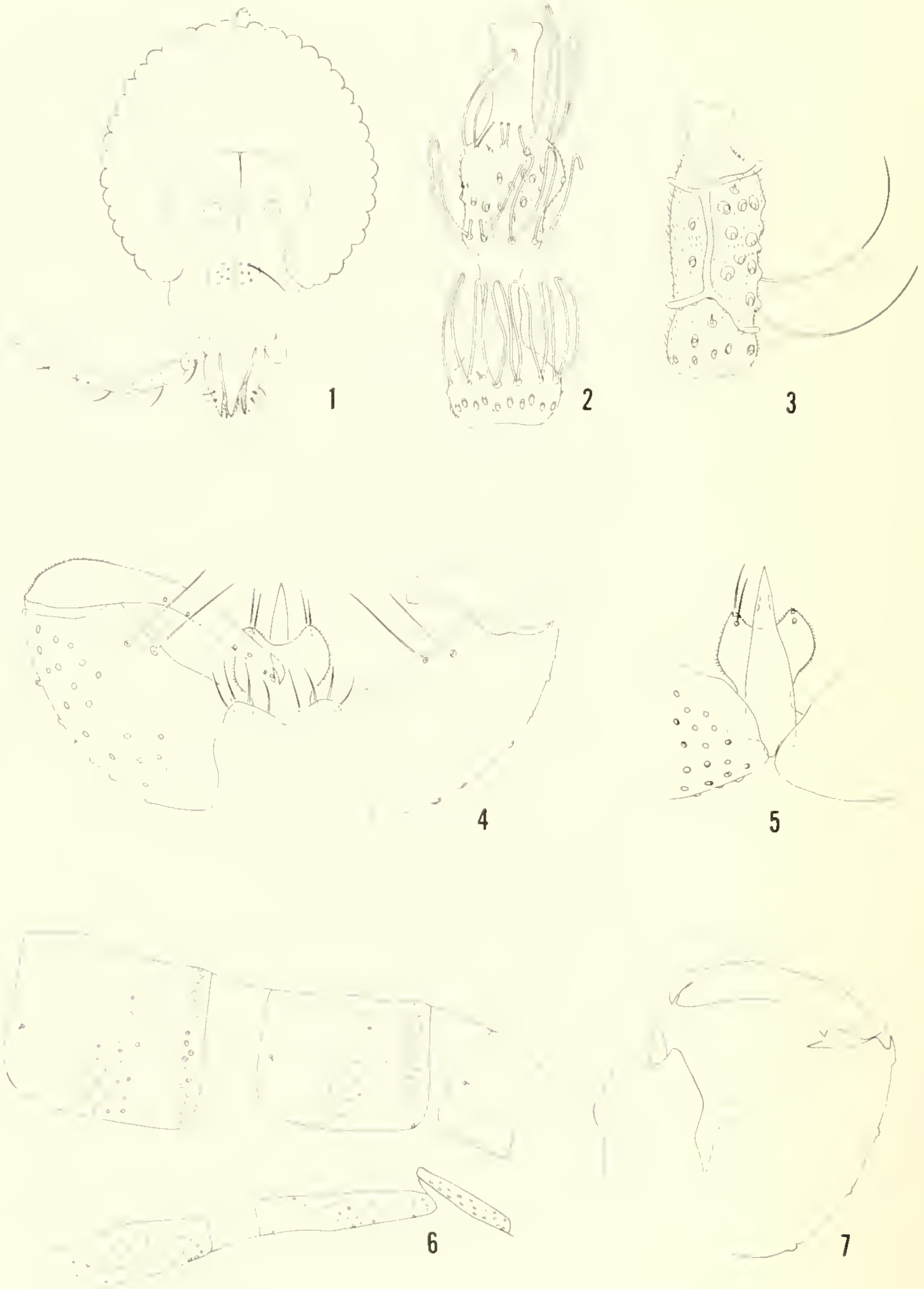
Diagnosis.—*Adult:* Eyes very extensive, about 15 facets long at vertex. Postvertical peak long, narrow. Male flagellomeres regular, binodal, tricircumfilar. Female flagellomeres cylindrical, regular. Wing with long, curved R_5. Tarsal claws simple, bent near basal third. Male genitalia: cerci convex, short; hypoproct concave posteriorly; aedeagus short, pointed, and gonocoxites unlobed. Ovipositor long, protrusible, the cerci short, ovoid, separate. *Larva:* Spatula present, clove-shaped, anal segment with 1 pair of papillae corniform, recurved.

Möhn (1955) suggested that larval characters aligned this species with *Contarinia* and its relatives. The shape of the male genitalia of *Xylodiplosis* is further evidence of the relationship. If the two genera are related, the shape of the tarsal claws in Cecidomyiidi, at least, must lose some importance as a distinguishing character for higher categories.

Xylodiplosis was described by Kieffer (1895) for specimens he identified as *Cecidomyia praecox* Winnertz. Earlier Winnertz (1853) had based that species on a female or females collected on freshly cut logs in the vicinity of Bonn, Germany. His specimens were presumably destroyed with the rest of his collection in Bonn during World War II. Kieffer (1900) gave a fairly detailed description of his observations of the biology of this species in the environs of Bitche, Alsace, now in France, then part of the German Empire. In 1904, Kieffer described a new species, *Xylodiplosis aestivalis*, also from logs, and outlined some differences between that species and *praecox*. Kieffer evidently kept no specimens of these species but gave a series of both to Felt. The purported differences in the antennae, wings, and legs are not evident in Kieffer's series of *praecox* and *aestivalis* now in the Felt Collection. Although no females are in the *praecox* series, it seems unlikely that that species could lack the hyaline, sensory setae on the female cerci according to Kieffer's description, inasmuch as all known species of the supertribe Cecidomyiidi have them.

Felt (1911) transferred *Cecidomyia nigritarsis* Zetterstedt (1856) to *Xylodiplosis*, but as a junior synonym of *praecox* (Winnertz). Kieffer (1913) gave *nigritarsis* full species ranking. *Xylodiplosis nigritarsis* was described from 2 females from Denmark that Zetterstedt implied fit the description of the female of *Cecidomyia nigra* Meigen and Meigen's (1818) illustration of a whole female. That illustration could represent a *Xylodiplosis* female in gross aspect and was probably Felt's basis for assigning *nigritarsis* to the genus, but the figure could as well represent other taxa such as *Resseliella* spp. and *Contarinia* spp. Zetterstedt's types are probably extant in Copenhagen, and it should be possible in due course to assign the specimens at least to genus.

In addition to the three European species, four Indian species have been placed in *Xylodiplosis*. They are *Xylodiplosis kempi* Mani (1934), known from a male and female caught in flight, *Xylodiplosis fici* Grover (1967a) from fruit of *Ficus carica* L. (Moraceae), *Xylodiplosis orientalis* Grover (1967b) from leaf galls of *Ficus religiosa* L., and *Xylodiplosis sisso* Bakhshi and Grover (1976) (unjustifiably emended to *sissua* Grover in 1979), from buds of *Dalbergia sissoo* Roxb. ex DC. (Fabaceae). *Xylodiplosis kempi* possibly belongs to *Xylodiplosis*, but the other three species belong elsewhere inasmuch as their tarsal claws are curved beyond midlength, unlike those of true *Xylodiplosis* spp.



Figs. 1–7. 1–6, *Xylodiplosis longistylus*. 1, Head of male. 2, Male flagellomere 4. 3, Female flagellomere 4. 4, Male genitalia (dorsal). 5, Aedeagus and hypoproct (ventral). 6, Male abdominal segments 6–8. 7, *Xylodiplosis nigritarsis* male genitalia (partial, dorsal).

Xylodiplosis longistylus Gagné, New Species

Figs. 1–6, 8–12

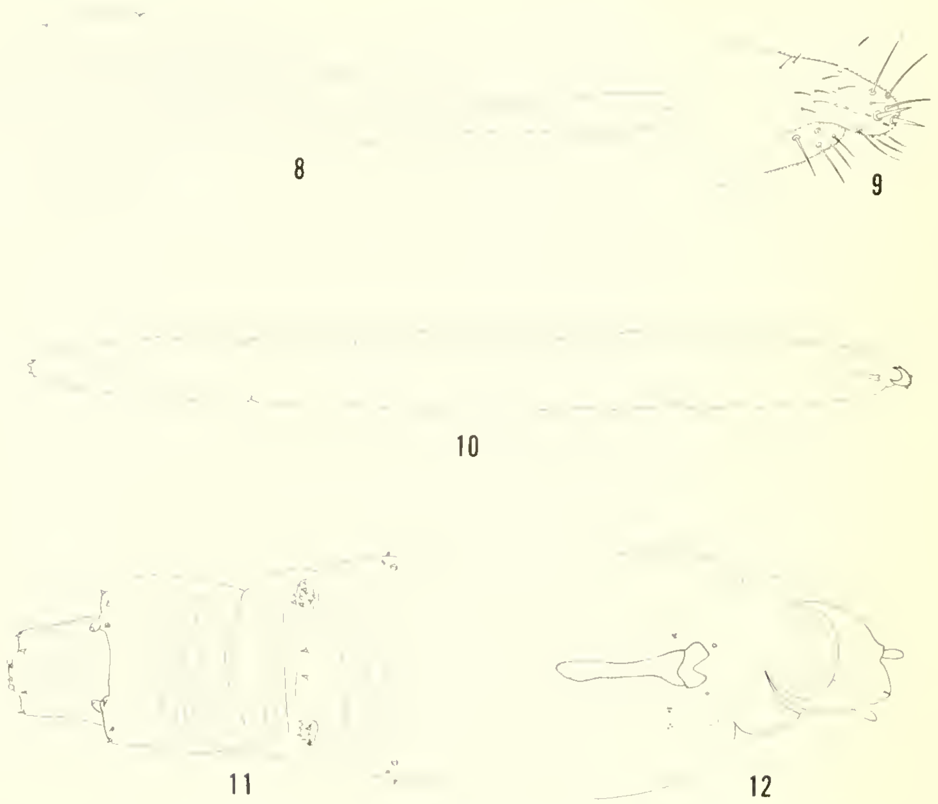
Adult.—Body and appendages uniformly dusky. *Head* (Fig. 1): Eyes about 15 facets long at vertex; facets hexagonoid, closely approximated. Postocciput reduced in size, abruptly narrowing dorsally to long peak bearing several large setae. Frontoclypeus with several setae. Labrum long, pointed, rimmed laterally with long setulae. Hypopharynx long, pointed, laterally with long, dense setulae. Labella long and narrow in frontal view, hemispherical in lateral view, with several long, wide setae laterally and 2 short setae and long pile mesally. Palpus 4-segmented. Antennal flagellomeres 1 and 2 connate; male flagellomeres (Fig. 2) binodal, tricircumfilar, the circumfilar loops subequal except in apical set with 2–3 loops longer than others; length of nodes, internode, and neck variable; female flagellomeres (Fig. 3) cylindrical, the circumfila regular, short looped.

Thorax: Scutum with 2 dorsocentral and 2 lateral rows of setae. Anepisternum with scattered scales on dorsal half. Anepimeron with several setae. Wing: C broken at juncture with R_5; R_5 long, curved apically to join C beyond wing apex; Rs not evident; M_{3+4} weak; Cu forked. Legs long. Tarsal claws robust, untoothed, bent near basal third. Empodia attaining bend in tarsal claws.

Male abdomen (Figs. 4–6): Tergites 1–6 rectangular, with caudal row of setae mostly single, continuous, many lateral setae, covered with scales, and with basal pair of trichoid sensilla; tergite 7 as for preceding except caudal row with mostly double row of setae with fewer scales; setose area of tergites more strongly sclerotized than elsewhere; tergite 8 rectangular but weakly sclerotized caudally, without vestiture except pair of trichoid sensilla. Sternites quadrate, mostly covered with setae and setiform scales, and with 2 closely approximated trichoid sensilla; caudal area usually more strongly sclerotized than elsewhere. *Terminalia* (Figs. 4–5): cerci short, broadly rounded to straight at apex, with 4 caudoventral setae; hypoproct widest beyond midlength, then narrowing to concave caudal edge, with 2 pairs of caudal setae and evenly short-setulose; aedeagus longer than hypoproct but shorter than gonocoxites, narrowing gradually from base to pointed apex; gonocoxite without prominent mesobasal lobes, mesal surface with 2 strong setae, remainder evenly setose; gonostylus narrow, slightly longer than gonocoxite, setulose only basolaterally, with several short setae along its length. Gonocoxal apodemes not conspicuous.

Female abdomen (Figs. 8–9): Tergites 1–7 wider than long, vestiture as for male but more extensively scaly; tergite 8 longer than wide, with scattered short setae and basal pair of trichoid sensilla; caudal margin more strongly sclerotized than elsewhere. Sternites 1–7 as for male but longer and progressively narrower from basal to apical segments. Ovipositor (Fig. 8) long, but extremely variable in length, the distance from tergite 7 to the cerci from 1–2 times length of abdomen. Cerci (Fig. 9) short, dorsolaterally-ventromesally flattened, with several setae of varying length, 2 strong sensory setae, and covered with setulae. Hypoproct short with 2 long setae. Caudal area ventrad of ovipositor mesally divided into 2 short lobes.

Last instar larva (Figs. 10–12).—Body extremely long and slender with horizontally striated integument. Basic complement of papillae for supertribe present (Möhn, 1955) but setae very short; anal segment with 3 pairs of setiform and 1



Figs. 8–12. *Xylodiplosis longistylus.* 8, Female abdominal segments 7 to end. 9, Female cerci. 10, Larva (ventral). 11, Posterior segments of larva (dorsal). 12, Anterior segments of larva (ventral).

pair of corniform papillae. Spatula clove-shaped. Tergum 7 with area surrounding lateral pairs of dorsal papilae conspicuously spinose.

Holotype.—♂, reared from larvae out of xylem vessels of hickory (*Carya* sp.), 10-IX-1981, Canal Fulton, Ohio, E. Rock, deposited in NMNH, Washington, D.C. Paratypes (unless otherwise stated, all are adults reared from larvae out of xylem vessels in Canal Fulton, Ohio by E. Rock): 2 ♀, same data as holotype; ♂, ♀, hickory, 28-VIII-1981; larva, 8-VI-1981; ♂, ♀, elm (*Ulmus* sp.), 28-VIII-1981; ♂, ♀, elm, 14-IX-1981; 5 larvae, elm, 25-IX-1981; 3 ♂, ♀, willow (*Salix* sp.), 1-3-IX-1981; 5 larvae, willow, 24-VIII-1981; ♂, 2 ♀, ash (*Fraxinus* sp.), 7-IX-1981; ♂, ash, 1-IX-1981; 5 larvae, ash, 17-VIII-1981; 2 ♂, 7 ♀, sassafras, 28-VII-1982; 6 ♀ caught with ovipositor stuck in xylem vessels, sassafras (*Sassafras albidum* (Nutt.) Nees.), 26-VII-1982; ♂, ♀, sassafras, 31-V-1982; 5 larvae, oak (*Quercus* sp.), 8-VIII-1981; 3 larvae, oak, 31-VII-1982; larva, oak 9-IX-1981; 2 ♂ caught in Malaise trap, 15-VIII-1972, Silver Spring, MD, W. W. Wirth.

The new species was compared with adult specimens that were identified by J. J. Kieffer as *Xylodiplosis praecox* (Winnertz) and *Xylodiplosis aestivalis* Kieffer and are presently in the Felt Collection in the National Museum of Natural History in Washington. Males of both European series are similar and do not show the differences between them outlined by Kieffer (1903); both series differ from *longistylus* only in their much shorter gonostylus and somewhat narrower hypoproct (Fig. 7). Kieffer's females are similar to those of *longistylus*. The larva of the new species resembles the illustrations of a *Xylodiplosis* sp. from Germany in Möhn (1955) except that the peculiar spinose areas found on abdominal tergum 7 of the American species were not noted for Möhn's species. Larvae from oak in England sent to me by K. M. Harris, Commonwealth Institute of Entomology, London, fit the new species in all particulars. A male specimen he loaned to me differs from both the American species and Kieffer's series by the posterior border of the hypoproct being convex instead of concave. Its gonostyli are slightly longer than those of Kieffer's series, but are still much shorter than those shown here for longistylus.

The name *longistylus* is a noun in apposition and refers to the long gonostylus.

***Trogodiplosis* Gagné, New Genus (Cecidomyiinae: Supertribe Cecidomyiidi)**

Adult.—*Head:* Eyes very extensive, about 17 facets long at vertex. Postocciput very narrow, terminating in long dorsal peak with 2 long setae. Male antennal flagellomeres binodal, tricircumfilar. Mouthparts sexually dimorphic, in male unmodified from usual plan of supertribe, in female larger, more inflated than in male, the hypopharynx lined laterally with large, wide teeth instead of more usual, long setulae. Palpus 4-segmented. *Thorax:* Wing with long, curved R_5, weak M_{3+4}, without evident Rs. Legs long. Tarsal claws robust, bent near basal third, untoothed.

Male abdomen: Tergites 1–7 rectangular, with basal pair of trichoid sensilla and caudal and lateral setae; tergite 8 without vestiture except basal pair of trichoid sensilla. Sternites 2–8 with trichoid sensilla. Cerci narrow, triangular. Gonocoxite angular, gonostylus strongly curved, mostly striate. Hypoproct covered with recurved setulae. Aedeagus short, pointed.

Female abdomen: Tergites 1–7 as for male; tergite 8 longer than wide, with short, caudal setae, and basal pair of trichoid sensilla. Sternites 2–7 with trichoid sensilla. Ovipositor extremely long, much longer than abdomen. Cerci separate, small, setose and setulose throughout, each with 2 apical trichoid sensilla.

Larva unknown.

Type-species, *Trogodiplosis flexuosa* Gagné, by present designation.

The female mouthparts are unique among known Cecidomyiidae, particularly in the inflated labella and the hypopharynx lined with "teeth" in place of the usual long setulae. The female abdomen is generally similar to that of *Xylodiplosis*, perhaps because they are adapted to the same use. The length of the ovipositor and the diminutive cerci are presumably adaptations for laying eggs within xylem vessels. The male genitalia are unlike any other genus known to me. The claws bent near the basal third are a character shared with *Xylodiplosis*, but also with many genera such as *Clinodiplosis*, *Karshomyia*, and *Aphodiplosis*, whose larvae are mycophagous.

The name *Trogodiplosis* is of feminine gender and is derived from the Greek "trox," to chew, and "diplosis," double. The latter part is a common suffix for genera in the supertribe Cecidomyiidi in reference to the binodal male antennal flagellomeres. The peculiar female mouthparts may be used for rasping or chewing, but their action has not been observed.

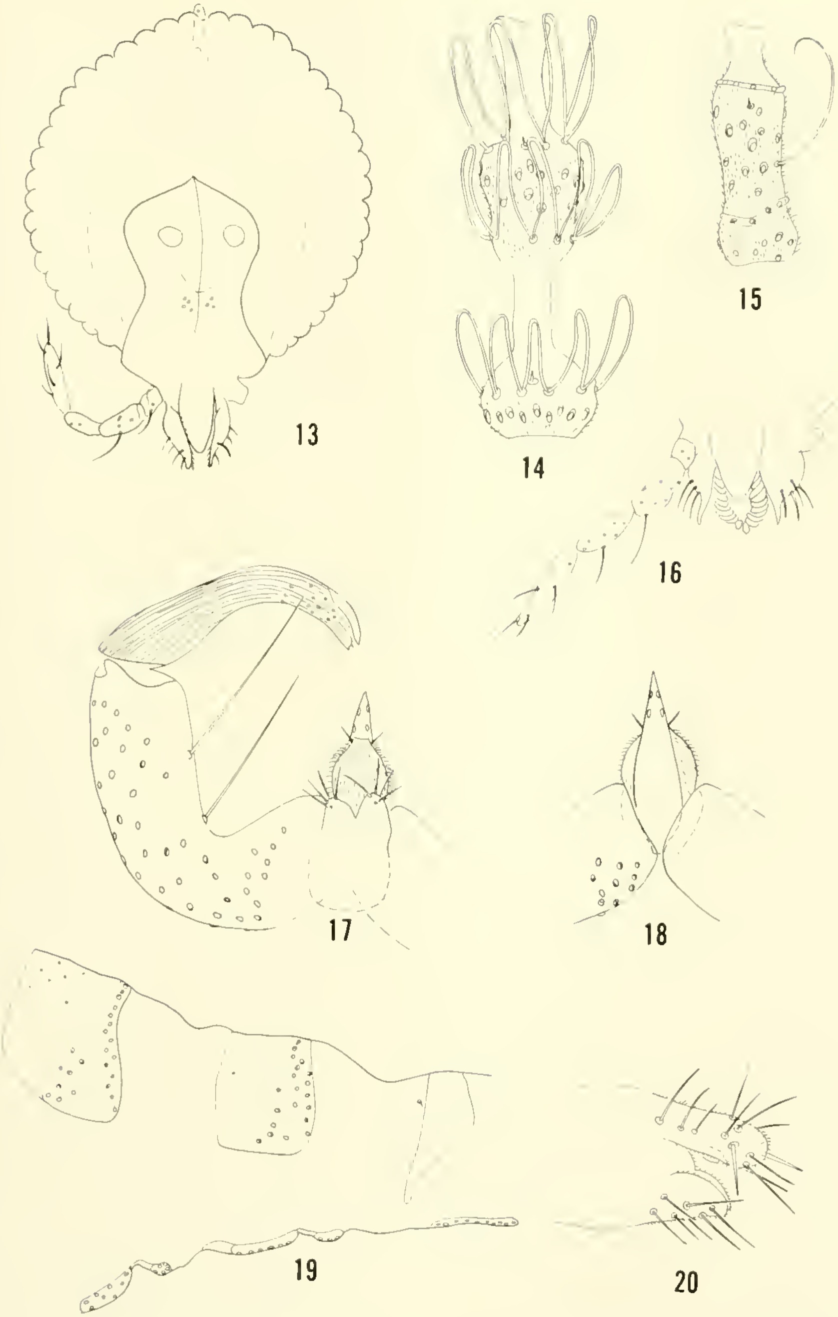
Trogodiplosis flexuosa **Gagné, New Species**

Figs. 13–20

Adult.—Body dusky but antennae and legs usually with alternating light and dark bands; wings usually light with some dark areas. *Head* (Figs. 13, 16): Eyes very large, about 15 facets long at vertex; facets hexagonoid, closely approximated. Frontoclypeus with several setae. Male mouthparts (Fig. 13): labrum narrower, longer than in female, without long setulae laterally, with 2 peg-like setae ventrally; labella in frontal view laterally convex and drawn to a point apically, with several long lateral setae, 2 short setae on mesal surface, and covered with setulae mesoventrally; hypopharynx long, attenuate, with long lateral setulae. Female mouthparts (Fig. 16): swollen, larger than in male; labrum convex, tapering to rounded, glabrous tip, without setulae but with 2 peglike setae ventrally; labella more convex than in male, tapered abruptly before apex; hypopharynx glabrous, the margin in frontal view modified into a ring of large, wide, closely appressed teeth. Palpus 4-segmented. Antennal flagellomeres 1 and 2 connate; male flagellomeres (Fig. 14) binodal, tricircumfilar, the circumfilar loops subequal within a set; female flagellomeres (Fig. 15) cylindrical, with necks slightly longer than wide, the circumfila regular. *Thorax:* Scutum with 2 dorsocentral and 2 lateral rows of setae. Anepisternum without vestiture. Anepimeron with several setae. Wing: C broken at juncture with R_5; R_5 long, curved apically to join C beyond wing apex; Rs not evident; M_{3+4} weak; Cu forked. Legs long. Empodia attaining bend in tarsal claws.

Male abdomen (Figs. 17–19): Tergites 1–6 with mostly single, continuous row of caudal setae, many lateral setae, anterior tergites generally covered with scales, posterior ones with fewer scales; tergite 7 as for preceding segment except with mostly double caudal row of setae and with fewer scales; setose areas more strongly sclerotized than elsewhere, caudal and lateral areas discrete except continuous on tergite 7; tergite 8 without vestiture except for pair of trichoid sensilla, sclerotized only basally, sclerotization invading the pleural area. Sternites quadrate, mostly covered with setae and setiform scales and with 2 closely approximated trichoid sensilla; caudal and midlength areas usually more strongly sclerotized than elsewhere. Terminalia (Figs. 17–18): cleft between cerci shallow, cerci triangular; hypoproct shorter than aedeagus and covered with long, recurved setulae, with several short, apical setae; aedeagus shorter than gonocoxite or gonostylus, tapering evenly from base to pointed apex; gonocoxite covered with setae except mesal surface with only 2 long setae; gonostylus more or less evenly cylindrical except for basal bulge and strongly curved, with scattered short setae on distal third, asetulose, striate.

Female abdomen: Tergites 1–7 wider than long, vestiture as for male but more extensively scaly; tergite 8 longer than wide, with scattered short setae and basal pair of trichoid sensilla; caudal margin more strongly sclerotized than elsewhere. Sternites 1–7 as for male but longer and progressively narrower from basal to apical segments. Ovipositor extremely long, sinuously curved inside abdomen. Cerci (Fig. 20) short, dorsolaterally-ventromesally flattened, with several setae of varying length, 2 strong transparent setae, and covered with setula. Hypoproct short with 2 long setae. Part below egg exit mesally divided into 2 short lobes.



Figs. 13–20. *Trogodiplosis flexuosa.* 13, Male head. 14, Male flagellomere 4. 15, Female flagellomere 4. 16, Female mouthparts and palpus. 17. Male genitalia (dorsal). 18, Aedeagus and hypoproct (ventral). 19. Male abdominal segments 6–8. 20, Female cerci.

Holotype.—♂, reared from larvae out of elm (*Ulmus* sp.) xylem vessels, VIII-28-1981, Canal Fulton, Ohio, E. Rock, deposited in NMNH, Washington, D.C. Paratypes: 3 ♂, 2 ♀, same data as holotype; 3 ♀, from larvae out of oak (*Quercus* sp.), 21-VIII-1981, Canal Fulton, Ohio. E. Rock; 2 ♂, 2 ♀, from larvae out of oak, IX-1982, Akron, Ohio, E. Rock; 12 ♂, light trap, VIII-1972, Silver Spring, MD, W. W. Wirth.

I know the male of another, undescribed species of *Trogodiplosis* caught in flight in Maryland. It is similar to *flexuosa* except that the gonocoxal lobe bears strong basal spines.

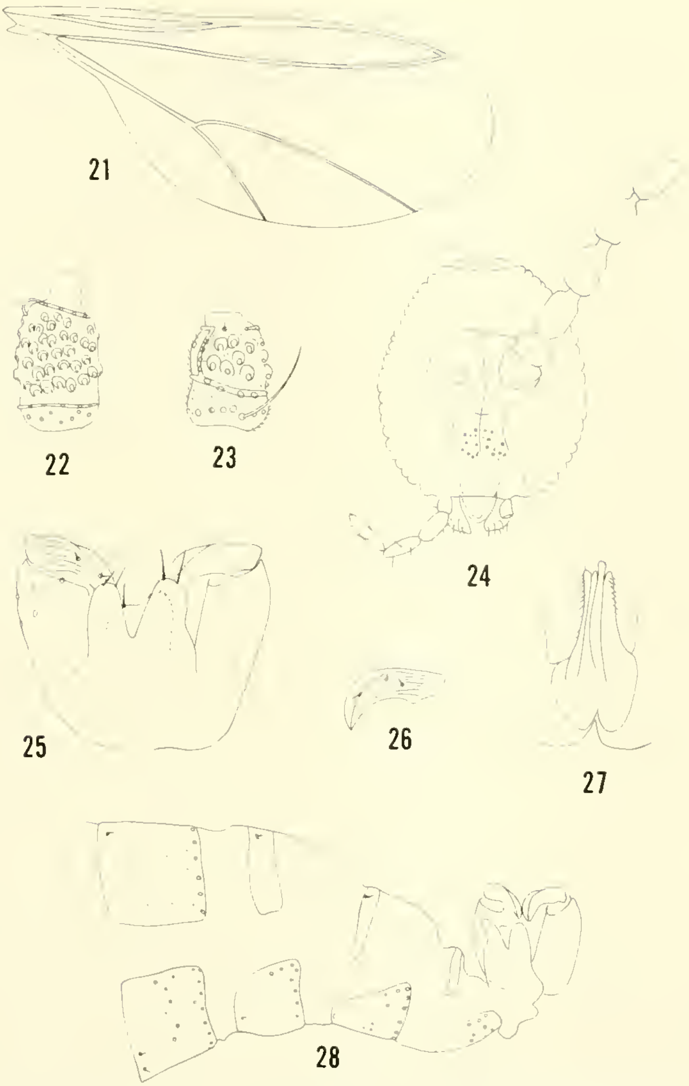
The name *flexuosa* is an adjective and refers to the long sinuous ovipositor.

***Ledomyia* Kieffer (Cecidomyiinae: Supertribe Oligotrophidi)**

The concurrent discoveries of three new species of *Ledomyia* and of a possible type-specimen of *Ledomyia lugens* (Kieffer), the type-species of the genus. make this a good occasion to review the genus and present a key to the known North American species. I am able to narrow the definition of the genus to include three new species reared from oak and hickory and four other Nearctic species previously listed under *Ledomyia* only in the broad sense (Gagné, 1976). The genus in the strict sense also includes the name *Neuromyia* Felt and one Afrotropical and at least five Palearctic species. All the species are probably xylophilous, although only three previously described ones have been associated with logs.

Diagnosis.—*Adult:* Posterior surface of head, much of mesonotum, wing, legs, and abdomen covered with scales; vestiture usually yellow-brown on head, mesonotum and some leg surfaces, brown elsewhere. Eye bridge short, 4–5 facets long, entirely on anterior surface of head; facets circular, slightly farther apart at eye bridge and at midheight of eye than elsewhere. Antenna with 8–12 flagellomeres. Frontoclypeus with several setae and interspersed scales. Labrum and hypopharynx triangular, shorter than labellae; labellae hemispherical in frontal view, with several scales laterally. Palpus 4-segmented. Scutum with lateral and dorsocentral rows of setae, disposition of scales variable. Anepimeron with vertical row of setae. Wing: R_5 joining C anteriad of wing apex; M_{3+4} not evident; C forked at about midlength, the tines widely separated. Fore tarsal claws with, mid and hind claws with or without teeth; when toothed, claws broadly rounded at midlength, when untoothed, abruptly rounded; empodia as long as claws, pulvilli about half as long.

Abdomen: Tergites 1–5 rectangular, the fifth narrower than preceding, each with single, continuous row of caudal setae, 0 lateral setae, a basal pair of widely separated trichoid sensilla, and elsewhere covered with scales. Sternites 2–5 rectangular, with mostly single, continuous row of caudal setae, a sparse horizontal row of setae at midlength, 2 basal, closely approximated trichoid sensilla, and covered with scales elsewhere including area immediately cephalad of caudal row of setae. Male: tergites 6–8 very short, with sparse vestiture; sternites 6–8 long, large, but each narrower than preceding; gonocoxites simple, robust; gonostyli short, dorsoventrally-flattened, long-toothed; hypoproct simple, concave caudally; claspettes subdivided apically, lateral projection glabrous, the mesal with recurved setulae. Female: tergites 6–8 and sternites 6–7 variable; ovipositor short to very



Figs. 21–28. *Ledomyia* spp. 21, *L. parva*, wing. 22, *L. emilyae*, male flagellomere 4. 23, *L. mira*, female flagellomere 4. 24–28, *L. emilyae*. 24, Male head. 25, Male genitalia (dorsal). 26, Gonostylus. 27, Aedeagus and claspettes. 28, Male abdominal segments 5 to end.

long; when long, twice telescoped; cerci separate, each with 2 ventrolateral sensory setae and assorted vestiture.

Last instar larva (Figs. 38–40): Integument reticulate, with clove-shaped spatula, a sclerotized structure on dorsum of prothorax, circular spinose area on dorsum of anal segment, and elliptical papillae between segments. Papillar pattern as follows (all numbers given for one longitudinal half of body): supernumerary segment with 1 dorsal and 2 ventrals; each thoracic segment with 3 + 2 dorsals

(2 without setae; 1 of these aligned with the 3 with setae, the other sited more cephalad), 2 pleurals, 1 interior pleural, 2 groups of 3 laterals, and 1 sternal; abdominal segments 1–8 with 3 + 2 dorsals (arranged as for thorax), 1 posterior ventral (except segment 8 with 2), and 2 anterior ventrals; anal segment with 3 anal papillae and 4 terminals.

A noteworthy characteristic of *Ledomyia* adults is that abdominal sternites 2–5 are uniformly sclerotized, without the weakened area usually seen in Oligotrophidi immediately cephalad of the caudal row of setae. The scales on those sternites are continuous on the whole sclerite, without the usual interruption immediately cephalad of the caudal setal row. Within the genus the female postabdomen is remarkably diverse in structure, as can be seen by comparing Figs. 29–37, and the antennal flagellomeres vary in number. Edwards (1937) suggested that females of a particular species might have all toothed claws while males had only the fore claws untoothed. The actual situation is even more unusual, with females of a given species having either all or only the fore claws toothed. Because the female abdomens are so distinctive among species, I have chosen females as holotypes of the 3 new species described here.

The larva of only one species of *Ledomyia* is known, that of *Ledomyia flavotibialis* (Felt). I have illustrated parts of it in detail in Figs. 38–40. Of particular note are the reticulated integument, and the presence of elliptical papillae between the segments, a circular area with recurved setulae on the dorsum of the terminal segment, a unique, sclerotized structure on the dorsal surface of the prothorax, and 10 dorsal papillae on abdominal segments 1–7. The 4 extra dorsal setae have not been noted in other Oligotrophidi.

Since Felt (1911), the name *Lasiopteryx* Stephens has been applied to some *Ledomyia* species. Although *Lasiopteryx* cannot properly be used for these species, it has been, so it is worth giving a brief synopsis here of its complicated history. Meigen (1818) described the genus *Lasioptera* with 2 divisions, A and B, and described several species in each. Division B contained species having the first tarsal segment longer than the others, a character that precludes referring that division to the Cecidomyiinae. Stephens (1829), in a list of species in his own collection, gave the name *Lasiopteryx* to Meigen's division B and listed under it only one named species, *obfuscata* Meigen. His specimen was not properly identified. Westwood (1840) later designated *obfuscata* Meigen as type-species of *Lasiopteryx* Stephens and cited the long first tarsal segment of Meigen's description, not the specimen determined as *obfuscata* in Stephen's collection. Felt (1911) redescribed *Lasiopteryx*, basing his concept on Stephen's specimen. That specimen has a short first tarsal segment so cannot fit *obfuscata* of Meigen. A figure drawn by Meigen of a wing of *Lasioptera obfuscata* was published in Morge (1975). The wing could belong to a *Brachineura* but not to any lestremiine, which still would not agree with the particular tarsal character Meigen noted. Meigen could have been mistaken about this character in his *Lasioptera obfuscata*, but it is also possible that the wing drawn by Meigen was from a specimen other than that on which he based his original description. Because it seems impossible to know what Meigen had before him, *Lasiopteryx* should be considered a nomen dubium.

Type specimens of most of Kieffer's types do not exist, but I found a possible type of his *Ledomyia lugens*, the type-species of *Ledomyia*, mounted on a slide in the Felt Collection and labelled "*Ledomyia lugens* Kieff./Type/from J. J. Kieffer." It cannot be known whether this specimen was part of Kieffer's original type series but it could have been. It almost certainly came from the same general locality in France as the type and could be the basis for a neotype designation if one were deemed necessary and no other known specimens were available. Although it generally conforms to Kieffer's (1894) description, it is a poor specimen and has the shrivelled appearance of a specimen put into Canada balsam directly from alcohol with the body contents still intact. Remounting such a poor, tiny specimen might not make the parts more visible, but fresh material collected in France and compared to the specimen would probably allow one to fix the name of *L. lugens.*

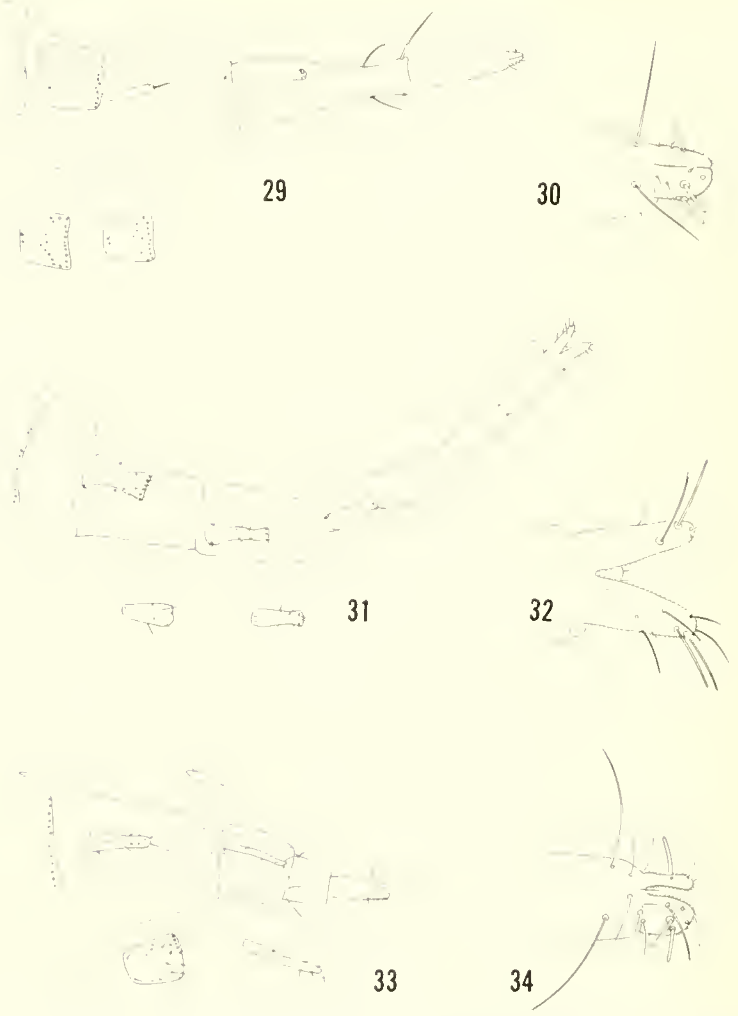
Neuromyia Felt (1911), based on *Ledomyia minor* (Felt), is a subjective synonym of *Ledomyia. Ledomyia* in the strict sense now includes the previously described species listed below. All but three of those species were caught in flight. *L. flavotibialis, lineata,* and *lugens* were reared in association with logs, the last two from fresh cut and stacked logs held overwinter.

Ledomyia aestiva (Mamaev). New Combination. Europe.
Ledomyia alternata (Mamaev). New Combination. Europe.
Ledomyia brevicauda (Felt). Eastern North America.
Ledomyia flavotibialis (Felt). Eastern North America.
Ledomyia lepida (Mamaev). New Combination. Europe.
Ledomyia lineata Kieffer. Europe.
Ledomyia lugens (Kieffer). Europe.
Ledomyia minor (Felt). Eastern North America.
Ledomyia phosphila (Felt). Eastern North America.
Ledomyia styloptera Kieffer. Seychelles Is.

KEY TO NEARCTIC SPECIES OF *LEDOMYIA* (S.S.)

Both sexes are known only for *flavotibialis* and *emilyae* new species. Felt caught a female similar to *brevicauda* at the same time he took the male holotype of *phosphila.* In Felt's Collection that female is labelled "*phosphila,*" so it is possible that *brevicauda* and *phosphila* are synonyms. On the other hand, E. Rock reared three species from the same cord of oak logs. Felt (1915) wrote that the antenna of *phosphila* "probably" had 12 flagellomeres, but all but the basal two are lost on the slide preparation of the *phosphila* type-specimen.

1. Antenna with 12 flagellomeres 2
   Antenna with 8–10 flagellomeres 3
2. Female (postabdomen as in Fig. 37) .... *L. brevicauda* (Felt)
   Male .... *L. phosphila* (Felt)
3. Antenna with 10 flagellomeres, those of male with neck more than ⅔ length of node .... *L. minor* (Felt)
   Antenna with 8–9 flagellomeres, those of male with neck no more than slightly longer than ½ length of node 4
4. Anepisternum covered with scales; female tergites 6–8 long and narrow (Fig. 33) .... *L. mira,* new species
   Anepisternum with scales only on dorsocaudal angle 5
5. Anterior ½ of scutum almost completely covered with scales between



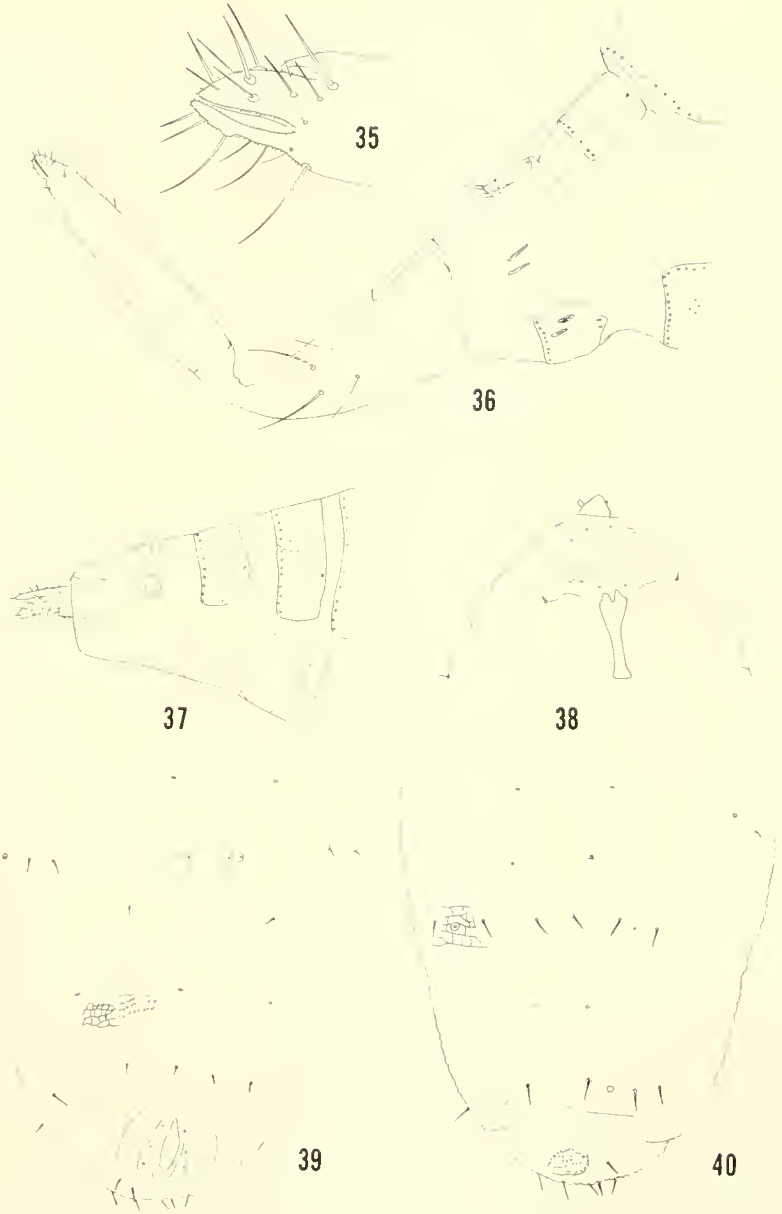
Figs. 29–34. *Ledomyia* spp. female abdomen, posterior end of segment 5 to cerci and detail of cerci (dorsoventral view). 29–30, *L. emilyae*. 31–32, *L. parva*. 33–34, *L. mira*.

dorsocentral setal rows; female tergite 6 long and narrow, only slightly wider than tergite 7 (Fig. 31) .... *L. parva*, new species

Anterior ½ of scutum with a distinct bare area between dorsocentral setal rows; female tergite 6 square, much wider than tergite 7 (Figs. 29–36) 6

6. Male flagellomere necks slightly more than ½ length of nodes; female tergites 6–8 progressively narrower, distal half of ovipositor about 3 × length tergite 5 (Fig. 36) .... *L. flavotibialis* (Felt)

Male flagellomere necks about ¼ length of nodes (Fig. 22); female tergites 7–8 of same width, much narrower than tergite 6 (Fig. 29); ovipositor about 5 × length tergite 5 .... *L. emilyae*, new species



Figs. 35–40. *Ledomyia* spp. 35–36, *L. flavotibialis*. 35, Female cerci (dorsoventral). 36, Posterior end of segment 5 to cerci of female abdomen. 37, *L. brevicauda* female abdomen, posterior end of segment 5 to cerci. 38–40, *L. flavotibialis* larva. 38, Anterior segments (ventral). 39, Posterior segments (ventral). 40, same (dorsal).

Ledomyia emilyae **Gagné, New Species**

Figs. 22, 24–30

Adult.—*Head:* male antenna with 9 flagellomeres, third with neck about ¼ length node; female with 8–9 flagellomeres, third with very short neck as in Fig.

23. *Thorax:* Scutal dorsocentral row of setae and scales at midlength about twice width of mesal bare stripe. Anepisternum with scales only on dorsocaudal angle. Tarsal claws all toothed, untoothed on mid and hind claws, or untoothed only on hind claws. Wing: length 8.5–11.0 mm (avg. of 10, 10.0); extreme base of costa with yellow scales and setae, contrasting with dark scales elsewhere; R_5 terminating at 0.92 length wing (avg. of 10). *Male abdomen:* as in Figs. 25–28. *Female abdomen* (Figs. 29–30): Tergite 6 square, with single row caudal setae, scales on caudal half, and 2 basal trichoid sensilla; tergite 7 very narrow with a few to several scales and setae caudally and 2 trichoid sensilla at about ⅖ length from base; tergite 8 narrow, longer than 7, without vestiture except for 2 trichoid sensilla at about ⅖ length from base, caudal edge with 2 pits; sternites 6–7 square, unreduced; distal half of ovipositor about 5 times length of tergite 5; cerci short, the sensory setae blunt-tipped.

Holotype.—♀, ex oak logs, Akron, Ohio, VI-6-1982, E. Rock, deposited in National Museum of Natural History, Washington, D.C. Paratypes (all from oak logs and collected by E. Rock unless otherwise indicated): 2 ♂, 4 ♀, Akron, Ohio, VII-12-1982; 2 ♀, Akron, Ohio, VI-7-1982; 5 ♂, 1 ♀, Canal Fulton, Ohio, VIII-1982; 7 ♀, Canal Fulton, Ohio, VI-7-1982; 1 ♀, Malaise trap, North Eastham, Mass., VII-12-1975, R. J. Gagné; 1 ♀, Malaise trap, Montgomery Co., Md., VI-8-1975, R. J. Gagné.

This species is unusual for the fact that the mid and hind claws are toothed on some specimens, untoothed in others. Alternatively, one could define the specimens with or without toothed claws as distinct species, but they would have identical female postabdomens.

Ledomyia emilyae is named in honor of Emily A. Rock, the collector of the six species described in this paper.

Ledomyia mira **Gagné, New Species**

Figs. 23, 33–34

Adult (♀ only).—*Head:* Antenna with 8 flagellomeres, the last segment partially divided in some specimens, 3rd flagellomere with very short necks as in Fig. 23. *Thorax:* Scutal dorsocentral row of setae and scales at midlength narrower than mesal bare stripe. Anepisternum covered with scales. Tarsal claws all toothed. Wing: Length 1.2–1.4 mm (avg. of 5, 1.4 mm); extreme base of costa with yellow scales and setae, contrasting with dark scales elsewhere; R_5 terminating at 0.97 wing length (avg. of 5). *Female postabdomen* (Figs. 33–34): tergite 6–8 greatly narrowed but not longer than previous tergites, each decreasing gradually in width, with sparse setae and scales, scattered on distal half, and 2 basal trichoid sensilla basally; sternites 6–7 subequal, narrowed, with sparse setae caudally and 2 trichoid sensilla basally; ovipositor about 3 times length tergite 5; cerci long, the sensory setae also long, tapering to dull point.

Holotype.—♀, ex oak logs, Canal Fulton, Ohio, VI-7-1982, E. Rock, deposited in National Museum of Natural History, Washington D.C. Paratypes: 6 ♀, same data as holotype except 1 collected on VI-5-1981 and 2 on II-12-1982.

The name *mira* is an adjective meaning marvellous.

Ledomyia parva Gagné, New Species

Figs. 22, 31–32

Adult (♀ only).—*Head:* Antenna with 9 flagellomeres, 3rd with very short neck. *Thorax:* Scutal dorsocentral rows of setae at midlength continuous with one another, not separated by a bare stripe. Anepisternum with scales only on dorsocaudal angle. Tarsal claws all toothed. Wing (Fig. 22): length, 1.0–1.4 mm (avg. of 10, 1.1 mm); extreme base of costa with yellow scales and setae, contrasting with dark scales elsewhere; R_5 terminating at 0.90 length wing (avg. of 10). *Female abdomen* (Figs. 31–32): tergite 6 very narrow, with scattered setae and scales on distal half and 2 trichoid sensilla basally; tergite 7 narrow and longer than 6, with a few long setae caudally and 2 trichoid sensilla at about two-fifths length; tergite 8 short, narrow, about half length of tergite 7, on some specimens with 2 trichoid sensilla evident near midlength; sternite 6 approximately square with reduced vestiture; sternite 7 very narrow and elongate, with a few long setae caudad and 1–2 trichoid sensilla at about two-fifths length from base; ovipositor about 4.3 times length tergite 5; cerci short, the sensory setae blunt-tipped.

Holotype.—♀, ex oak logs, Canal Fulton, Ohio, VI-5-1981, E. Rock, deposited in National Museum of Natural History, Washington. Paratypes: 12 ♀, all with same data as holotype except 1 collected on VI-8-1981, 6 on VI-7-1982, and 3 on VI-12-1982; 3 ♀ ex hickory logs, Canal Fulton, Ohio, VI-8-1981, E. Rock; 1 ♀, Urbana, Ill. VI-28-1915.

The name *parva* is an adjective meaning tiny.

***Trichopteromyia* Felt (Lestremiinae: Micromyini)**

The new species described below is the second known in this genus. The other, *Trichopteromyia modesta* Williston, is known from North America, the West Indies, Europe, and the Seychelles Islands. *Trichopteromyia modesta* was taken from hornbeam wood in Russia and its larva was described by Mamaev and Krivosheina, 1965. The new species will key to *Trichopteromyia* in Gagné (1981).

Trichopteromyia denticauda Gagné, New Species

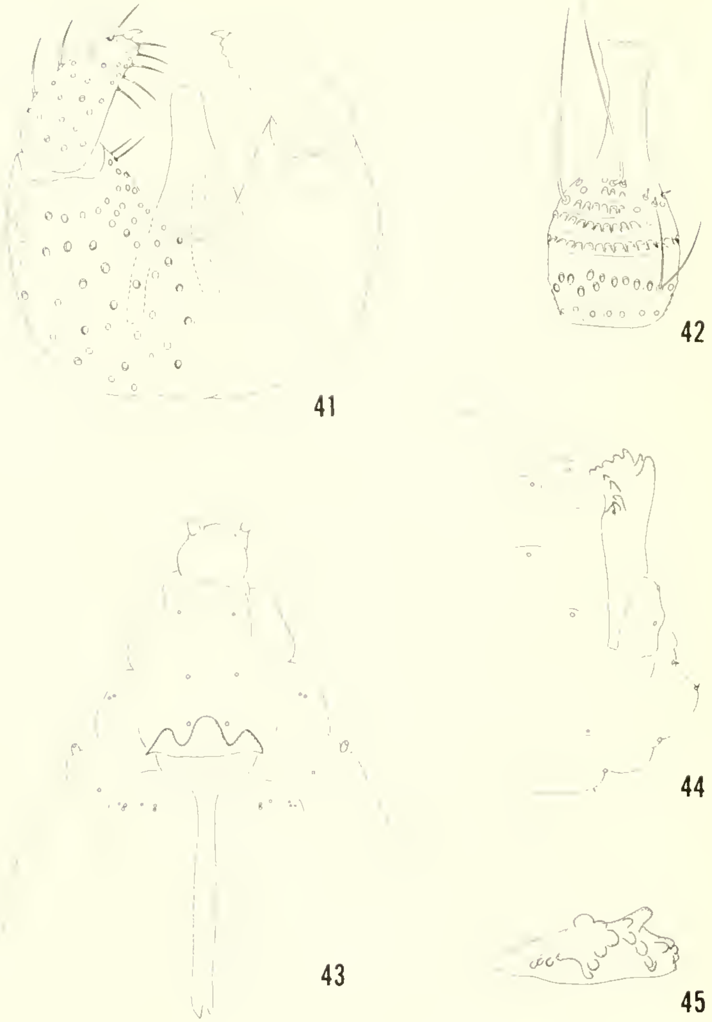
Figs. 41–45

Adult.—*Head:* Eyes large, 7–8 facets long at eye bridge. Palpus 3-segmented, segment 1 large, globular, segments 2 and 3 long, narrower than 1, segment 3 about twice length of 2. Antenna: number of flagellomeres unknown because apical segments are lost; male flagellomere 4 (Fig. 42) with 4 crenulate whorls of setae ventrally, 1 dorsally. *Wing length:* male, 2.0–2.1 mm. *Male abdomen:* Terminalia as in Fig. 41.

Last instar larva.—Length, 5.6–7.2 mm. Sternal spatula tridentate (Fig. 43). Caudal segment with a sclerotized dorsal comb (Figs. 44–45).

Holotype.—♂, from oak logs, Canal Fulton, Ohio, VIII-1982, in National Museum of Natural History, Washington, D.C. Paratypes, ♂ and 5 larvae, same data as holotype.

The larva of *T. modesta* described in Mamaev and Krivosheina (1965) is elongate, as is the new species, but the terminal segment of *modesta* has 2 long, sclerotized projections instead of a comblike structure. Adult gonocoxites are more



Figs. 41–45. *Trichopteromyia denticauda.* 41, Male genitalia (ventral). 42, Male flagellomere 4. 43, Larval anterior segments (ventral). 44, Larval posterior segments (lateral). 45, Larval posterior comb (dorsal).

broadly joined and the paramere is greatly narrowed at midlength in *denticauda.* The eye bridge of the new species is 7–8 facets long as opposed to 6 facets long in *modesta.*

The name *denticauda* is a noun in apposition and refers to the comblike structure of the terminal larval segment.

Changes in a Key to Genera

The two genera new to the Nearctic fauna and the redefinition of *Ledomyia* necessitate the following changes in the key to cecidomyiid genera in Gagné (1981):

1. Couplet 130. On line 6 change last sentence to, "Female flagellomeres with distinct, usually long necks," and change "131" to "131a."
2. Couplet 131. Change to 131a. On line 2, replace, "*Clinodiplosis* Kieffer, in part" with "131b." Delete line 3.
3. Add new couplets 131b and 131c:

131b. Aedeagus and hypoproct approximately as long as gonocoxites, more or less parallel-sided; hypoproct narrowing apically; ovipositor less than ½ length abdomen, the cerci large .... Clinodiplosis Kieffer, in part
See couplet 121.
– Aedeagus much shorter than gonocoxites, tapering from base to pointed apex; hypoproct widest beyond midlength; ovipositor very long, usually longer than abdomen, the cerci tiny .... 131c.
131c. Male hypoproct simple, narrowed at apex, with recurved setulae; gonostylus strongly curved, striate throughout; female mouthparts inflated, hypopharynx lined with teeth .... *Trogodiplosis* Gagné
1 sp., *flexuosa* Gagné
– Male hypoproct bilobed, without recurved setulae; gonostylus only weakly curved, not conspicuously striate; female mouthparts tapering, lined with long, fine setulae as in male .... *Xylodiplosis* Kieffer
1 sp., *longistylus* Gagné

4. Couplet 179. Change to "179a." On line 5 replace "*Ledomyia* Kieffer (sens. lat.)" with "179b." Delete line 6. Add new couplet 179b:

179b. R_5 shorter than wing, curved to join C anteriad of wing apex; male gonostylus short, stubby, dorsoventally flattened, widest at apical tooth; female postabdomen protrusible although short in some species ... . *Ledomyia* Kieffer (sens. str.)
7 spp., Gagné 1985
– R_5 at least as long as wing, joining C at or posteriad of wing apex; male gonostylus long, cylindrical, tapered from base to narrow tooth; female abdomen not protrusible .... *Ledomyia* Kieffer (sens. lat.)
12 spp.

ACKNOWLEDGMENTS

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LITERATURE CITED

Bakhshi, M. and P. Grover. 1976. On the study of cocoons of some gall-midges (Cecidomyiidae: Diptera). Cecidol. Indica 11: 83–115.

Barnes, H. F. 1951. The occurrence of xylophilous gall midge larvae (Dipt., Cecidomyiidae) in the pantry. Entomol. Mon. Mag. 36: 241.

Felt, E. P. 1911. A generic synopsis of the Itonidae. J. N. Y. Entomol. Soc. 19: 31–62.

———. 1915. Appendix: A study of gall midges. II. N.Y. State Mus. Bull. 175: 79–213, pls. 1–15.

Gagné, R. J. 1976. New Nearctic records and taxonomic changes in the Cecidomyiidae (Diptera). Ann. Entomol. Soc. Am. 69: 26–28.

———. 1981. Cecidomyiidae, pp. 257–292. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera. Vol. 1. Research Branch. Agriculture Canada. Monograph No. 27. vi and 674 pp.

Grover, P. 1967a. *Xylodiplosis fici*—a new midge from *Ficus carica* L. Cecidol. Indica 22: 133–137.

———. 1967b. Studies on Indian gall midges. XX. Two gall midges reared from the leaf galls of pipal (*Ficus religiosa* L.). Marcellia 34: 45–56.

———. 1979. A revision of the subfamily Cecidomyiinae. Cecidol. Indica 14: 10–186.

Kieffer, J. J. 1894. Ueber die Heteropezinae. Wien. Entomol. Z. 13: 200–212, pl. 1.

———. 1895. Changement de nom. Bull. Soc. Entomol. Fr. 64:cccxx.

———. 1900. Monographie des cécidomyides d'Europe et d'Algerie. Ann. Soc. Entomol. Fr. 69: 181–472 & pls. 15–44.

———. 1904. Nouvelles cécidomyies xylophiles. Ann. Soc. Sci. Bruxelles 28 (Mem.) 367–410.

———. 1911. No. XIV. Diptera, Cecidomyiidae, der Seychellen-Inseln aus der Sammlung von Mr. H. Scott. Trans. Linn. Soc. Lond. (2), Zool. 14: 315–330.

———. 1913. Diptera. Fam. Cecidomyidae. Genera Insectorum. Fasc. 152, 346 pp., 15 pls.

Mamaev, B. M. 1967. Gall midges of the USSR. 7. New species of non-cecidogenous gall midges of the tribe Oligotrophini (Diptera, Cecidomyiidae). Entomol. Obozr. 46: 873–883. (Transl. in Entomol. Rev. 46: 522–528).

Mamaev, B. M. and E. P. Krivosheina. 1965. Larvae of gall midges. Diptera, Cecidomyiidae. Akad. Nauk USSR. Moscow. 278 pp.

Mani, M. S. 1934. Studies on Indian Itonididae (Cecidomyidae: Diptera). Rec. Ind. Mus. 36: 371–451, pl. VII.

Meigen, J. W. 1818. Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten. Vol. 1, xxxvi & 333 pp., pls. 1-11. Aachen.

Möhn, E. 1955. Beiträge zur systematik der larven der Itonididae (= Cecidomyiidae, Diptera). 1. Teil: Porricondylinae und Itonidinae Mitteleuropas. Zoologica 105 (1 & 2): 1–247 & 30 pls.

Morge, G. 1975. Dipteren-Farbtafeln nach den bisher nicht veröffentlichten Original-Handzeichnungen Meigens: "Johann Wilheml Meigen: Abbildung der europaeischen zweiflügeligen Insekten, nach der Natur." Pars. I. Beitr. Entomol. 25: 383–500.

Rock, E. A. and D. Jackson. 1985. The biology of xylophilic Cecidomyiidae (Diptera). Proc. Entomol. Soc. Wash. 87: 135–141.

Stephens, J. F. 1829. A systematic catalogue of British insects. Vol. 2. 388 pp. London.

Westwood, J. O. 1840. Order XIII. Diptera Aristotle, pp. 125–58. *In* An introduction to the modern classification of insects. Synopsis of the genera of British insects. 158 pp. London.

Winnertz, J. J. 1853. Beitrag zu einer Monographie der Gallmucken. Linn. Entomol. 8: 154–322, 4 pls.

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 135–141

THE BIOLOGY OF XYLOPHILIC CECIDOMYIIDAE (DIPTERA)

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Abstract.—The general biology of six new Nearctic species of wood vessel-inhabiting Cecidomyiidae is described. Adults have fixed activity periods which vary with species. Females oviposit in exposed, non-decayed hardwood vessels. Host wood becomes progressively less attractive for oviposition as fungal growth on exposed surfaces increases. In all species larval development requires a minimum of 14 days, but emergence from the vessel may be delayed for several weeks. Emergence requires rainfall sufficient to saturate the wood. Pupation takes place in the ground and the length of the period varies with species and sex; the minimum time between generations is 24 days. The insects overwinter either as larvae in the vessels or as larvae in cocoons in the soil. Sex ratios in two species are 3:1 and 4:1 respectively with a predominance of females. Larvae are parasitized by platygasterid wasps; the parasitism rate is approximately 5%. Ovipositing female midges are preyed upon by empid flies. Techniques for rearing the midges in the laboratory are described.

Larvae of the family Cecidomyiidae have a great diversity of feeding habits. Most attack the meristematic tissues of a wide variety of plants such as hard and soft wood trees, root crops, grains, and fruits, and many are of economic importance. In some species the larvae are zoophagous, attacking small prey such as aphids, scale insects, and mites. Others feed on decaying vegetation and some are mycophagous.

Amidst this diversity there occurs a unique group of xylophilic larvae that live in the xylem vessels of freshly cut hardwoods. The adult females seek out newly felled logs and broken branches and oviposit into the exposed vessel openings. Kieffer (1900, 1913) described several species of xylophilic cecidomyiids and outlined the main events in the life cycle of some European species, but no significant contributions to the biology of this group have been published subsequently. We are reporting the general biology of species of xylophilic Cecidomyiidae found during a period of study in northeast Ohio. The study involved the collection and identification of xylophilic species and observations on the general life cycle.

MATERIALS AND METHODS

Field and laboratory observations were made on larvae and adults collected from local populations. *Quercus alba* L. (Fagaceae) and *Fraxinus americana* L.

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(Oleaceae) were used early in the study as suitable hosts. Initially all wood samples were at least 12.5 cm in diameter and 30 cm long. As the study progressed, branches of varying sizes and additional species of hardwood including *Juglans nigra* L. (Juglandaceae), *Ulmus americana* L. (Ulmaceae), *Carya ovata* (Mill.) K. Koch (Juglandaceae) and *Sassafras albidum* (Nutt.) Nees (Lauraceae) were tested for host suitability.

Two field sites chosen were a tree-line on the edge of an open field in Canal Fulton, Ohio and a heavily wooded yard in Akron, Ohio. In both of these areas the wood samples were well shaded, which prevented rapid desiccation of the logs. Field study dates for 1981 were from June 3 to November 15. In 1982, observations began on May 15 and continued through December 7 as the weather was unseasonably warm.

Wood samples were observed for insect activity and records were kept of oviposition and subsequent larval emergence. Emerging larvae were collected by placing the wood samples in large rectangular plastic bins. Once a connection between rainfall and larval emergence was established, water was added to the bins to stimulate the emergence of mature larvae. The larvae were then collected from the water in the bins with Pasteur pipettes. All larvae, adults and parasitic wasps for taxonomic identification were preserved in 70% ethanol.

A system was designed for laboratory rearing of adult midges from collected larvae. Several inches of sterile potting soil were packed into 10 cm diameter plastic plant pots and covered with 5 cm of loose soil (Peterson, 1964). The collected larvae were counted and added to the surface of the dampened soil; no more than 300 larvae were placed in a single pot. As cecidomyiid larvae can spring a distance of several centimeters (Richards and Davies, 1977), a 10 cm glass Petri dish lid was placed over each pot to prevent escape. The pots were held indoors at room temperature and sprayed with water as needed to prevent dessication. After pupation the Petri dish lid was removed and replaced with an inverted 10 cm plastic funnel with nylon mesh covering the stem opening. This facilitated collection of the emerging adults. All pots were examined daily for the presence of adult midges and the length of the pupation period was recorded for both sexes. Eclosion time was noted for each species.

New adults were placed in cages constructed from glass aquaria with tightly fitting nylon mesh coverings. One pot was placed in each 30 cm × 50 cm × 25 cm cage. A 5% sugar solution in small glass vials with cotton wicks (Peterson, 1964) was kept in the cages as a food source for the adults. Humidity was maintained by misting the sides of the cages. The cages were held in rooms at ambient temperature (15–30°C) and kept from direct sunlight. All pots were held for several weeks past midge ecolsion in order to collect and record the emergence of any parasitic wasps.

RESULTS AND DISCUSSION

TAXONOMY

Adult and larval gall midge identifications were made by Raymond J. Gagné, Systematic Entomology Laboratory, IIBIII, USDA, Washington, D.C. Six new species in one new and three extant genera were represented and are described as *Trogodiplosis flexuosa*, *Xylodiplosis longistylus*, *Ledomyia emilyae*, *Ledomyia mira*, *Ledomyia parva*, and *Trichopteromyia denticauda* in Gagné (1985).

LIFE CYCLES

We observed that larvae overwinter either in the soil or in the vessels of the hardwood hosts. Unseasonably high temperatures in December and January may thaw the ground and temperatures of 21°C or higher may enable the larvae to leave their above-ground location in the wood and enter the soil. Here they spin loose silken cocoons; they do not pupate, but remain in the larval form. In northeast Ohio, pupation occurs about the end of April and the adults begin to emerge in mid-May. Our studies confirm Barnes's (1946) observations that gall midge adults emerge at fixed periods in the day. Adults of *X. longistylus* and *T. flexuosa* emerge from the soil in late afternoon and *Ledomyia* spp. and *T. denticauda* emerge during the morning hours (Table 1).

Males generally emerged two to three days before females and consequently a population of new adults consists mostly of males. The average adult life lasts 3 to 5 days, but under laboratory conditions some females lived as long as 9 days. Although in some cecidomyiids the sex ratio is 1:1, there is a predominance of females in many species. Mamaev (1968) cites an average ratio of 35:65 of males to females in many phytophagous species; we have observed ratios as high as 1:4 in xylophilic species. The sex ratios listed in Table 1 are based on the percentages of all adults collected from the caged populations.

Although we have observed mating in caged populations we have not seen it under field conditions. Kieffer (1900), however, noted that mating occurs on the ground almost immediately after the females emerge, even before the females are able to fly. After coupling, only females leave the eclosion site to search for freshly cut hardwood; thus the males are not attracted to the oviposition site. Kieffer suspected this and we have confirmed it in field and laboratory observations.

The females of each genus have a fixed activity period for oviposition (Table 1). *Ledomyia* spp. and *T. denticauda* oviposit throughout most of the afternoon; *X. longistylus* and *T. flexuosa* are nocturnal, with some *Trogodiplosis* females ovipositing as late as 5 A.M. There is very limited movement outside of these oviposition periods, the adults often remaining quiescent for many hours.

When approaching a suitable host, the females use a flight pattern adopted by many female insects in the location of oviposition sites (Dethier, 1947). Initially, flight is apparently random, but when the females are within several centimeters of the wood surface their flight takes a straight-line pattern to the edge of the log and they alight. The search for a vessel suitable for oviposition begins immediately; the end of the abdomen is deflexed and the tip of the ovipositor is applied with obvious pressure to the wood surface. While the female walks in an apparently random pattern (even walking backwards), the tip of the ovipositor is in constant contact with the surface. The end of each vessel is probed with the tip of the ovipositor; eventually a suitable vessel is located, the abdomen lowered and the ovipositor extended into the vessel. Although the search appears random and may take several minutes, the female always limits her search to the outer edges of the xylem (sapwood vessels).

Once oviposition has been initiated, the female is not easily disturbed. During normal resting periods, however, females are easily agitated by such factors as vibrations, abrupt changes in light intensity, or contact with other individuals. Barnes (1951) noted that females of *Xyboliplosis praecox* Winnertz oviposit "so intently that they can easily be picked up with the fingers." We have noted that

Table 1. Life cycle data of six species of xylophilic cecidomyiids encountered during this study.

Cycle	*Xylodiplosis longistylus*	*Trogodiplosis flexuosa*	*Ledomyia* spp	*Trichopteromyia denticauda*
Eclosion period	3 PM to 5 PM	3 PM to 5 PM	8 AM to 10 AM	8 AM to 10 AM
Oviposition period	8 PM to 11 PM	12 AM to 5:30 AM	1 PM to 5 PM	2 PM to 6 PM
Minimum length of larval stage	14 days	14 days	14 days	14 days
Length of pupal stage:				
Male	14 to 16 days	10 to 12 days	14 to 16 days	<14*
Female	15 to 17 days	12 to 14 days	15 to 17 days	>20*
Sex ratio: male : female	1:3	1:4	*	*

* Insufficient data.

neither bright microscope lamps or contact with other searching females interrupts oviposition.

Sometimes, even when the vessel appears to be of suitable diameter, the ovipositor is withdrawn immediately and searching resumed. Possibly the vessel is rejected because of some obstruction below the surface or because it already contains an egg. Although we have no direct evidence that a female will not oviposit in an already occupied vessel, we have never observed more than one larva emerging from a vessel.

We were unable to follow early developmental stages in the vessels partly because of problems in recovering undamaged eggs or larvae from the woody tissue. However, the duration of the larval stage was determined for all the genera studied (Table 1). In all the species, the mature larvae begin to emerge from the vessels 14 days after oviposition if conditions for emergence are favorable.

We have confirmed Kieffer's (1913) observation that rainfall is an essential factor in creating the conditions that are favorable for larval emergence. During a summer with frequent rainfall the larvae emerge on a steady basis and several generations are possible. If several days elapse between rainfalls, the surface of the wood dries and the larvae remain in the vessels until the next hard rain. Kieffer (1913) suggested that the moisture is needed to soften the wood, thus easing the escape of the larvae from the vessels. However, we observed no change in vessel diameter when dry wood samples (wood held in the laboratory for 2 weeks) were soaked in water for several hours. Barnes (1946, 1956) noted that moisture is essential to the survival of mature emerged larvae of several genera of cecidomyiids and we observed that emerged xylophilic larvae are very susceptible to dessication unless promptly given a moist medium in which to pupate. Therefore, rain appears to act as a sign stimulus for the release of emergence behavior; when the larvae react to this stimulus they are more likely to encounter moist soil in which to pupate.

Once the larvae leave the vessels, moisture is essential. As long as they remain in the wood they can withstand extended periods of drought. Kieffer (1900) noted that during a dry spell larvae of *X. praecox* remained in the vessels for one month past maturity. We have held *U. americana* logs (10 cm diameter × 60 cm long) inhabited by xylophilous larvae in the laboratory for 60 days at 20 to 22°C and approximately 55% humidity, during which time no larvae emerged from the logs. At the end of this period the logs were placed in bins of water and within 3 hours the larvae began to emerge.

Once free of the vessel, the larvae either fall to the ground directly or spring from the log. Once on the soil, the larvae immediately begin digging but do not penetrate more than 5 cm deep. The vast majority of the larvae then spin a silken cocoon.

LARVAL FOOD

Many cecidomyiid larvae that develop in wood are mycophagous and are typically found in wood with obvious decay. Kieffer (1900) expressed surprise after observing cecidomyiid larvae emerging from oak logs which had no trace of decomposition; we have confirmed this observation. Although we have not identified the source of the larval food, the following observations are pertinent. *Xylodiplosis* shows some relationship to *Contarinia*, a large genus of primarily plant feeders (see Gagné, 1985), but the other xylophilic larvae encountered during this study belong to groups that are mycophagous. Nijveldt (1969) and Batra and Batra (1967) have suggested that some cecidomyiid females supply fungal spores to the developing larvae. It is possible that the larvae feed on inconspicuous yeast or molds in the vessels, but we have not been able to detect such fungi by light microscopy. We have observed, however, that in damp weather fungi develop within a few weeks over the cut surface of the logs and such logs yield fewer larvae. Originally we suspected that this was due to competition for food between the developing larvae and the established fungi. However, experiments on host selection (ms in preparation) indicate that there is a progressive loss of oviposition site-attractiveness in the presence of fungi.

Parasites and Predators

Larvae of most Platygasteridae (Hymenoptera) parasitize cecidomyiid larvae, and several species have been reported from xylophilic larvae. We observed females of several species of *Synopeas* and *Leptacis* ovipositing in vessels previously visited by female cecidomyiids. Development of the parasite larvae is suppressed until the host larvae leave the wood and pupate. The parasites then develop rapidly and begin to emerge 14 days after the nonparasitized adult midges emerge. An overall parasitism of approximately 5% was observed.

While remaining in the vessels, the xylophilic larvae are relatively safe from predators. However, both Kieffer (1900) and Huggert (1980) noted that after emergence many larvae became trapped in spider webs below the stacked logs. Huggert described the larvae and pupae being attacked by a cimicoid bug, *Loricula elegantula* (Bär). Several times we observed a dance fly (Empididae: Diptera) preying upon ovipositing midges. The fly concealed itself in the edge of the bark, quickly ran onto the cut surface of the log, captured the female midge, and returned with its prey to a crevice in the bark. The activity period of the dance fly appeared to correspond with the peak activity period of the diurnal midges.

Acknowledgments

We thank Raymond J. Gagné, Systematic Entomology Laboratory, USDA, Washington, D.C. for his enthusiastic help, for drawing our attention to references on the biology of the cecidomyiids, and for translating passages of some papers.

Literature Cited

Barnes, H. F. 1946. Gall midges of economic importance, vol. 1 (Root and vegetable crops). Crosby Lockwood and Son, Ltd., London. 104 pp.

———. 1951. The occurrence of xylophylous gall midge larvae (Dipt., Cecidomyiidae) in the pantry. Entomol. Mon. Mag. 86: 241.

———. 1956. Gall midges of economic importance, vol. 7 (Cereal crops). Crosby Lockwood and Son, Ltd., London. 261 pp.

Batra, Suzanne W. T. and Lekh R. Batra. 1967. The fungus gardens of insects, pp. 203–210. *In* The Insects: Readings from Scientific American. Selected by Eisner, T. and Wilson, E. W. H. Freeman Co., San Francisco.

Dethier, Vincent G. 1947. Chemical insect attractants and repellants. The Blakiston Company, Toronto. 289 pp.

Gagné, R. J. 1985. Descriptions of new Nearactic Cecidomyiidae (Diptera) that live in xylem vessels of fresh-cut wood and a review of *Ledomyia* (s. str.). Proc. Entomol. Soc. Wash. 87: 116–134.

Huggert, L. 1980. Taxonomical studies on some genera and species of Platygastrinae (Hymenoptera: Proctotrupoidea). Entomol. Scand. 11: 97–112.

Kieffer, J. J. 1900. Monographie des Cécidomyies d'Europe et d'Algérie. Ann. Soc. Entomol. Fr. 69: 341–343.

———. 1913. Diptera Fam. Cecidomyidae. Fasc. 152, 346 pp., 15 pls. *In* Wystsman, P., ed., Genera Insectorum. Bruxelles.

Mamaev, B. M. 1968. Evolution of gall forming insects-gall midges. The British Library, Wetherby. Translated from Russian by A. Crozy. 317 pp.

Nijveldt, W. 1969. Gall midges of economic importance, Volume 8, Miscellaneous. Crosby Lockwood and Son, Ltd., London. 221 pp.

Peterson, A. 1964. Entomological techniques. 10th ed. Columbus, Ohio. published by author. 435 pp.

Richards, O. W. and R. G. Davies. 1977. Imms' general textbook of entomology, vol. 2., 10th ed. Chapman and Hall, London. 1354 pp.

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A RE-EXAMINATION OF *ENTEUCHA CYANOCHLORA* MEYRICK AND ITS SUBSEQUENT TRANSFER TO THE NEPTICULIDAE (LEPIDOPTERA: NEPTICULOIDEA)

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Abstract.—The unique holotype of *Enteucha cyanochlora* Meyrick is re-examined and illustrated. On the basis of head structure and male genitalia, it is concluded that the genus and species are members of the family Nepticulidae and are not closely allied to *Opostega*, as orginally inferred by Meyrick.

One of the oddities of the rather aberrant family Opostegidae is that only one generic name, *Opostega*, has ever been attributed to this group, in spite of its widespread, largely cosmopolitan distribution. Consequently, the precise family relationships of the genus *Enteucha*, described by Edward Meyrick (1915) from a unique male from Guyana and supposedly "intermediate in character between *Opogona* and *Opostega*," is of some interest.

Enteucha was first proposed in the ditrysian family Lyonetiidae along with several new species of *Opostega* and *Phyllocnistis* (the latter now placed in the Gracillariidae). Its' "intermediacy" between the ditrysian *Opogona* and the monotrysian *Opostega* was a typical generalization by Meyrick due to his unfamiliarity with the basic morphology of Microlepidoptera. Subsequent to the original description, I know of only one other reference to *Enteucha*, that being by Fletcher (1929), wherein the genus is retained in the Lyonetiidae.

During the course of my studies on the Opostegidae, I have examined the holotype of *Enteucha cyanochlora* Meyrick. Dissection has shown the taxon to be a member of the Nepticulidae, the closest ally of the Opostegidae. Within the Nepticulidae, *Enteucha* appears most akin to *Artaversala* Davis, described mining the leaves of *Coccoloba uvifera* (L.) in southern Florida, USA (Davis, 1979). The two genera are similar in their male genital structure, particularly by the absence of an uncus; a rounded, largely membranous tegumen; deeply furcate valvae; and triangular vinculum-saccus. *Enteucha* differs from *Artaversala* in having the gnathos of the male genitalia even less developed and by the presence of a slender, spikate juxta. Because of the uniqueness of the holotype, it was not possible to remove the wings for venational analysis.

A description of the holotype may be summarized as follows:

Fig. 1. *Enteucha cyanochlora*; ♂ holotype. Length of forewing 2.8 mm; Bartica, Guyana.

Enteucha cyanochlora Meyrick

Figs. 1–4

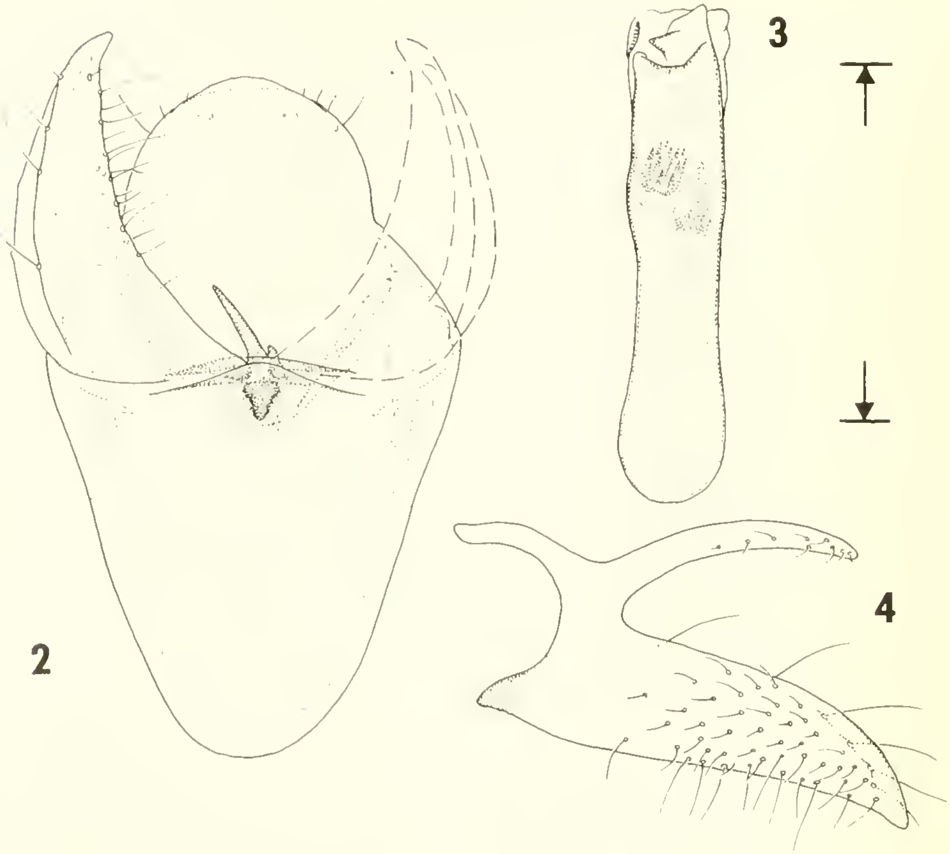
Enteucha cyanochlora Meyrick, 1915: 241.—Fletcher, 1929: 78.—Davis, 1984: 18.

Adult (Figure 1).—Length of forewing: ♂, 2.8 mm.

Head: Vestiture of vertex rough, pale yellowish buff; occiput smooth, brownish fuscous with purple iridescence. Eyes round, interocular index approximately 1.0. Ocelli absent. Antennae approximately 0.6 the length of forewing, 36 segmented; scape flattened into a broad, oblong eyecap approximately ×3 the eye diameter in length; uniformly pale yellowish buff; pecten absent; flagellum same color as scape. Maxillary palpi pale yellowish buff, elongate, apparently 5-segmented with fourth and fifth segments approximately equal. Labial palpi reduced, considerably shorter than maxillary palpi; pale yellowish buff with a few scattered brownish scales near apex.

Thorax: Pronotum brownish fuscous with purple iridescence. Venter pale buff. Forewings uniformly dark brownish fuscous with purple iridescence except for a slightly oblique, triangular pale yellowish buff spot on distal third of costa and an apical fringe spot of the same color. Hindwings approximately same color as forewings; uniformly brownish fuscous with a slight purple iridescence. Forelegs shiny buff ventrally, dark brownish fuscous dorsally. Midlegs uniformly buff. Hindlegs buff with dorsal vestiture of tibial and tarsal segments brownish fuscous.

Abdomen: Dark brownish fuscous dorsally, pale yellow buff ventrally.



Figs. 2–4. *Enteucha cyanochlora*. 2, Male genitalia, ventral view. 3, Aedeagus, ventral view. 4, Right valva, mesal view. Scale = 0.2 mm.

Male genitalia: As shown in figures 2–4. Uncus absent. Tegumen broadly rounded, mostly membranous. Gnathos indistinct, mostly membranous. Vinculum-saccus well developed, nearly equalling length of valva, triangular, tapering to a broadly rounded anterior end. Valvae deeply furcate; dorsal (costal) branch much smaller and shorter than ventral branch. Aedeagus moderately slender, 0.65 the length of genital capsule; a small cluster of approximately 12 cornuti positioned centrally.

Female and immature stages unknown.

Type.—Holotype, ♂ (BMNH).

Type locality.—GUYANA: Bartica.

Host.—Unknown

Flight period.—February.

Distribution.—Known only from the type locality, which is located in the Guiana costal plain near the junction of the Essequibo and Mazaruni Rivers.

Material examined.—GUYANA: Bartica: 1 ♂, 2.13, Parish (BMNH).

ACKNOWLEDGMENTS

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LITERATURE CITED

Davis, D.R. 1979. New leaf-mining moths of the family Nepticulidae from Florida. Fl. Entomol. 61(4): 209–224, figs. 1–36.

———. 1984. Nepticulidae. *In* Heppner, J. R., ed., Atlas of Neotropical Lepidoptera, Vol. 2, Checklist, part 1 (Micropterigoidae To Immoidea). W. Junk, The Hague.

Fletcher, T. B. 1929. A list of the generic names used for Microlepidoptera. Mem. Dept. Agric. India, Entomol. Series 11: ix + 246 p.

Meyrick, E. 1915. Descriptions of South American Microlepidoptera. Trans. Entomol. Soc. Lond. Part 2, p. 201–256.

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ETHOLOGY OF THREE COEXISTING SPECIES OF *EFFERIA* (DIPTERA: ASILIDAE) IN MEXICO

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Abstract.—The behavior of *Efferia cressoni* (Hine), *E. subcuprea* (Schaeffer) and *E. triton* (Osten Sacken) was studied on a mountainside 80 km north in Chihuahua, Mexico. The three species were able to coexist in the same habitat because of differences in foraging/feeding sites, in time of peak foraging and in prey selection. Because they occupied different levels in the vegetation (*E. cressoni*, 5–20 cm; *E. triton*, 18 cm—1.3 m; *E. subcuprea*, 1–2 m), contact between species was apparently minimal. Although Diptera and Homoptera were primary food items, prey of different mean lengths (*E. cressoni*—5.0 mm, *E. subcuprea*—6.1 mm, *E. triton*—9.5 mm) were chosen with little overlap. Peak feeding for *E. cressoni* occurred in mid-morning and late afternoon, whereas that for *E. subcuprea* and *E. triton* occurred in mid-afternoon. These observations make a contribution to the poorly documented phenomenon of coexisting, congeneric robber flies.

According to Martin (1965), 37 species of *Efferia* (Asilinae) occur in Mexico. To our knowledge, information on the ethology and/or ecology of this genus in Mexico has been published for only one species, *E. argyrogaster* (Macquart) (Lavigne, 1979). The present study reports on the ethology and ecology of three species, (*E. cressoni* (Hine), *E. subcuprea* (Schaeffer) and *E. triton* (Osten Sacken)), which were studied primarily at Rancho Experimental "La Campana" located 80 km north of Chihuahua, during the period, April 2–11, 1972. Limited observations on *E. cressoni* were also made at the junction of Route 45 and the road to Balneario San Diego, south of Chihuahua.

Voucher specimens from populations of the asilids forming the basis for this paper have been placed in the U.S. National Museum of Natural History, Washington, D.C. as Lot #48, 49 and 50.

The habitat at "La Campana" is oak brush savannah in the foothills just below the Ponderosa Pine zone (Fig. 1). The savannah is dominated by the grasses, *Elyonurus* sp., *Aristida ternipes* Cav. and *Bouteloua gracilis* (H. B. K.) Lag. ex Steud., intermixed with red oak, *Quercus rubra* L., and two or three additional species of oak. Less common plants include *Andropogon barbinodis* Lag., *Prosopis glandulosa* Torr., *Drymaria arenaroides*, Humb. & Bonpl. ex. Roem. & Shult., *Brikelia spinuloso* Gray and *Nolina texana* Wats.

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Methods

Methods for gathering and analyzing ethological data for this study were essentially the same as those described for *Neoitamus vittipes* (Macquart) in Lavigne (1982).

Ethology of Individual Species

Efferia cressoni

Foraging and feeding behavior.—*Efferia cressoni* foraged from soil, rocks and vegetation (5 to 20 cm above the ground), depending on the surface temperature of the substrate. Usually this species foraged from the ground until the surface temperature reached 41°C, but some individuals waited until the temperature reached 48°C before moving onto vegetation. Once the asilids moved to vegetation they generally foraged from shaded areas.

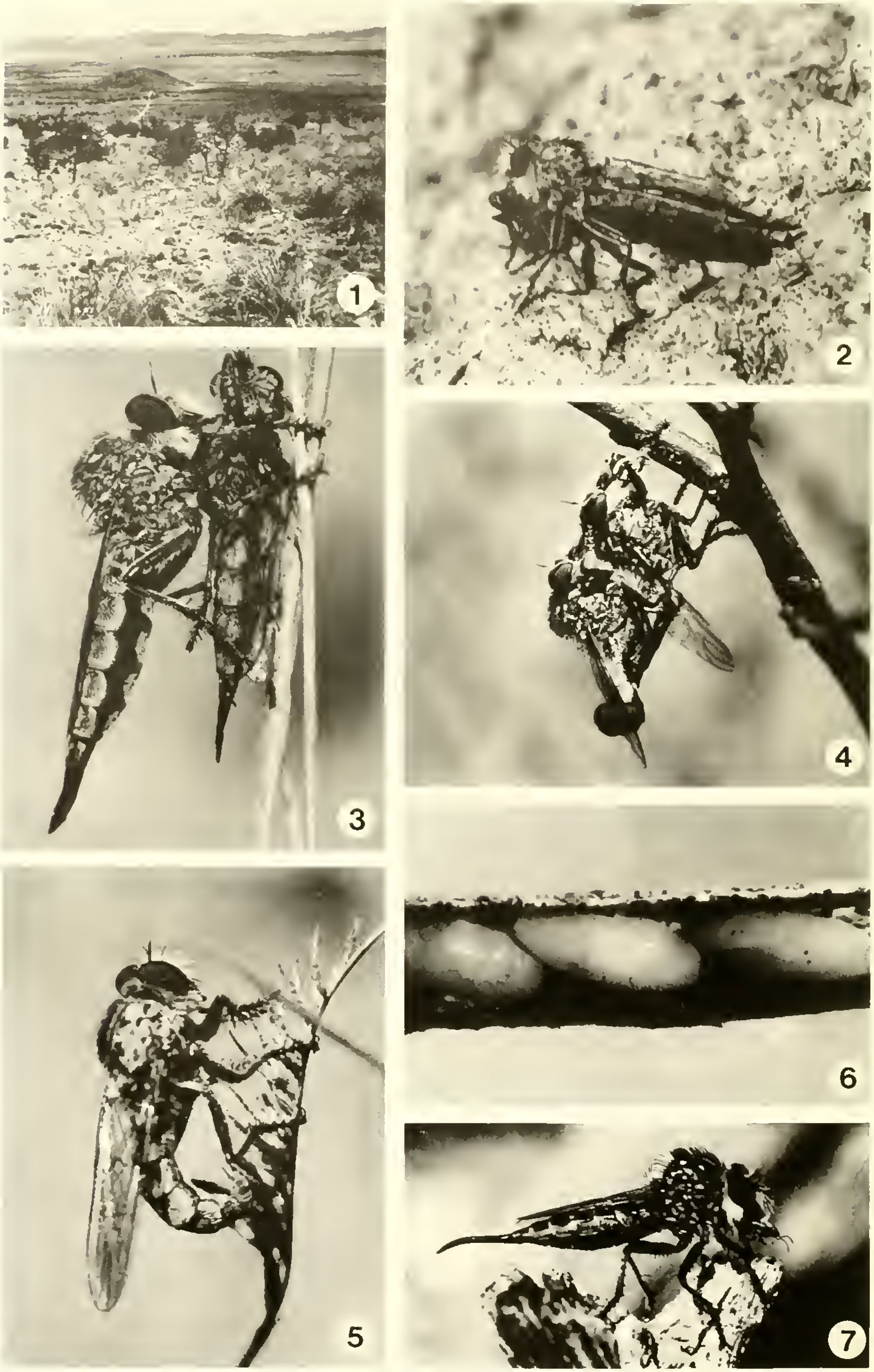
This species exhibited positional changes in relation to the sun while resting on the ground. In the morning and late afternoon when surface temperatures varied between 24 and 37°C, individuals generally oriented themselves broadside to the sun. As the surface temperature increased, they turned to face directly into the sun.

Efferia cressoni captured prey in flight. Forage flights usually covered a distance of 1 m or less. Five to eight flights were frequently made before prey were captured.

Intermittently during feeding (Fig. 2), as has been observed for most *Efferia* spp., the asilid hovered and manipulated its prey with all six tarsi prior to reinserting its hypopharynx. Two incomplete feedings were observed to last 11 (Cixiidae: *Oecleus* sp.) and 15.5 minutes (prey unidentified); one complete feeding lasted 18 minutes (Scythridae: *Scythris* sp.). At the completion of feeding, prey were pushed off the hypopharynx with the foretarsi while the asilid was still at the feeding site or prey were dropped in flight as the asilid resumed foraging.

The following is a list of prey taken by *E. cressoni*. The number and sex of the predator are indicated in parentheses following the recorded prey.

COLEOPTERA, Anthicidae: *Anthicus* sp., IV-8-72 (♂); Cleridae: *Phyllobaenus discoideus* (LeConte), IV-8-72 (♀); Scarabaeidae: *Aphodius vittatus* Say, IV-6-72 (♀). DIPTERA, Agromyzidae: *Calycomyza* sp., IV-11-72 (♀): *Liriomyza* sp., IV-8-72 (♀); Anthomyiidae: *Hylemya* sp., IV-4-72 (♀), IV-5-72 (♀); Asilidae: *Efferia cressoni* (Hine), IV-8-72 (♀); Bombyliidae: *Lepidanthrax proboscideus* (Loew), IV-11-72 (♀); *Mythicomyia* sp., IV-8-72 (♂); Cecidomyiidae: *Neolasioptera* sp., IV-8-72 (♀), IV-11-72 (♀); unidentified, IV-8-72 (♂,♀); Chloropidae: *Conioscinella* sp., IV-8-72 (♀); Muscidae: *Limnophora* sp., IV-5-72 (♀); *Orthellia caesarion* (Meigen), IV-6-72 (♀); Sarcophagidae: *Blaesoxipha* sp., IV-6-72 (♀); Tachinidae: *Mochlosoma* sp., IV-9-72 (♀); Tephritidae: *Trupanea wheeleri* Curran, IV-6-72 (♀), IV-8-72 (♂), IV-11-72 (♀). HEMPITERA, Lygaeidae: *Crophius heidemanni* Van Duzee, IV-6-72 (♂); *Geocoris* sp., IV-5-72 (♀); Rhopalidae: *Niesthrea sidae* (Fabricius), IV-9-72 (♀); Tingidae: *Gargaphia opacula* Uhler, IV-5-72 (♀). HOMOPTERA, Aleyrodidae: unidentified, IV-9-72 (♂), IV-11-72 (♀); Aphididae: *Arytainia* sp., IV-9-72 (♀), IV-11-72 (2 ♀); *Macrosiphum* sp., IV-8-72 (♀), IV-9-72 (♀); Cicadellidae: *Balclutha* sp., IV-8-72 (♀); *Deltocephalus sonorus* Ball, IV-11-72 (♀); *Dikraneura* sp., IV-8-72 (♂,♀); *Exitianus exitiosus* (Uhler), IV-8-72 (♀); *Norvellina* sp., IV-8-72 (♂); *Stirellus obtutus* (Van Duzee), IV-8-72 (♀); *Texananus pergradus*



Figs. 1–7. 1, Overview, "Rancho Campana," *Efferia* habitat. 2, Female *E. cressoni* feeding on *Hylemya* sp. 3, Cannibalism by female *E. cressoni*. 4, *E. cressoni* pair in copula. 5, *E. cressoni* female ovipositing in *Bouteloua* sp. seed head. 6, Eggs of *E. cressoni*. 7, *E. subcuprea* female feeding on *Geocoris* sp.

Table 1. Comparison, by number and percent, of the composition of prey, by Order, taken by *Efferia cressoni, E. subcuprea* and *E. triton.*

	Male						Female						Total					
	E. cressoni		*E. subcuprea*		*E. triton*		*E. cressoni*		*E. subcuprea*		*E. triton*		*E. cressoni*		*E. subcuprea*		*E. triton*	
Order	No	%	No	%	No	%	No.	%	No.	%	No.	%	No.	%	No	%	No.	%
Areneae									1	5.9					1	5.3		
Coleoptera	1	8.3			8	19.0	2	4.7			6	14.0	3	5.5			14	16.5
Diptera	3	25.0	1	50.0	17	40.5	17	39.5	7	41.2	12	27.9	20	36.4	8	42.1	29	34.1
Hemiptera	1	8.3			7	16.7	3	7.0	1	5.9	5	11.6	4	7.3	1	5.3	12	14.1
Homoptera	5	41.7	1	50.0			15	34.9	6	35.3	2	4.7	20	36.4	7	36.8	2	2.4
Hymenoptera	1	8.3			3	7.1					9	20.9	1	1.8			12	14.1
Lepidoptera	1	8.3			6	14.3	5	11.6	1	5.9	5	11.6	6	10.9	1	5.3	11	12.9
Neuroptera					1	2.4			1	5.9	3	7.0			1	5.3	4	4.7
Orthoptera											1	2.3					1	1.2
Unidentified							1	2.3					1	1.8				
Total	12		2		42		43		17		43		55		19		85	

Table 2. Comparison of relation between length of asilids and that of their prey for *Efferia cressoni*, *E. subcuprea* and *E. triton*.

Species by Sex	Predator Length (mm)[a]			Prey Length (mm)			No. of Prey Measured	Mean Ratio of Predator to Prey
	Minimum	Maximum	Mean	Minimum	Maximum	Mean		
Efferia cressoni ♂	11.4	14.2	12.8	0.5	10.7	5.9	10	2.2
Efferia cressoni ♀	11.3	15.0	13.4	1.1	13.5	4.3	37	3.1
Species mean			13.1			5.0		2.6
Efferia subcuprea ♂	15.3	17.7	16.4	4.8	4.8	4.8	1	3.4
Efferia subcuprea ♀	15.8	20.4	19.1	1.5	8.7	6.2	14	3.1
Species mean			17.9			6.1		2.9
Efferia triton ♂	16.7	23.5	20.9	2.8	20.0	10.2	38	2.0
Efferia triton ♀	21.8	26.0	23.8	2.5	26.5	8.9	43	2.7
Species mean			22.3			9.5		2.3

[a] 10 predators of each were measured.

(DeLong), III-7-72 (♀) (Jct. Rte. 45 and Balneario San Diego); Cixiidae: *Oecleus* sp., IV-6-72 (♀); Delphacidae: *Bostaera* sp., IV-6-72 (♀); Issidae: *Aphelonema* sp., IV-8-72 (♂,♀); Psyllidae: *Craspedolepta pulchella* Crawford, IV-8-72 (♂). HYMENOPTERA, Anagymini, IV-8-72 (♀). LEPIDOPTERA, Gelechiidae: *Gnorimoschema* sp., IV-8-72 (♀); *Sophronia* sp., IV-8-72 (♀), IV-9-72 (♀); Olethreutidae: unidentified, IV-2-72 (♀); Pyralidae: Peoriinae, IV-8-72 (♀); Scythridae: *Scythris* sp., IV-6-72 (♀). Unidentified: IV-6-72 (♀).

As indicated in the prey list, a female *E. cressoni* was observed preying on another female. This asilid species also was preyed upon occasionally by *E. triton* (Fig. 3).

Both sexes of *E. cressoni* generally fed on the same orders of prey, with Diptera and Homoptera making up at least 66 percent of the prey (Table 1). However, males fed on slightly larger prey, as indicated by a smaller mean ratio of predator to prey (Table 2). Overall this species was 2.6 times as large as its prey.

Mating behavior.—Male *E. cressoni* performed searching flights for receptive females with which to mate. Males weaved in and out of the vegetation, flying approximately 5 to 30 cm above the ground. During these flights males attempted to mate with females as well as with other males.

Only two complete matings were observed. Both matings were initiated in flight. The male grasped the female on the dorsum of her thorax and the struggling pair fell to the ground where the male proceeded to clasp the female's genitalia. The mated pair then flew onto vegetation, 60 cm above the ground.

During copulation *E. cressoni* remained in the male over female position (Fig. 4) as did *E. subcuprea* and *E. triton*. While in this position the male's abdomen curved around to the right or left of the female's abdomen and clasped her genitalia from below. The male's and female's wings were generally spread at a 30 to 45 degree angle to their bodies (one male was observed with his wings closed over his dorsum). The male's foretarsi rested on the female's eyes.

As mating neared completion, (within 1 to 2.5 minutes), males frequently briefly buzzed their wings. Then, just before termination, males buzzed their wings again, moved to the female's side and pushed off with all six legs.

The two observed complete matings lasted 7 and 7.5 minutes. Temperatures at mating heights (40 cm and 80 cm) were 27.2°C and 29.4°C, respectively. An additional pair already in copula when first observed, remained so for six minutes on a thornbush branch 40 cm above the substrate.

Oviposition behavior.—Female *E. cressoni* oviposited 18 to 30 cm above the ground in *Bouteloua* sp. seed heads (Fig. 5), and between the sheath and stem of the stalks. While searching for a suitable site to deposit eggs and during oviposition, females oriented in a head-up position. Ovipositions, at temperatures of 33–34°C, were completed in 45 to 60 seconds once a suitable location was found.

After ovipositing, females searched for another oviposition site or began foraging. Followed females oviposited at least twice before initiating foraging or being lost to sight.

Females deposited 2 to 5 eggs per oviposition. All eggs were oval and creamy-white (Fig. 6). Eggs ranged in length from 1.36 to 1.45 mm ($\bar{x}$ 1.41 mm). The range in width was 0.51 to 0.57 mm, with a mean of 0.54 mm.

Daily rhythm of activity.—*Efferia cressoni* foraged/fed throughout the day; however, peak periods occurred during the morning (1000 to 1100 h) and early evening (1800 to 1900 h), i.e. during cooler parts of the day (Fig. 14). These foraging periods generally corresponded with or preceeded the peak mating and oviposition periods, possibly because of the large amount of energy required for the latter behaviors. Also, during the peak foraging periods more prey were in flight and *E. cressoni* could backlight the prey making them more readily visible. During peak behavior periods, the air temperature 15 to 40 cm above the ground, varied between 27 and 34°C.

Efferia subcuprea

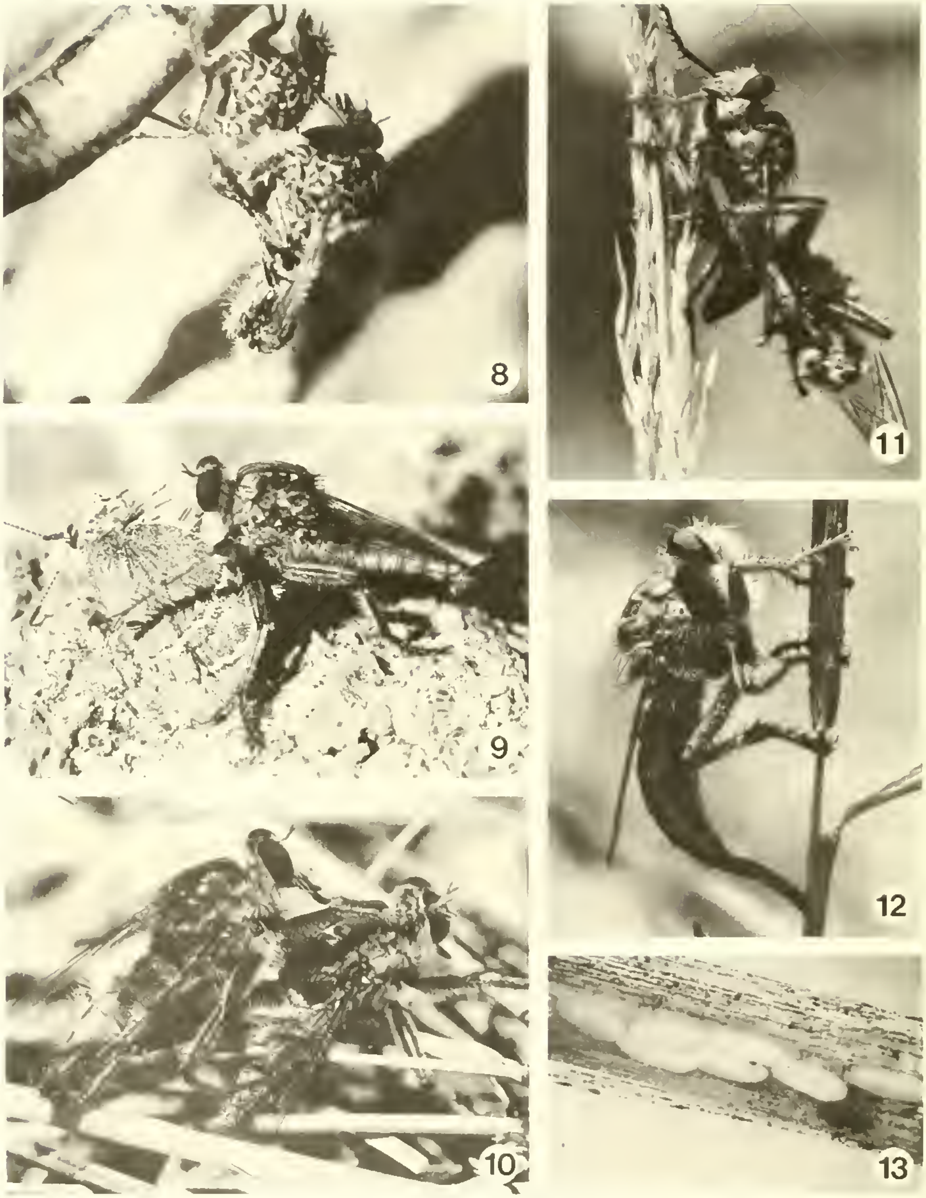
Foraging and feeding behavior.—*Efferia subcuprea* usually foraged from vegetation, in particular *Quercus* sp., 1 to 2 m above the ground, although some individuals were observed foraging as high as 3 m. This species was rarely observed foraging from the ground (i.e. soil, rocks, sticks).

Whether on ground or vegetation, *E. subcuprea* adjusted its body to temperature changes. In the early morning and late afternoon-evening when it was relatively cool, the asilids flattened themselves against the substrate and/or oriented their bodies broadside to the sun. During warmer parts of the day they faced the sun with their bodies held off the substrate.

Efferia subcuprea often initiated foraging flights from the same branch several times in succession. Generally, the asilids faced into the sun so that potential prey were backlighted. Forage flights covered distances up to 18 to 24 cm, but most prey were captured 60 cm to 15 m from the foraging site.

Prey were always captured in flight. If they were deemed unsuitable, they were released following manipulation with all six tarsi as the asilid hovered. Acceptable prey were generally immobilized in flight immediately following capture or as the asilid hovered and manipulated the prey. The hypopharynx was usually initially inserted in the prey's head or between the head and thorax (Fig. 7). However, one asilid was observed inserting its hypopharynx in the prey's thorax after landing to feed.

During feeding prey were manipulated either, (1) with all six tarsi as the asilid



Figs. 8–13. 8, *E. subcuprea* pair in copula. 9, *E. triton* male feeding on *Sandia macfarlandi*. 10, *E. triton* pair in copula. 11, *E. triton* male separating from female. 12, *E. triton* female ovipositing on grass stem. 13, Eggs of *E. triton*.

hovered above its feeding site, or (2) with the foretarsi as the asilid remained on its feeding site.

One complete feeding on *Hippelates robertsoni* Sabrosky (Diptera: Chloropidae) lasted 4 minutes. This was followed by a 1 minute interfeeding time after which the asilid captured another prey and was lost to sight.

At the completion of feeding, prey were discarded in one of two ways: (1) they

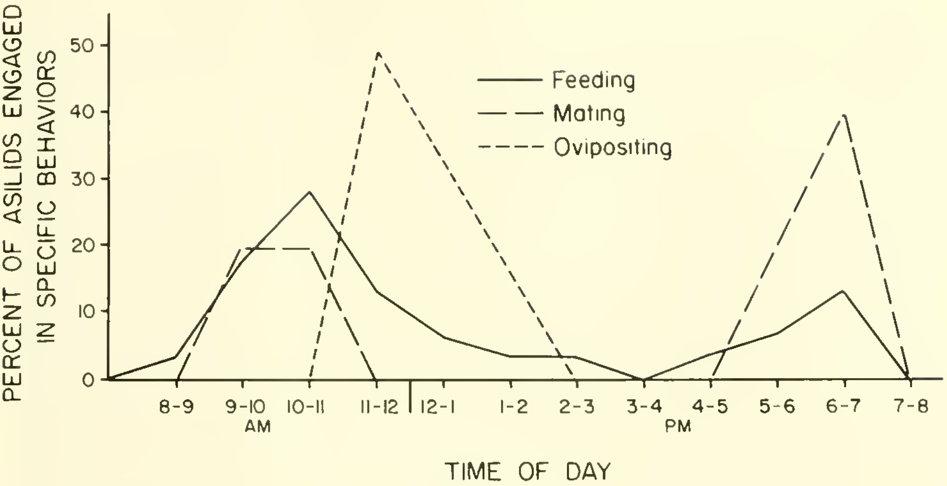


Fig. 14. The diurnal rhythm of activity of *Efferia cressoni.* (The percentage of asilids engaged in specific behavior patterns was calculated from the total number of observations for each behavior—60, 5, and 6 for feeding, mating and oviposition, respectively).

were either dropped in flight as the asilid moved to another location and/or resumed foraging, or (2) they were pushed off the asilid's hypopharynx with the foretarsi while the asilid remained at the feeding site.

Only 19 prey were recovered from captured *E. subcuprea,* as follows: ARANEIDA, Araneae: unidentified, IV-6-72 (♀). DIPTERA, Chloropidae: *Hippelates robertsoni* Sabrosky, IV-5-72 (2 ♀), IV-11-72 (♀); Drosophilidae: *Sinophthalmus pictus* Coquillett, IV-3-72 (♀); Phoridae: *Megaselia* sp., IV-9-72 (♀); Sarcophagidae: *Ravinia lherminieri* (Robineau-Desvoidy), IV-4-72 (♀); Sepsidae: *Sepsis neocynipsea* Melander and Spuler, IV-2-72 (♀); Tephritidae: *Trupanea ageratae* Benjamin, IV-4-72 (♂). HEMIPTERA, Lygaeidae: *Geocoris* sp., IV-3-72 (♀). HOMOPTERA, Cixiidae: *Oecleus* sp., IV-10-72 (♀); Membracidae: *Cyrtolobus* sp., IV-11-72 (♂); Psyllidae: *Kuwayama medicaginis* (Crawford), IV-4-72 (2 ♀), IV-8-72 (♀), IV-10-72 (♀), IV-11-72 (♀). LEPIDOPTERA, Olethreutidae: unidentified, IV-6-72 (♀). NEUROPTERA, Chrysopidae: *Eremochrysa punctinervis* (McLachlan), IV-2-72 (♀).

As can be seen from Table 1, *E. subcuprea* like *E. cressoni,* preyed primarily on Diptera and Homoptera. These two orders made up approximately 80 percent of the prey of *E. subcuprea.*

Since it was possible to measure only one prey for a male, it is difficult to say anything about the mean ratio of predator to prey for males (Table 2). Females were approximately 3 times as large as their prey.

Mating behavior.—Three mating pairs of *E. subcuprea* were observed. Of these, two complete matings were recorded to last 6.5 minutes. Temperatures during matings ranged from 24–30°C.

Mating occurred in the male over female position following initiation in flight. The male's abdomen curved around to the right or left of the female's abdomen and his genitalia clasped her genitalia from below (Fig. 8). The male's foretarsi

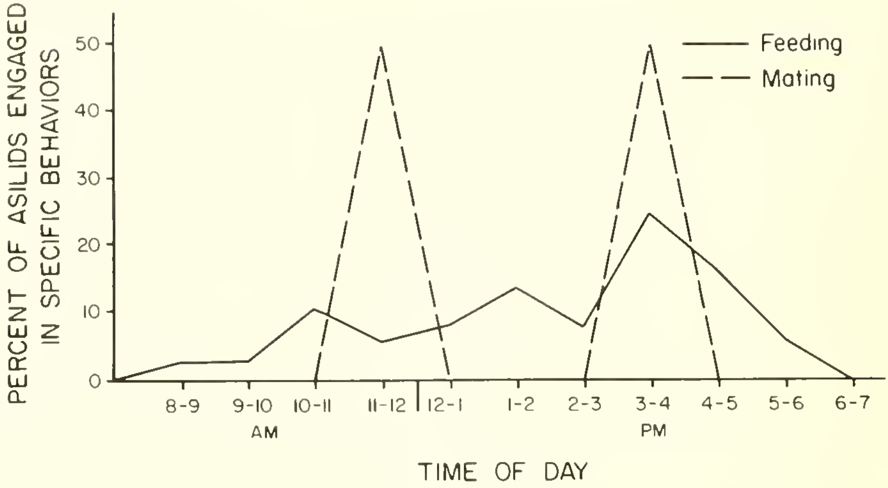


Fig. 15. The diurnal rhythm of activity of *Efferia subcuprea*. (The percentage of asilids engaged in specific behavior patterns was calculated from the total number of observations for each behavior—36 and 2 for feeding and mating, respectively).

rested on the female's eyes and his wings were closed over his dorsum. The female's wings were at a 45 degree angle to her body.

The male of one mating pair was observed to palpate the female's abdomen with his hindtarsi 1.5 minutes before the termination of mating. In addition, for 30 seconds prior to the termination of mating, the male intermittently buzzed his wings.

Mating was terminated by the male climbing up on the female or falling to one side and then pushing off with all six tarsi.

Oviposition behavior.—Female *E. subcuprea* were not observed ovipositing. However, because this species spends most of their time on *Quercus* sp. and since females have long, laterally flattened ovipositors, cracks and crevices in the tree bark or seed heads of composites probably serve as oviposition sites.

Daily rhythm of activity.—*Efferia subcuprea* foraged/fed at a fairly constant level throughout the day, beginning between 0800 and 1000 h and continuing to 1700 to 1800 h. (Fig. 15). The peak observed feeding period occurred between 1500 and 1600 h.

One observed mating occurred simultaneously with the peak feeding period, whereas another mating occurred in the morning between 1100 h and 1200 h.

Efferia triton

Foraging and feeding behavior.—As was observed for *E. cressoni, E. triton* foraged from both the ground and vegetation (18 cm to 1.3 m above the ground), depending upon the temperature of the ground surface. This species usually foraged from the ground, including rocks, until the surface temperature reached 37 to 39°C. Some asilids remained on the ground until the temperature reached approximately 49°C, however at that temperature their foretarsi were elevated above their heads.

Efferia triton also has developed additional behaviors to adapt to temperature variations. During cooler parts of the day when the surface temperature was 32 to 36°C or less, the asilids would flatten themselves against the ground with their broadside to the sun. As substrate temperatures increased they lifted their bodies high above the substrate and faced into the sun.

As *E. triton* foraged, it made several round trip flights from a single location. Generally flights were initiated every 15 to 90 seconds covering distances of 15 cm to 2.5 m. This species successfully captured prey at these distances. Other species of Asilidae which we have observed usually capture prey at shorter distances than those over which they forage. This observation suggests that *E. triton* may have better vision than some other asilid species. Melin (1923) also noted differences in the visual acuity of the species that he studied.

When this species changed foraging positions, it flew 3 to 4 m in and out of the vegetation, 3 to 4 cm above the ground. If the wind blew in excess of 16 to 19 km/h the asilids minimized all activity and flattened themselves against the surface upon which they were resting.

As was observed for the other two species of *Efferia*, *E. triton* was most successful when the prey was backlighted. Melin (1923) also noted that, ". . . robberflies often catch their prey against the sun . . . ."

Efferia triton caught most of its prey in the air although one female attacked and captured an unidentified grasshopper nymph clinging to a grass stem. Following prey capture, the asilids would often hover and manipulate the prey with all six tarsi. Unsuitable prey were then released, whereas the asilids inserted their hypopharynx in the dorsum of the head, thorax or abdomen of acceptable prey. During the feeding process abdomens were typically pierced last (Fig. 9).

Intermittently during feeding *E. triton* would hover above its feeding site and manipulate prey with all six tarsi prior to reinserting its hypopharnyx. This behavior often occurred two to four times as the asilids fed. One female manipulated a prey by falling on her side and using all six tarsi to reposition the prey prior to reinserting her hypopharynx.

Efferia triton fed on prey for periods ranging from 2 to 40 minutes ($\bar{x}$ 14 min.). There was a positive correlation between prey length and the time spent feeding. Prey with an average length of 6.8 mm (e.g. Hymenoptera: Anthophoridae, *Ceratina* sp.) were fed on for approximately 5.5 minutes. Larger prey, such as *Ravinia lherminieri* (R.-D.) (Diptera: Sarcophagidae) with an average length of 9.8 mm, were fed on for an average of 30 minutes.

At the completion of feeding, prey were pushed off the asilid's hypopharynx with the foretarsi while the asilid was at the feeding site or prey were dropped in flight as the asilid resumed foraging and/or moved to a new location.

This species has an interfeeding time of 4 to 12 minutes, ($\bar{x}$ 7.5 min.). These interfeeding times are relatively short when one considers the large size of the prey which *E. triton* captures. Asilids of similar size which feed on prey similar in size to that of *E. triton* usually have longer interfeeding times (Dennis and Lavigne, 1976, 1979).

The following is a list of prey taken by *E. triton*: COLEOPTERA, Bruchidae: *Zabrotes* sp., IV-9-72 (♂); Chrysomelidae: *Coscinoptera mucorea* (LeConte) or near, IV-11-72 (♀); *Pachybrachys* sp., IV-5-72 (♂), IV-8-72 (♂), IV-11-72 (♀); Scarabaeidae: *Anomala* sp., IV-2-72 (2 ♂, ♀), IV-3-72 (♂,♀), IV-4-72 (♀), IV-5-72 (♂), IV-9-72 (♂,♀). DIPTERA, Asilidae: *Efferia cressoni* (Hine), IV-2-72 (♂), *Efferia* *subcuprea* (Schaeffer), IV-8-72 (♂), IV-9-72 (2♂), IV-10-72 (♂), IV-11-72 (2♂); Bombyliidae: *Lepidanthrax proboscideus* (Loew), IV-6-72 (♂); *Lordotus apicula* (Coquillett), IV-11-72 (♀); *Lordotus divisus* Cresson, IV-6-72 (♀), IV-11-72 (♂); Calliphoridae: *Phormia regina* (Meigen), IV-3-72 (♂), IV-8-72 (♂,♀), IV-9-72 (♀), IV-10-72 (♀); Cecidomyiidae: *Neolasioptera* sp., IV-9-72 (♀); Chloropidae: *Thaumatomyia* sp., IV-9-72 (♀); Sarcophagidae: *Ravinia lherminieri* (Robineau-Desvoidy), IV-2-72 (♀), IV-4-72 (♀), IV-9-72 (♀); Scenopinidae: *Scenopinus* sp., IV-9-72 (♂); Stratiomyiidae: *Pachygaster* sp., IV-9-72 (♂); Syrphidae: *Eristalis latifrons* Loew, IV-10-72 (♀); Tachinidae: *Olenochaeta kansensis* Townsend, IV-11-72 (♂), *Paradidyma singularis* (Townsend), IV-10-72 (♀); *Peleteria* sp., IV-11-72 (♂); unidentified, IV-11-72 (♂); Tephritidae: *Trupanea actinobola* (Loew), IV-10-72 (♂). HEMIPTERA, Alydidae: *Alydus eurinus* (Say), IV-10-72 (♂); *Stachyocnemus apicalis* (Dallas), IV-9-72 (♂); Cydnidae: *Cydnoides renormatus* (Uhler), IV-6-72 (♂), IV-9-72 (♀); Lygaeidae: *Xyonysius californicus* (Stål), IV-3-72 (♂); Miridae: *Neurocolpus nubilus* (Say), IV-10-72 (♂); Pentatomidae: *Thyanta pallidovirens* (Stål), IV-2-72 (♂); *Trichopepla* sp., IV-6-72 (♀); Rhopalidae: *Arhyssus lateralis* (Say), IV-8-72 (♀), IV-9-72 (♀); Scutelleridae: *Homaemus parvulus* (Germar), IV-3-72 (♂), IV-10-72 (♀). HOMOPTERA, Cixiidae: *Oecleus* sp., IV-10-72 (♀); Membracidae: *Ophiderma* sp., IV-9-72 (♀). HYMENOPTERA, Anthophoridae: *Ceratina* sp., IV-2-72 (♀); Apidae: *Apis mellifera* L., IV-11-72 (2 ♀); Ichneumonidae: *Anomalon* sp., IV-10-72 (♀); *Carinodes* sp., IV-5-72; *Coccygomimus* sp., IV-5-72 (♀); unidentified, IV-9-72 (♀); Pompilidae: *Agenioideus birkmanni* (Banks), IV-11-72 (♀); Sphecidae: near *Tachysphex* sp., IV-3-72 (♀), IV-8-72 (♂); *Tachyspex* sp., IV-3-72 (♂), IV-11-72 (♂). LEPIDOPTERA: Gelechiidae: *Eudactylota* sp., IV-6-72 (♂); *Filatima albilorella* (Zeller), IV-9-72 (♀); prob. *Filatima* sp., IV-6-72 (♀); Geometridae: *Semiothisa californiaria* (Packard), IV-9-72 (♀); Lycaenidae: *Hemiargus isola alce* (W. H. Edwards), IV-9-72 (♂); *Sandia macfarlandi* Clench and Miller, IV-3-72 (♀), IV-4-72 (♂); Noctuidae: *Bulia* sp., IV-9-72 (♂); Pieridae: *Nathalis iole* Boisduval, IV-6-72 (♂); Pyralidae: Peoriinae, IV-10-72 (♀), *Pyrausta perrubralis* (Packard), IV-8-72 (♂). NEUROPTERA, Chrysopidae: *Eremochrysa punctinervis* (McLachlan), IV-10-72 (2 ♀), IV-11-72; Myrmeleontidae: *Brachynemurus sackeni* Hagen, IV-11-72 (♀). ORTHOPTERA, Acrididae: *Psoloessa texana pusilla* (Scudder), IV-2-72 (♀).

As can be seen from the prey list, *E. triton* preyed on both male and female *E. cressoni* and *E. subcuprea*. Since only male *E. triton* were observed preying on these species, they may have been initially trying to mate. As was observed for *Machimus callidus* (Williston) (Dennis and Lavigne, 1979), male *E. triton* may need to make contact with another asilid before being able to determine its suitability as a mate. In addition, prey size and movement stimulate both foraging and mating.

Efferia triton fed primarily on Diptera, which comprised approximately 34 percent of the prey (Table 1). Coleoptera, Hemiptera and Hymenoptera each made up about 14 to 17 percent of the prey, respectively, followed by Lepidoptera, Neuroptera, Homoptera and Orthoptera. Male and female *E. triton* exhibited similar food choices. Males fed mainly on Diptera while females fed on both Diptera and Hymenoptera.

This species was 2.3 times as large as its prey (Table 2). Females fed on smaller prey than did males and thus had a larger predator to prey ratio.

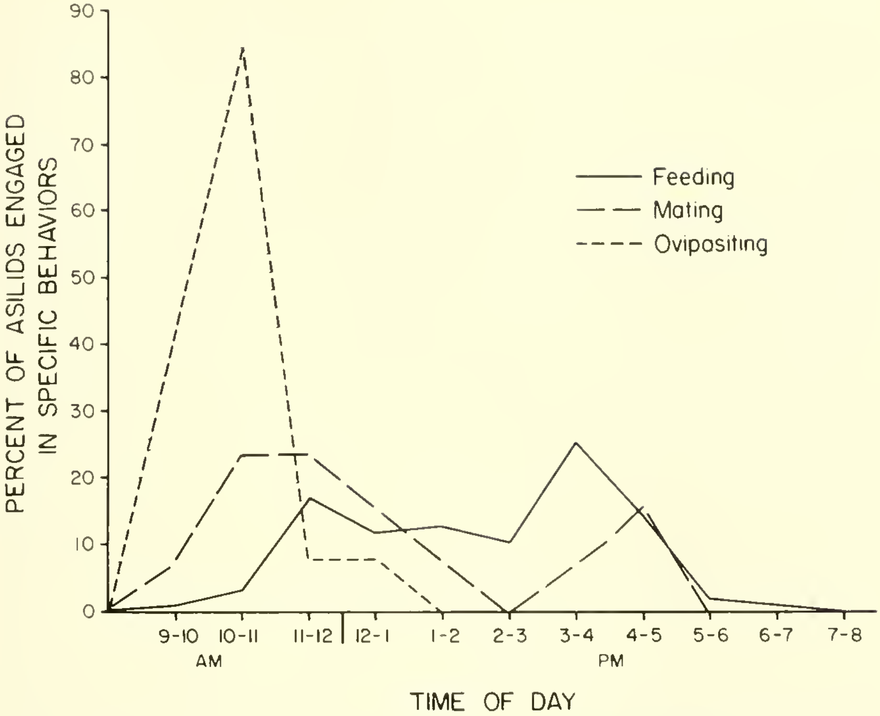


Fig. 16. The diurnal rhythm of activity of *Efferia triton*. (The percentage of asilids engaged in specific behavior patterns was calculated from the total number of observations for each behavior—115, 13 and 13 for feeding, mating and oviposition, respectively).

Mating behavior.—Male *E. triton* exhibited searching flights for receptive females with which to mate. These flights covered 5 to 10 m during which the males often buzzed their wings.

Matings were ordinarily initiated in flight, although one mating was initiated when a male landed on a female resting on the vegetation. Additionally, males could be stimulated to chase and mate by releasing females in their vicinity.

The mating sequence and position taken (Fig. 10) was similar to that observed for *E. cressoni* and *E. subcuprea*. However, matings lasted for only 45 to 90 seconds, with an average of 61 seconds. As mating neared completion the male generally buzzed its wings continuously for 5 to 30 seconds, then fell to the females' right or left side and used all six legs to separate (Fig. 11). One male buzzed his wings during the entire 45 second mating. Another male buzzed his wings for 28 seconds, stopped, and then buzzed another 8 to 10 seconds before separating from the female.

Once copulated *E. triton* moved onto vegetation 7.5 cm to 2.5 m above the ground. The air temperature at the height of mated pairs varied between 25 and 34°C ($\bar{x}$ 29.6°C).

Oviposition behavior.—*Efferia triton* females oviposited 10 to 30 cm above the ground between the sheath and stem of dead grass stalks (Fig. 12), dead Asteraceae (Compositae) and *Nolina texana* (Lilaceae) stems. While searching for a suitable site to deposit eggs, each female crawled up and around vegetation probing with its ovipositor.

Females deposited 3 to 13 eggs per oviposition with an average of 7 eggs, over a 35 second to 2 minute period. Eggs were oval and creamy-white (Fig. 13). Ninety-four eggs were measured which ranged in length from 1.48 to 1.87 mm ($\bar{x}$ 1.72 mm) and width and from 0.43 to 0.71 mm ($\bar{x}$ 0.58 mm).

Following an oviposition, females would begin searching for another oviposition site or forage. Females oviposited from 5 to 12 times before initiating foraging or being lost to sight. Temperatures at heights where ovipositing females were encountered varied from 29–36°C.

Daily rhythm of activity.—*Efferia triton* also foraged/fed throughout the day (Fig. 16). However, this species exhibited two peak foraging periods one between 1100 and 1200h and the other between 1500 and 1600 h.

Mating *E. triton* were observed mainly between 1000 h and 1200 h. However, another peak period occurred between 1600 and 1700 h. Oviposition also took place mainly in the morning between 1000 and 1100 h.

Since the peak foraging/feeding periods generally followed mating and oviposition, this species was probably replenishing the energy expended during these activities.

SPECIES COEXISTENCE

Limited information has been published on factors that potentially allow several species of Asilids to coexist in a given habitat. Thus, it is of interest to examine the data presented in this paper and speculate on the factors which might allow the three congeneric species to coexist.

Because limited data are presented for some behaviors, especially those for *E. subcuprea,* it is not possible to consider all factors which may be important. The available pertinent data concerns: (1) foraging/feeding sites, (2) prey type, (3) foraging times, and (4) predator and prey length.

All three species foraged and fed at different elevations in the vegetation, with very little overlap. *Efferia cressoni* utilized the microhabitat 10 to 15 cm above the ground. Both *E. triton* and *E. subcuprea* foraged higher in the vegetation, 18 cm to 1.3 m and 1 to 2 m above the ground, respectively. Lehr (1969), in Russia, also noted that asilids utilize different levels in a habitat ("hunting zones") and thus partition resources. This strategy minimizes competition between asilids in a habitat. Lehr also observed that the Asilinae show a more distinct layering of hunting zones than do the Dasypogoninae.

Because *E. cressoni, E. triton* and *E. subcuprea* foraged and fed at different levels in the vegetation, one might expect them to feed on different prey. However, examination of Tables 1 and 2 show that the three species exhibited high overlap in terms of insect orders taken. *Efferia cressoni* and *E. subcuprea* fed predominately on Diptera (36, 42%) and Homoptera (36, 37%), whereas *E. triton* fed mainly on Diptera (34%). Conversely, a close examination of the prey lists shows that these species exhibited very little overlap at the genus and species levels. Each species presumably fed on prey which inhabited their foraging levels. Dennis and Lavigne (1976) have previously observed that differences in prey type contributed to the coexistence of seven species of Asilidae, including two species of *Efferia.*

All three *Efferia* sp. foraged and fed more or less continuously throughout the day (Figs. 14, 15 and 16). However, they exhibited very little overlap in peak foraging periods. *Efferia cressoni* most actively foraged during mid-morning and early-evening; *E. subcuprea* foraged primarily during late-afternoon, and peak foraging for *E. triton* was during late-morning and late-afternoon. Differences in foraging peaks might also contribute to differences in prey selected. Such temporal partitioning might also eliminate opportunities for interspecific attacks.

Differences in prey selection also were reflected in predator prey ratios (Table 2). The three species fed on prey of different sizes, with the most noticeable difference being between *E. triton* and the other two species. *Efferia triton* fed on prey ($\bar{x}$ 9.5 mm) which were approximately twice as large as those of *E. cressoni* ($\bar{x}$ 4.6 mm) and 1.5 times as large as those of *E. subcuprea* ($\bar{x}$ 6.1 mm). Dennis and Lavigne (1976) have indicated that partitioning of prey by size allowed for species coexistence in the species they studied.

Because *E. cressoni, E. subcuprea* and *E. triton* occupied different levels in the vegetation, observed contact between species was minimal. The latter species was the only one which was observed occasionally to prey on the other two species, presumably because of its intermediate level in the vegetation and larger size. Thus, it is assumed that competition for mates and the potential for interbreeding was reduced.

In summary, we speculate that, in combination, the aforementioned factors allow the three *Efferia* species to coexist. In addition to these factors, morphological differences and other behavioral adaptations as observed by Dennis and Lavigne (1976) also may contribute to the coexistence of these species.

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LITERATURE CITED

Dennis, D. S. and R. J. Lavigne. 1976. Ethology of *Efferia varipes* with comments on species coexistence (Diptera: Asilidae). J. Kans. Entomol. Soc. 49: 48–62.

———. 1979. Ethology of *Machimus callidus* with incidental observations on *M. occidentalis* in Wyoming (Diptera: Asilidae). Pan-Pac. Entomol. 55: 208–221.

Lavigne, R. J. 1979. Notes on the ethology of *Efferia argyrogaster* (Diptera: Asilidae) in Mexico. Proc. Entomol. Soc. Wash. 81: 544–551.

———. 1982. Ethology of *Neoitamus vittipes* (Diptera: Asilidae) in South Australia. Proc. Entomol. Soc. Wash. 84: 617–627.

Lehr, P. A. 1969. An ecological and morphological analysis of the robber flies (Diptera: Asilidae). Communication II. Entomol. Rev. 48(3): 341–357.

Martin, C. H. 1965. Distribution patterns and corrected identifications of asilid species reported as common to North and South America (Diptera: Asilidae). Trans. Am. Entomol. Soc. 91: 1–37.

Melin, D. 1923. Contributions to the knowledge of the biology, metamorphosis and distribution of the Swedish asilids in relation to the family of asilids. Zool. Bidrag Uppsala 8: 1–317.

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87(1), 1985, pp. 161–170

PLACEMENT OF THE GENERA *ABELUS* STÅL AND *HEMICENTRUS* MELICHAR IN THE SUBFAMILY CENTROTINAE (HOMOPTERA: MEMBRACIDAE)[1]

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Abstract.—Distinguishing features of the homopterous families Aetalionidae and Membracidae are listed. The tribe Abelini (including *Ischnocentrus* Stål, 1869, new placement, and *Abelus* Stål, 1869) is reassigned to the membracid subfamily Centrotinae, and a key is given to the three New World centrotine tribes. *Hemicentrus* Melichar, 1914, is assigned to the Old World centrotine tribe Leptocentrini, new placement. Centrotinae, Abelini, and Leptocentrini are described and illustrated.

The taxonomic limits of the family Aetalionidae are in dispute. Evans (1946, 1948) summarized earlier opinions on its composition and concluded that only *Aetalion* Latreille, 1810, and *Darthula* Kirkaldy, 1900, belong to the family. Funkhouser (1951) placed *Euwalkeria* Goding, 1926, with *Aetalion* in the Aetalionidae, but listed *Darthula* in the Membracidae. Metcalf and Wade (1965) placed eight genera in Aetalionidae, including the two genera discussed here: *Abelus* Stål, 1869, and *Hemicentrus* Melichar, 1914. While not including *Abelus* or *Hemicentrus*, Hamilton (1971) assigned 21 genera to the Aetalionidae, seven of which (along with *Euwalkeria*) have since been removed to the membracid subfamily Stegaspidinae (Deitz, 1975, 1983).

Having examined representatives of all 25 genera placed in the Aetalionidae by Metcalf and Wade (1965) or Hamilton (1971), I concur with the classifications of Evans (1946, 1948) and Davis (1975) which listed only *Aetalion* and *Darthula* as definite aetalionids. Although lacking the posterior pronotal process which is characteristic of membracids (Table 1), *Abelus* and *Hemicentrus* have definite relatives among the membracid subfamily Centrotinae. Based on similarities in the male and female genitalia, wing venation, and chaetotaxy of the legs, *Abelus* (Figs. 23–32), type-genus of the tribe Abelini, is related to *Ischnocentrus* Stål, 1869 (Figs. 33–43). Likewise, *Hemicentrus* (Figs. 12–22) is related to *Leptocentrus* Stål, 1869, type-genus of the tribe Leptocentrini (Figs. 1–9). Further research, including cladistic analyses, is in progress on the placement of the other genera formerly assigned to the Aetalionidae. Distinguishing features of the Aetalionidae and Membracidae, as here understood, are summarized in Table 1. Davis (1975) previously contrasted the Aetalionidae and Cicadellidae.

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Table 1. Comparison of the families Aetalionidae and Membracidae (Homoptera: Auchenorrhyncha: Membracoidea).

Character	Aetalionidae	Membracidae
Pronotum:	*(See Evans, 1946 for figs.)*	*(Figs. 2, 13, 24, 37)*
Posterior process	absent	present (except in *Abelus* Stål, 1869, and *Hemicentrus* Melichar, 1914)
Suprahumeral horns	absent	present or absent
Wings:	*(See Evans, 1946 for figs.)*	*(Figs. 3, 20, 25, 38)*
Radius	unbranched in fore- and hindwings	branched in fore- or hindwing or both
Claval apex in forewing	uniformly tapered and acute	abruptly acute (most tribes and subfamilies) *or* uniformly tapered and acute (Hysoprorini, Centrodontini, and Stegaspidinae)
Metathoracic legs:	*(See Davis, 1975 for figs.)*	*(Figs. 4, 15, 27, 34)*
Tibial row I	absent	present (except in *Thuris* Funkhouser, 1943, *Mendicea* Goding, 1926, *Bilimekia* Fowler, 1895, some *Marshallella* Goding, 1927, the Stegaspidini, Hemikypthini, and some Darnini)
Tibial row II	present (some Aetalioninae) *or* absent	present (except in *Lirania* Stål, 1862 and *Proterpia* Stål, 1867)
Tibial row III	present (Aetalioninae) *or* absent (Darthulinae)	present (except in *Mendicea, Bilimekia,* some Stegaspidini, and most Membracinae)
Tibial apex	without a fixed spine at each end of transverse row of apical spurs	with a fixed spine at each end of transverse row of apical spurs
Tarsomere I	with numerous short, thin setae on plantar surface	with relatively few setae on plantar surface
Abdomen:	*(See Evans, 1946 for figs.)*	
Coarse punctation	absent	present or absent
Segment IX (pygofer)	enormously prolonged in both sexes (Darthulinae) *or* normal (Aetalioninae)	not prolonged *(Figs. 7, 17, 30, 34)*
Female second valvulae:	*(See Davis, 1975 for figs.)*	*(Figs. 5, 11, 20, 26, 43; also Deitz, 1975)*
Shape in lateral aspect	bladelike and relatively straight *or* with prominent dorsal convexity	variously shaped, often consistent within tribes
Base of blade with dorsolateral group of small setae	present	absent

Terminology (including wing venation) and methods used here follow Deitz (1975). Lengths represent the distance from the cephalic apex to the abdominal apex. The sections entitled "Material examined" list only specimens studied in detail as a basis for the descriptions of the Leptocentrini and Abelini. For each specimen the determiner, present location, Deitz's code designation, and the sex are included for future reference. In referring to institutions and collections which hold the material, the following abbreviations are used: AMNH—American Museum of Natural History, New York; JARC—J.A. Ramos Collection, University of Puerto Rico, Mayaguez; NCSU—North Carolina State University, Raleigh; USNM—United States National Museum of Natural History, Washington, D.C.

Family Membracidae Rafinesque, 1815

Subfamily Centrotinae Amyot and Serville, 1843

Figs. 1–43

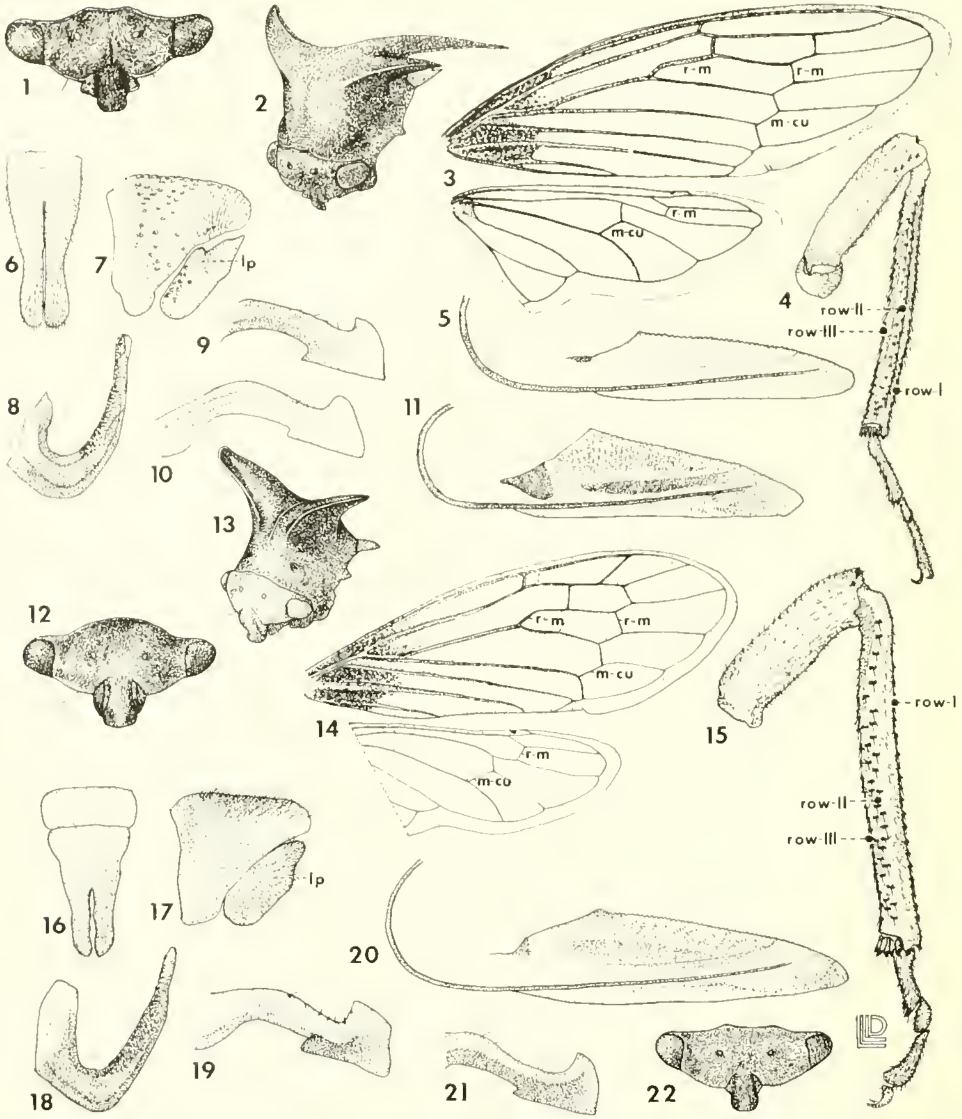
Type-genus: *Centrotus* Fabricius, 1803.

Diagnostic features.—Scutellum laterally or fully exposed. Forewing (Figs. 3, 14, 25, 38) with 2 or 3 r-m crossveins (exception: *Brachybelus* Stål, 1869, with 1 r-m crossvein and R_{4+5} and M_{1+2} contiguous at a single point and separate beyond), claval apex abruptly acute. Tibiae not strongly foliaceous, metathoracic tibia (Figs. 4, 15, 27, 34) more or less triquetrous with 3 longitudinal rows of cucullate setae, row II or III double in some genera. Abdomen moderately to coarsely punctate dorsally and in some genera ventrally.

Description.—Length 2–8 mm. Color black, brown, tan, or mottled, in some genera with contrasting areas of pale pubescence or yellow markings. *Head:* shape of frontoclypeus and ventral margins of vertex various (Figs. 1, 12, 22, 23, 35). *Thorax:* pronotum (Figs. 2, 13, 24, 33, 37) convex, with or without suprahumeral horns, posterior process variable in extent from projecting just slightly above scutellum to projecting beyond abdominal apex (exceptions: *Abelus* Stål and *Hemicentrus* Melichar which lack a posterior pronotal process); scutellum laterally or fully exposed, apex entire or emarginate; forewing (Figs. 3, 14, 25, 38) translucent to hyaline, fully exposed in repose, often coriaceous and punctate basally, venation simple to distally reticulate, with 2 or 3 r-m crossveins (exception: *Brachybelus* Stål with 1 r-m crossvein and R_{4+5} and M_{1+2} contiguous at a single point and separate beyond), with 1 or more m-cu crossveins, clavus abruptly acute apically and with 2 distinct veins, apical limbus moderately broad; hindwing venation various; pro- and mesopleura without ventral processes (contrasted with Oxyrhachinae; Capener, 1962); tibiae not strongly foliaceous; mesothoracic tibia with (tribe Abelini, Figs. 28, 36) or without longitudinal rows of cucullate setae; metathoracic femur (Figs. 4, 15, 27, 34) with or without longitudinal row of prominent cucullate setae, tibia usually triquetrous with 3 longitudinal rows of cucullate setae, row II or III double in some genera, tarsus longer than pro- or mesothoracic tarsus, tarsomere I with 2 or fewer cucullate setae apically, tarsomeres II and III without cucullate setae. *Abdomen:* segments moderately to coarsely punctate dorsally and in some genera ventrally. *Male:* lateral plates (Figs. 7, 17, 30, 42) distinct, not fused to pygofer; aedeagus (Figs. 8, 18, 31, 39) U-shaped, shaft with minute teeth or scales on anterior surface. *Female:* sternum VII with posterior margin deeply and broadly emarginate; second valvulae variously shaped (Figs. 5, 11, 20, 26, 43; also Deitz, 1975).

Distribution.—The Centrotinae occur in all major zoogeographical regions of the world (Metcalf and Wade, 1965). Kosztarab's (1982) statement that all New World membracids belong to the subfamily Membracinae is incorrect.

Discussion.—Although apparently related to the subfamilies Oxyrhachinae, Stegaspidinae, and Nessorhininae, the Centrotinae may be distinguished by features



Figs. 1–22. Leptocentrini. 1–5, *Leptocentrus bos.* 1, Head, frontal aspect. 2, Pronotum, anterolateral. 3, Right wings. 4, Left metathoracic leg, ablateral. 5, Female second valvulae, lateral. 6–9, *L. taurus.* 6, Male subgenital plate, venter. 7, Male pygofer and lateral plate (lp), lateral. 8, Aedeagus, lateral. 9, Male left style apex, lateral. 10, *Nilautama minutispina,* male left style apex, lateral. 11, *Otinotus bantuantus,* female second valvulae, lateral. 12–20, *Hemicentrus cornutus.* 12, Head, frontal. 13, Pronotum, anterolateral. 14, Right wings. 15, Metathoracic leg, ablateral. 16, Male subgenital plate, venter. 17, Male pygofer and lateral plate (lp), lateral. 18, Aedeagus, lateral. 19, Male left style apex, lateral. 20, Female second valvulae, lateral. 21–22, *H. retusos.* 21, Male left style apex, lateral. 22, Head, frontal.

noted by Deitz (1975) and Capener (1962). Wing venation, the chaetotaxy of the hindlegs and the shape of clavus in the forewings are helpful in separating members of the Centrotinae from the Aetalionidae.

The classification of the Old World Centrotinae needs revision. In Capener's (1968) tribal revision of the African Centrotinae, he noted that the traditional separation of groups based on the presence or absence of suprahumeral horns is largely artifical. Likewise, the present study suggests that less emphasis should be placed on pronotal shape and more emphasis on the genitalia, wing venation, and chaetotaxy of the legs. Although lacking a posterior pronotal process (Fig. 13), the genus *Hemicentrus* Melichar nevertheless belongs to the Old World tribe Leptocentrini which is redescribed below.

The New World centrotine genera have been placed in 2 tribes, Boocerini and Platycentrini (Deitz, 1975), and here the tribe Abelini is added to these (see key below). Again, the previous placement of Abelini in the Aetalionidae was seemingly based on superficial features of the pronotum.

KEY TO THE NEW WORLD TRIBES OF CENTROTINAE

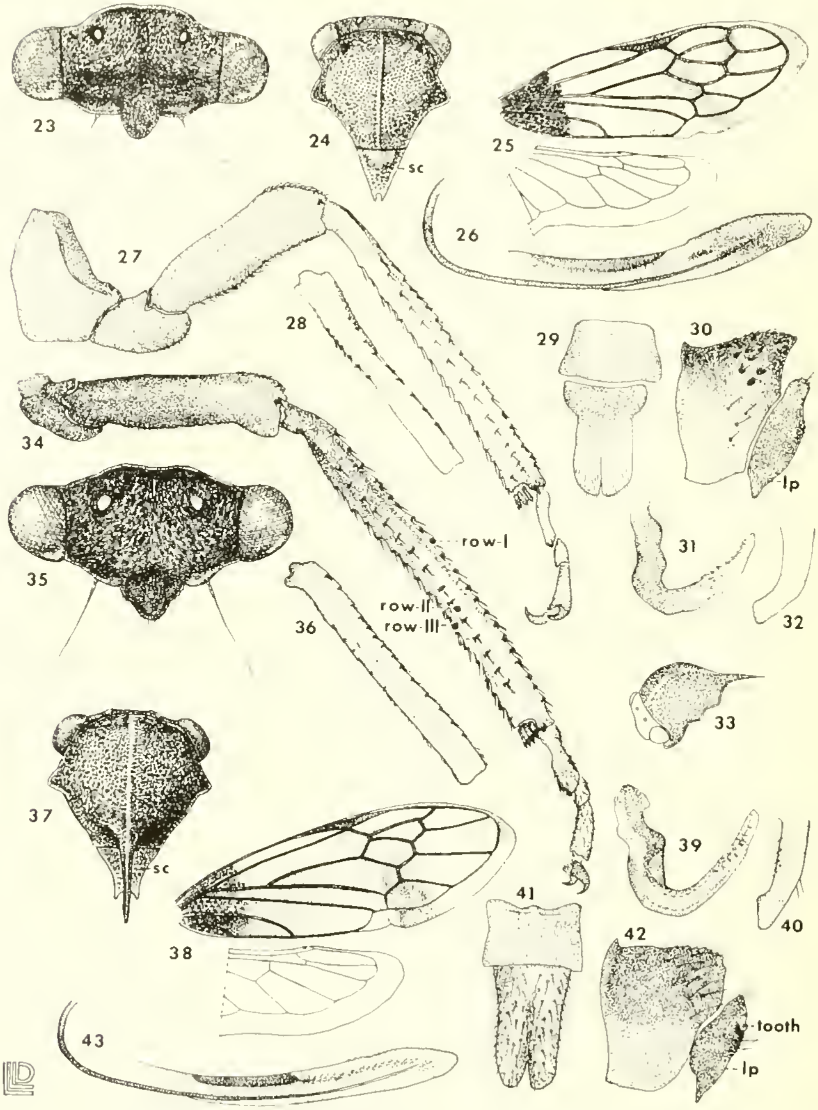
1. Mesothoracic tibia (Figs. 28, 36) with 2 longitudinal rows of cucullate setae; posterior pronotal process absent (Fig. 24) or greatly reduced and spinelike (Figs. 33, 37) .... Abelini
— Mesothoracic tibia without longitudinal rows of cucullate setae; posterior pronotal process better developed 2
2. Forewings with 2 or more m-cu crossveins; scutellum exposed laterally but concealed by pronotum medially .... Platycentrini
— Forewings with 1 m-cu crossvein (exception: *Ophicentrus* Fowler, 1896, which lacks m-cu crossvein but has M_{3+4} and Cu_1 contiguous at 1 point and separate beyond); scutellum either exposed laterally or entirely ... . Boocerini

Tribe Abelini Goding, 1930 (New World)
Figs. 23–43

Type-genus: *Abelus* Stål, 1869.

Diagnostic features.—Head (Figs. 23, 35) with vertex lacking toothlike ventral projections; frontoclypeal lobes not distinct from frontoclypeus. Pronotum (Figs. 24, 33, 37) with posterior process absent or greatly reduced; scutellum fully exposed, apex emarginate. Forewing (Figs. 25, 38) with pterostigma, with 2 r-m and 1 m-cu crossveins. Hindwings with 1 r-m and 1 m-cu crossvein. Mesothoracic tibia (Figs. 28, 36) with 2 longitudinal rows of cucullate setae. Male lateral plate (Figs. 30, 42) with or without posterior tooth; styles (Figs. 32, 40) curved and more or less truncate apically. Female second valvulae (Figs. 26, 43) narrow and elongate, slightly broader apically.

Description.—Length 3–4 mm. Color black, brown, or tan, pronotum in some species with pale middorsal stripe, legs dark basally and pale distally; areas of pale pubescence present especially laterally; thorax in some species with white waxy secretions laterally and on base of scutellum. *Head:* vertex (Figs. 23, 35) without toothlike ventral projections; frontoclypeal lobes not distinct from frontoclypeus. *Thorax:* pronotum (Figs. 24, 33, 37) without suprahumeral horns, posterior process absent (*Abelus* Stål) or greatly reduced, spinelike, and elevated above scutellum (*Ischnocentrus* Stål); scutellum (Figs. 24, 37) fully exposed, apex emarginate; forewing (Figs. 25, 38) hyaline with dark markings, pterostigma present at confluence of Sc and R_1, with 2 r-m and 1 m-cu crossveins; hindwing (Figs.



Figs. 23–43. Abelini. 23–32, *Abelus luctuosus.* 23, Head, frontal aspect. 24, Pronotum and scutellum (sc), dorsal. 25, Right wings. 26, Female second valvulae, lateral. 27, Left metathoracic leg, ablateral. 28, Left mesothoracic tibia, ablateral. 29, Male subgenital plate, venter. 30, Male pygofer and lateral plate (lp), lateral. 31, Aedeagus, lateral. 32, Male left style apex, dorsolateral. 33, *Ischnocentrus niger,* pronotum, anterolateral. 34–42, *Ischnocentrus* sp., #83-331a ♂. 34, Left metathoracic leg, ablateral. 35, Head, frontal. 36, Left mesothoracic tibia, ablateral. 37, Pronotum and scutellum (sc), dorsal. 38, Right wings. 39, Aedeagus, lateral. 40, Male style apex, dorsolateral. 41, Male subgenital plate, venter. 42, Male pygofer and lateral plate (lp), lateral. 43, *Ischnocentrus* sp., #83-331b ♀, second valvulae, lateral.

25, 38) with 1 r-m and 1 m-cu crossvein; mesothoracic tibia (Figs. 28, 36) with 2 longitudinal rows of cucullate setae ablaterally; metathoracic femur (Figs. 27, 34) without rows of cucullate setae, tibia with all 3 rows single, tarsomere I with 1 to 3 cucullate setae apically. *Male:* lateral plate (Figs. 30, 42) with (*Ischnocentrus*) or without (*Abelus*) posterior tooth, with ventral lobe; style (Figs. 32, 40) curved and more or less truncate apically. *Female:* second valvulae (Figs. 26, 43) elongate, narrow in area of dorsomedial fusion, slightly broader apically, dorsal margin with small teeth apically.

Distribution.—The tribe Abelini occurs only in the Neotropical region, from Nicaragua south to Bolivia (material examined, Metcalf and Wade, 1965).

Discussion.—The tribe Abelini has all the features of the subfamily Centrotinae as described above, but its members are easily distinguished from those of other centrotine tribes by the presence of rows of cucullate setae on the mesothoracic tibiae (Figs. 28, 36). Additionally, the pronotum is quite simple (Figs. 24, 33, 37), armed at most with a short spinelike posterior process.

Abelini includes only 2 genera: *Abelus* Stål, 1869 (type-species: *A. luctuosus* Stål, 1869, by monotypy) and *Ischnocentrus* Stål, 1869 (type-species: *I. niger* Stål, 1869, by subsequent designation of Funkhouser (1927)).

Morphologically, the 2 genera differ primarily in the degree to which the posterior pronotal process is developed (Figs. 24, 33, 37) and in males, the presence or absence of a posterior tooth on the lateral plates (Figs. 30, 42). The geographic ranges of *Ischnocentrus* (Nicaragua, Costa Rica, Panama, Ecuador, Guyana, French Guiana, and Colombia) and *Abelus* (Colombia, Venezuela, Peru, and Bolivia) overlap in Colombia (material examined, Metcalf and Wade, 1965).

In Stål's (1869) original description of *Abelus*, he noted that the genus was related and structurally similar to *Ischnocentrus*, but Goding (1930) who erected the tribe Abelini (as Abelusini, in the Aetalioninae, Membracidae) included in it only the genus *Abelus*. Although Funkhouser (1951) appropriately treated Abelini as a tribe of the Centrotinae (Membracidae), he placed in the tribe 12 additional genera, while assigning *Ischnocentrus* to the "Hebesini" (the latter is not considered to be validly derived because it is not based on a published genus name). Lastly, Metcalf and Wade (1965) placed *Ischnocentrus* in the tribe Boocerini (Membracidae: Centrotinae), but assigned the Abelini to the Aetalionidae, with the result that *Abelus* and *Ischnocentrus* were not only in different tribes, but also different families. Aside from the type-genus, none of the genera formerly placed in the Abelini (Funkhouser, 1951; Metcalf and Wade, 1965) are appropriately ascribed to this tribe.

Material examined.—*Abelus* sp., determined L. L. Deitz, JARC, #83-331c ♂, #83-331d ♀; *A. luctuosus* Stål, det. W. D. Funkhouser, USNM, #82-83b ♂—as det. in Funkhouser Collection, USNM, #82-83c ♀; *Ischnocentrus* sp(p)., det. L. L. Deitz, AMNH, #72-148e ♂, #72-148f ♂, #72-148g ♀, #72-148h ♀—NCSU, #70-231c ♀, #70-231d ♂, #83-331a ♂—JARC, #83-331b ♀; *I. niger* Stål, as det. in USNM, #71-81h ♀, #71-81i ♂.

Tribe Leptocentrini Distant, 1908 (Old World)

Figs. 1–22

Type-genus: *Leptocentrus* Stål, 1866.

Diagnostic features.—Head (Figs. 1, 12, 22) with vertex lacking toothlike ventral projections; frontoclypeal lobes more or less prominent. Pronotum (Figs. 2, 13) with or without posterior process extending above scutellum; scutellum fully exposed, apex emarginate. Forewing (Figs. 3, 14) without pterostigma, with 2 or 3 r-m crossveins and 1 m-cu crossvein. Hindwing with 1 r-m and 1 m-cu crossvein.

Mesothoracic tibia without rows of cucullate setae. Male lateral plate (Figs. 7, 17) without tooth; style apex (Figs. 9, 10, 19, 21) expanded, triangular. Female second valvulae (Figs. 5, 11, 20) broadened dorsally near midlength and gradually tapering apically.

Description.—Length 4–8 mm. Color black, brown, or tan, often with areas of white or yellow pubescence laterally and ventrally. *Head:* (Figs. 1, 12, 22) vertex without toothlike ventral projections; frontoclypeal lobes more or less prominent. *Thorax:* pronotum (Figs. 2, 13) with or without suprahumeral horns, with (most genera) or without (*Hemicentrus* Melichar) elongate posterior process extending above scutellum; scutellum fully exposed, apex emarginate; forewing (Figs. 3, 14) without pterostigma, with 2 or 3 r-m crossveins and 1 m-cu crossvein; hindwing (Figs. 3, 14) with 1 r-m and 1 m-cu crossvein; mesothoracic tibia without rows of cucullate setae; metathoracic femur (Figs. 4, 15) without rows of cucullate setae, tibia with row II scattered or double. *Male:* lateral plate (Figs. 7, 17) without tooth; style apex (Figs. 9, 10, 19, 21) expanded, triangular. *Female:* second valvulae (Figs. 5, 11, 20) narrow basally, broadened dorsally near midlength and gradually tapering apically, dorsal margin with numerous, small teeth or crenulations posterior to broadest point of blade.

Distribution.—Members of the Leptocentrini, as defined above, occur in the Afrotropical, Oriental, and Palearctic regions (Metcalf and Wade, 1965; Capener, 1968; Nast, 1972). It is uncertain if any of the Australian genera should be ascribed to this tribe (Evans, 1966). All of the New World genera listed as Leptocentrini by Metcalf and Wade (1965) have been moved elsewhere (see discussion, below).

Discussion.—Metcalf and Wade (1965) assigned 38 genera to the Leptocentrini. Capener (1968) listed 17 genera of African Leptocentrini, including 4 new genera and 9 others not placed in the tribe by Metcalf and Wade; Capener removed *Xiphopoeus* Stål, 1866, to the Xiphopoeini (Centrotinae) and *Acanthophyses* Stål, 1866, to the Centrotini. Deitz (1975) assigned *Orthobelus* Stål, 1869, and the 14 strictly New World genera included in the Leptocentrini by Metcalf and Wade (1965) to various other tribes: Boocerini and Platycentrini (Centrotinae), Nessorhinini (Nessorhininae), Quadrinarcini (Smiliinae), and Microcentrini (Stegaspidinae).

The description above further limits the tribe to those genera in which there is a single m-cu crossvein in the forewings (Figs. 3, 14). This definition excludes a number of genera which differ from *Leptocentrus* in several other features, including the male and female genitalia: *Centrotusoides* Distant, 1916, and *Centruchus* Stål, 1866, placed in the Leptocentrini by Capener (1968), the Australian genera *Cebes* Distant, 1916, *Eufairmairia* Distant, 1916, *Eufrenchia* Goding, 1903, and *Lubra* Goding, 1902, and perhaps some other genera placed in the tribe by Metcalf and Wade (1965) which I have not examined.

A complete listing of the genera belonging to the Leptocentrini as defined above necessarily awaits further studies of the Old World centrotine genera.

Placement of *Hemicentrus* Melichar in the Leptocentrini.—*Hemicentrus* Melichar, 1914 (type-species: *H. bicornis* Melichar, 1914, by original designation and monotypy), is morphologically very similar to *Leptocentrus* Stål, 1866 (type-species: *Centrotus bos* Signoret *in* Fairmaire and Signoret, 1858, by subsequent designation of Buckton (1903)), and the other leptocentrine genera studied (see material examined). Especially striking are similarities in the genitalia of both sexes (Figs. 6–11, 16–21). The lateral processes of the pronotum are also similar in *Hemicentrus* and *Leptocentrus* (Figs. 2, 13) but members of *Hemicentrus* lack the posterior pronotal process, and they have prominent frontoclypeal lobes (Figs. 12, 22) than members of *Leptocentrus* (Fig. 1).

Geographically, *Hemicentrus* occurs within the range of the tribe Leptocentrini, apparently being restricted to the Oriental region (Metcalf and Wade, 1965).

Historically, Melichar (1914) described *Hemicentrus* in the Centrotidae [sic], and Funkhouser (1927) placed the genus in the subfamily Centrotinae (Membracidae). Goding (1930) assigned *Hemicentrus* to the Aetalioninae (Membracidae) and later (1931, 1934) to the tribe Tolaniini of the Aetalionidae. (Although superficially similar to *Tolania* Stål, 1858, *Hemicentrus* differs in features of the forewings, male genitalia, and chaetotaxy of the legs, and also in having coarse abdominal punctuation.) Evans (1946), who treated the Aetalionidae as a distinct family, considered *Hemicentrus* to be a membracid. Funkhouser (1951) included *Hemicentrus* in the Darthulini (Membracidae: Centrotinae). (*Darthula* Kirkaldy, like *Hemicentrus*, occurs only in the Oriental region, but morphologically is much closer to *Aetalion* Latreille than to *Hemicentrus*.) Metcalf and Wade (1965) placed *Hemicentrus* in the tribe Tolanini (Aetalionidae: Aetalioninae). Lastly, Strümpel (1972) considered *Hemicentrus* to be closely related to the New World family Biturritiidae, but *Hemicentrus* differs greatly from *Biturritia* Goding, 1930, in features of the genitalia and forewings, and in the shape of head, scutellum, and pronotum.

Material examined.—*Bathoutha indicans* (Walker), as determined in USNM, #83-334b ♀; *Bocchar montanus* Jacobi, det. W. D. Funkhouser, USNM, #83-334c ♂—as det. in USNM, #83-334d ♀; *Hemicentrus cornutus* (Funkhouser), as det. Funkhouser Collection, USNM, #82-115d ♀, #82-115e ♂; *H. retusus* (Distant) [det. as *Sarritor retusus* Distant, by W. D. Funkhouser], USNM, #83-227a ♂; *Leptocentrus* sp., as det. in NCSU, #70-210c ♀; *L. bos* (Signoret *in* Fairmaire and Signoret), det. W. L. McAtee, USNM, #71-299b ♀; *L. lama* (Signoret *in* Fairmaire and Signoret), as det. in NCSU, #81-42b ♀; *L. taurus* (Fabricius), det. Z. P. Metcalf, NCSU, #81-42b ♀, #81-42c ♂; *Nilautama minutispina* Funkhouser, det. W. D. Funkhouser, USNM, #83-334g ♀—as det. in Funkhouser Collection, USNM, #83-334h ♂; *N. typica* Distant, as det. in NCSU, #81-42h ♀; *Otinotus bantuantus* (Distant), det. A. L. Capener, USNM, #83-334e ♂, #83-334f ♀; *O. elongatus* Distant, det. Z. P. Metcalf, NCSU, #81-42e ♀, #81-42f ♂.

CONCLUSIONS

Based on characters discussed above, the genera *Abelus* Stål and *Hemicentrus* Melichar belong to the membracid subfamily Centrotinae: *Abelus* in the New World tribe Abelini, *Hemicentrus* in the Old World tribe Leptocentrini. Nevertheless, both genera lack a posterior pronotal process, the presence of which is generally regarded as a synapomorphy of the family Membracidae. Its absence in *Abelus* and *Hemicentrus* is likely to be secondarily derived, rather than plesiomorphic, because members of both genera have a more reduced forewing venation (only 1 m-cu crossvein) than would be expected in an ancestor of the membracids. The lack of a posterior pronotal process in the Aetalionidae may be plesiomorphic, but its members, with R unbranched in both pairs of wings and with at most 2 rows of cucullate setae on the hind tibia, are also unlikely to have been ancestral to the Membracidae.

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LITERATURE CITED

Buckton, G. W. 1903. Pp. 181–296. *In* Buckton, G. W., ed., 1901–1903. A Monograph of the Membracidae. Lovell Reeve & Co., London. 296 pp.

Capener, A. L. 1962. The taxonomy of the African Membracidae. Part 1. The Oxyrhachinae. Entomol. Mem. 6, Dep. Agr. Services, Pretoria, South Africa. 123 pp.

———. 1968. The taxonomy of the African Membracidae. Part 2. The Centrotinae. Entomol. Mem. 17, Dep. Agr. Services, Pretoria, South Africa. 124 pp.

Davis, R. B. 1975. Classification of selected higher categories of auchenorrhynchous Homoptera (Cicadellidae and Aetalionidae). U.S. Dep. Agr. Tech. Bull. 1494. 52 pp.

Deitz, L. L. 1975. Classification of the higher categories of the New World treehoppers (Homoptera: Membracidae). N.C. Agr. Exp. Sta. Tech. Bull. 225. 177 pp.

———. 1983. Name changes in the Membracidae (Homoptera). Proc. Entomol. Soc. Wash. 85: 856–857.

Evans, J. W. 1946. A natural classification of leaf-hoppers (Homoptera, Jassoidea). Part 2: Aetalionidae, Hylicidae, Eurymelidae. Trans. R. Entomol. Soc. Lond. 97: 39–54.

———. 1948. Some observations on the classification of the Membracidae and on the ancestry, phylogeny and distribution of the Jassoidea. Trans. R. Entomol. Soc. Lond. 99: 497–515.

———. 1966. The leafhoppers and froghoppers of Australia and New Zealand (Homoptera: Cicadelloidea and Cercopoidea). Aust. Mus. Mem. 12. 347 pp.

Funkhouser, W. D. 1927. Membracidae. General Catalogue of the Hemiptera. Fascicle 1. Smith College, Northampton, Mass. 581 pp.

———. 1951. Homoptera Fam. Membracidae. Genera Insectorum, Fascicle 208, Brussels, Belgium. 383 pp.

Goding, F. W. 1930. Membracidae in the American Museum of Natural History. Am. Mus. Novit. 421: 1–27.

———. 1931. Classification of the Old World Membracidae. J. N. Y. Entomol. Soc. 39: 299–313.

———. 1934. The Old World Membracidae. J. N. Y. Entomol. Soc. 42: 451–480.

Hamilton, K. G. A. 1971. Placement of the genus *Microcentrus* in the Aetalionidae (Homoptera: Cicadelloidea), with a redefinition of the family. J. Ga. Entomol. Soc. 6: 229–236.

Kosztarab, M. 1982. Homoptera, pp. 447–470. *In* Parker, S. P., ed., Synopsis and Classification of Living Organisms. McGraw-Hill Inc., New York. Vol. 2. 1232 pp.

Melichar, L. 1914. Homoptera von Java, gesammelt von Herrn. Edw. Jacobson. Notes Leyden Mus. 36: 91–147.

Metcalf, Z. P., and V. Wade. 1965. General Catalogue of the Homoptera. A Supplement to Fascicle 1—Membracidae of the General Catalogue of Hemiptera. Membracoidea. Sections I and II. N.C. State University, Raleigh. 1552 pp.

Nast, J. 1972. Palaearctic Auchenorrhyncha (Homoptera), an annotated check list. Polish Scientific Publ. (Pol. Acad. Sci., Inst. Zool.), Warsaw. 550 pp.

Stål, C. 1869. Bidrag till Membraidernas kännedom. Öfvers. Kongl. Vetensk.-Akad. Förhandl. 1869: 231–300.

Strümpel, H. 1972. Beitrag zur Phylogenie der Membracidae Rafinesque. Zool. Jahrb. Abt. Syst. Ökol. Geogr. Tiere 99: 313–407.

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A NEW MEMBER OF THE *ENCHENOPA BINOTATA* SAY COMPLEX ON TULIP TREE (*LIRIODENDRON TULIPIFERA*)

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Abstract.—A new North American member of the *Enchenopa binotata* Say complex is reported on tulip tree, *Liriodendron tulipifera* (Magnoliaceae). Electrophoretic analysis indicates that it is distinct from other members of the *Enchenopa* complex. The phenology of *Enchenopa* on tulip tree differs dramatically from that of most members of the complex, though eggs hatch and nymphs molt to adults at about the same time as *Enchenopa* on *Robinia pseudoacacia.* Mating and oviposition, however, appear to occur after that on *R. pseudoacacia.*

Enchenopa binotata Say is a complex of six reproductively isolated species in North America. Each of these biological species is restricted to a single species of host plant. The hosts are *Ptelea trifoliata* L. (Rutaceae), *Viburnum prunifolium* L. (Caprifoliaceae), *Celastrus scandens* L. (Celastraceae), *Juglans nigra* L. (Juglandaceae), *Cercis canadensis* L. (Fabaceae), and *Robinia pseudoacacia* L. (Fabaceae). Female *E. binotata* when given a choice will 1) mate on their original host, 2) mate with males from the same host and 3) select their original host for oviposition (Wood, 1980). Electrophoretic analyses have confirmed that *Enchenopa* from each host are distinct by the presence of unique alleles or in the frequencies of alleles. Electrophoretic patterns of *Enchenopa* from each host are consistent from locality to locality (Guttman et al., 1981).

Speciation in this complex appears to be the result of host plant shifts (Wood, 1980) similar to that proposed for *Rhagoletis* flies (Bush, 1969, 1975). Differing host phenologies and nutritional quality were postulated to promote allochronic maturation and mating (Wood, 1980). Allochronic mating combined with diurnal differences in mating effectively inhibits gene flow among the six *Enchenopa* species (Wood and Guttman, 1981, 1982). Reproductive success of mated females that were forced to oviposit on hosts other than their original host is low. Such females deposit fewer egg masses with lower viability than on normal hosts. Eggs hatch on "adopted" hosts at the same time as those from females native to that host. Thus the host plant appears to regulate when eggs hatch and establish allochronic life histories. Survival of nymphs on "adopted" hosts is extremely low (Wood and Guttman, 1983).

Here we report a new member of the *E. binotata* Say complex on tulip tree, *Liriodendron tulipifera* L. (Magnoliaceae). *Enchenopa* on this host have been found in Ohio (Clinton Co.) and Delaware (New Castle Co.). This new form may

Table 1. Allele frequencies at six polymorphic loci coding for enzymes in *Enchenopa binotata* from 7 host plants.

Locus	Allele	*Liriodendron* N = 14	*Juglans* N = 150	*Ptelea* N = 158	*Cercis* N = 130	*Viburnum* N = 140	*Robinia* N = 26	*Celastrus* N = 158
Est-1	*a*					0.01		
	b	0.29	0.05	0.05	0.07	0.19		0.15
	c		0.67	0.58	0.07	0.29		0.41
	d	0.71	0.25	0.18	0.80	0.39	1.0	0.29
	e			0.19	0.08	0.10		0.10
	f					0.02		0.05
Pep-2	*a*		0.15	0.99				
	b	1.0	0.53	0.01	0.34			0.34
	c		0.30		0.64	0.98	1.0	0.66
	d		0.01		0.02	0.02		
Pgi-2	*a*		0.20	0.14		0.01		
	b	0.93	0.77	0.86	0.98	0.93	0.92	0.98
	c	0.07	0.01		0.02	0.06	0.08	0.01
	d		0.01					0.01
Pgm-2	*a*		0.01	0.14	0.02	0.02		0.01
	b					0.01		
	c	1.0	0.95	0.86	0.94	0.96	0.35	0.92
	d		0.03		0.02		0.04	0.03
	e		0.01		0.02		0.62	0.04
Cat-1	*a*	0.79	0.45		0.02	0.03	0.04	0.03
	b				0.34			
	c	0.21	0.46		0.62	0.22		0.25
	d		0.09	1.0	0.02	0.73	0.96	0.70
	e					0.02		0.01
Got-1	*a*							0.02
	b		0.03	0.08	0.08	0.03		0.19
	c	1.0		0.83	0.92	0.97	1.0	0.78
	d		0.97	0.09				0.01

N = number of genomes sampled.

Locus code: Est, esterase; Pep, peptidase; Pgi, phosphoglucose isomerase; Pgm, phosphoglucomutase; Cat, catalase; Got, glutamate oxaloacetate transaminase.

be geographically widespread but we have only found extremely isolated populations with low numbers of individuals; other members of the complex are generally abundant when found. Unlike other members of the complex, *Enchenopa* nymphs on tulip tree tend to be solitary or in small groups and have not been observed to be tended by ants. Nymphs after the first instar are green, making them difficult to locate when they are feeding in the leaf axils and apical meristem.

METHODS

Adult females were collected in August and September and forced to oviposit on branches covered with nylon netting. The following spring, branches with egg masses were observed daily and the number of nymphs counted. To compare the life history phenology of this *L. tulipifera* form to other members of the complex, similar data was collected from each of the six hosts. We treated the day that eggs hatched on the first host as day one and comparisons were made of the mean day eggs hatched on a given host (Wood and Guttman, 1982, 1983).

Table 2. Mean day *Enchenopa binotata* eggs hatched on 7 host species in 1983. Means with overlapping vertical lines represent no statistical differences (ANOVA and Duncan's Multiple Range Test).

Host Plant	$\bar{x}$ Day Eggs Hatched
V. prunifolium	3.17
C. scandens	5.40
P. trifoliata	6.43
J. nigra	6.36
C. canadensis	10.04
R. pseudoacacia	12.84
L. tulipifera	18.83

The genetic relationships of *E. binotata* on tulip tree and the other six species were determined by starch gel electrophoresis of soluble proteins using the methods of Guttman et al. (1981). Six enzyme loci are polymorphic and consistently resolvable in *E. binotata*. Allele frequencies at these loci are listed in Table 1. Genetic similarity, distance coefficients and dendrograms were computed from frequencies using the Biosys-1 program of Swofford and Selander (1981).

RESULTS AND DISCUSSION

Oviposition by females begins in late August and continues through October in Delaware and Ohio. Eggs are deposited in branches representing the most recent growth and then covered with egg froth similar in appearance to that of *E. binotata* from *Viburnum*. Clumping of egg masses on branches is not as pronounced as with other members of the complex. Seldom have we found more than twelve egg masses on a branch while the usual number is five to six. The reduced number of egg masses on branches and the apparent greater dispersion within a host may be an artifact of low population densities on trees or may reflect differences in the biology of this form.

Eggs hatched in 1982 and 1983 about May 19 approximately 12 days after *E. binotata* eggs began to hatch on other hosts (Table 2). On mature host plants egg hatch occurred when *L. tulipifera* was in flower. First instars moved from the woody branch where eggs were deposited to feed on the apical meristem. As with other *Enchenopa*, nymphs at this stage are black. In succeeding instars, nymphs become green but continue to feed on petioles, apical meristems, and green shoots.

Table 3. Matrices of genetic distance (above diagonal) and genetic identity (below diagonal) (Nei, 1972) between *Enchenopa binotata* from 7 host plants.

Host Type	1	2	3	4	5	6	7
1. *Liriodendron*	*****	0.137	0.192	0.073	0.136	0.187	0.101
2. *Juglans*	0.872	*****	0.173	0.134	0.157	0.256	0.111
3. *Ptelea*	0.825	0.841	*****	0.161	0.098	0.159	0.078
4. *Cercis*	0.929	0.874	0.851	*****	0.052	0.099	0.048
5. *Viburnum*	0.873	0.855	0.906	0.949	*****	0.054	0.013
6. *Robinia*	0.829	0.774	0.853	0.906	0.948	*****	0.074
7. *Celastrus*	0.904	0.895	0.925	0.954	0.987	0.929	*****

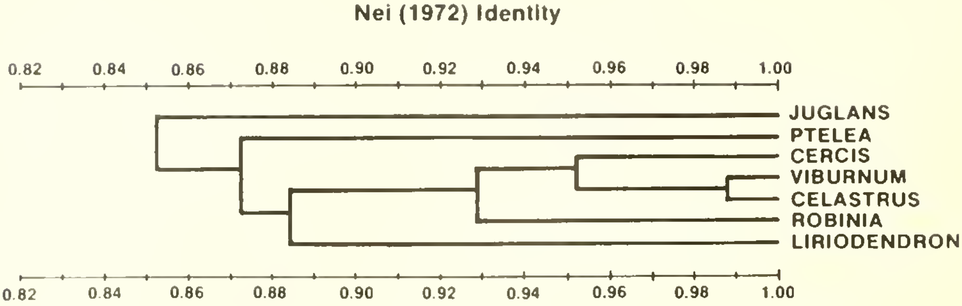

Fig. 1. Cluster analysis of *Enchenopa binotata* from seven hosts.

In 1983, nymphs began to mature on July 4, or 47 days after the first egg hatched. Eclosion to adults occurred over 10 days and began 8 days after that on *R. pseudoacacia*. *Enchenopa binotata* nymphs on *R. pseudoacacia* are always the last of the other members of the complex to turn adult. Because the number of *E. binotata* on *L. tulipifera* were low it is impossible to compare when mating occurred relative to other members of the complex. We did observe five matings and these took place when mating was almost over on all hosts except *R. pseudoacacia*.

Electrophoretically, *E. binotata* from *L. tulipifera* are distinct. Three (Pep-2, Pgm-1, Got-1) of the six loci were invariant in the seven insects examined from Clinton Co., Ohio and Delaware. One, three and four heterozygotes were found at the three remaining loci (Pgi-2, Cat-1, Est-1, respectively). The matrices of genetic distances and similarity coefficients (Table 3) indicate that while the *E. binotata* from *L. tulipifera* are uniformly distinct from those native to all other hosts they have their greatest affinity with treehoppers from *C. canadensis*. Cluster analysis (UPGMA), using Nei's genetic identity (I), indicates that *E. binotata* on *L. tulipifera* diverged after those on *P. trifoliata* but before those on *R. pseudoacacia* (Fig. 1).

Enchenopa binotata on *L. tulipifera* thus is a seventh member of the complex. Extremely limited observations suggest there may be an eighth on hickory, *Carya* (Juglandaceae). Adult *E. binotata* were reported on *Carya* by Funkhouser (1917) but until recently attempts to locate nymphs, adults and egg masses on this host have failed. The only *E. binotata* population on *Carya* we have been able to locate is in Clinton Co., Ohio. In a stand of four large *Carya*, one tree had *E. binotata* consistently over a 4 year period. Green nymphs were found on this tree feeding on the flower inflorescences next to developing nuts. Egg masses on this host were deposited below the apical bud in a fashion similar to those on *J. nigra*. Unfortunately the number of individuals on this host was low and our success in trying to build up a population on trees that were caged failed, so we did not compare the life history phenology nor electrophoretic patterns to other members of the complex.

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LITERATURE CITED

Bush, G. L. 1969. Sympatric host race formation and speciation in frugivorous flies of the genus *Rhagoletis* (Diptera: Tephritidae). Evolution 23: 237–251.

———. 1975. Modes of animal speciation. Ann. Rev. Ecol. Syst. 6: 339–364.

Funkhouser, W. D. 1917. Biology of the Membracidae of the Cayuga Lake basin. Cornell, Agr. Exp. Sta. Memoir 11. Ithaca, NY. pp. 117–445.

Guttman, S. I., T. K. Wood, and A. A. Karlin. 1981. Genetic differentiation along host plant lines in the sympatric *Enchenopa binotata* Say complex (Homoptera: Membracidae). Evolution 35: 205–217.

Swofford, D. L. and R. B. Selander. 1981. Biosys-1: a fortran program for the comprehensive analysis of electrophoretic data in population genetics and systematics. J. Hered. 72: 281–283.

Wood, T. K. 1980. Divergence in the *Enchenopa binotata* Say complex (Homoptera: Membracidae) effected by host plant adaptation. Evolution 34: 147–160.

———. 1982. Ant-attended nymphal aggregations in the *Enchenopa binotata* complex (Homoptera: Membracidae). Ann. Entomol. Soc. Am. 75: 649–653.

Wood, T. K. and S. I. Guttman. 1981. The role of host plants in the speciation of treehoppers: An example from the *Enchenopa binotata* complex, pp. 39–54. *In* Denno, R. R. and H. Dingle, eds. Insect life history patterns: Habitat and Geographic Variation. Springer-Verlag, NY.

———. 1982. The ecological and behavioral basis for the development of reproductive isolation in the sympatric *Enchenopa binotata* complex. Evolution 36: 233–242.

———. 1983. *Enchenopa binotata* complex: Sympatric speciation? Science 220: 310–312.

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ADDITIONS TO NEARCTIC *TRICHOGRAMMA* (HYMENOPTERA: TRICHOGRAMMATIDAE)

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Abstract.—Six new species of *Trichogramma* are described and compared to other members of the genus. The new species are *T. thalense, T. nomlaki, T. browningi* and *T. inyoense* from California, *T. drepanophorum* from Mississippi, and *T. offella* from Louisiana.

Since 1970, we have accumulated numerous unidentifiable populations of *Trichogramma* from North America. Many of these differ marginally from already named species and clarification of their taxonomic status must await detailed morphometric and bionomic investigations. Here we describe six new species from the United States which are easily separated from known congeners. Four are from California and two from southeastern states. These additions increase the number of described species of Nearctic *Trichogramma* to 26. As most areas of the continent have been sampled poorly or not at all, a significant portion of the fauna probably remains unknown.

We use the same terminology in the descriptions as in earlier papers (e.g. Pinto et al., 1978). Acronyms associated with the various structures of the male genitalia are introduced in the first description and used commonly thereafter (also see Figs. 1, 3). Quantitative data represent the mean standard deviation, followed by the range and sample size. All measurements represent maximum dimensions except for the anterior and posterior vein tracts of the hind wings, where the lengths and setal counts are determined from the level of the hamuli to the wing apex.

Specimens were mounted in Hoyer's medium for study. Holotypes and allotypes have been remounted in Canada balsam, ensuring more permanent mounts. Specimens remaining in Hoyer's medium have been ringed twice with Glyptal® to prevent desiccation.

Holotypes and allotypes are deposited in the collection of the United States Museum of Natural History, Washington, D.C. Paratype males are deposited in the collections of the divisions of Biological Control, University of California (Berkeley & Riverside), the British Museum, and United States National Museum.

Trichogramma thalense Pinto & Oatman, NEW SPECIES

Fig. 1a, b

Description based on culture material originating from San Luis Obispo and San Joaquin counties, California; reared on *Trichoplusia ni* (Hübner) eggs at 23–27°C and ca. 50% R.H.

Color.—Based on females preserved in 70% ethanol. Light yellow except pronotum, abdomen and coxae yellow brown.

Male.—*Length:* ca. 0.6 mm. *Antenna:* Flagellum elongate, broadly arcuate at base, 6.35 ± 0.53 (5.5–6.9) (n = 8) as long as wide, 1.06 ± 0.03 (1.0–1.1) (n = 9) as long as hind tibia; setae moderately long, tapering gradually from base to apex, length of longest seta 2.96 ± 0.2 (2.7–3.2) (n = 9) maximum width of flagellum, ca. 32–42 in number. *Forewing:* Vein tracts well defined, moderate number of setae between tracts, 38–61 setae in area between 4th and 5th tracts; length of longest postapical seta on margin ca. 2× maximum width of hind tibia and 0.2 greatest width of wing. *Hindwing:* Posterior vein tract complete almost to apex of wing, setae slightly increasing in length apically; anterior tract with 4–7 setae. *Mesoscutellum:* Anterior pair of setae moderately long, varying from 0.2–0.6 length of posterior pair. *Genital capsule:* Elongate, moderately narrow, 0.34 ± 0.02 (0.3–0.4) (n = 9) as wide as long, constricted at base of gonostyli and usually at middle; gonostyli (from apex to base of median ventral projection) comprising ca. 0.15 the length of genital capsule; dorsal expansion of gonobase (DEG) slightly lobed at base, posterior extension elongate and very narrow, its subapical width ca. 0.2 the distance between apex of gonostyli, apex of DEG usually anterior to apex of chelate structures, attaining 0.89 ± 0.03 (0.8–0.9) (n = 9) length of genital capsule; median ventral projection (MVP) short and slender, apex coinciding closely with that of DEG (but see Remarks) and remote from apex of chelate structures, MVP occupying no more than 0.2 the distance from its base to apex of gonostyli, attaining 0.87 ± 0.02 (0.8–0.9) (n = 9) length of genital capsule; chelate structures (CS) approximating apex of gonostyli, occupying ca. 0.75 distance from base of MVP to apex of gonostyli, attaining 0.96 ± 0.02 (0.94–0.98) (n = 9) length of genital capsule; chitinized ridge (CR) long, distinct, occupying ca. 0.6 distance from MVP to base of genital capsule. *Aedeagus:* 0.66 ± 0.04 (0.6–0.7) (n = 9) as long as hind tibia and ca. same length as genital capsule, apodemes comprising 0.48 ± 0.02 (0.4–0.5) (n = 9) total length of aedeagus.

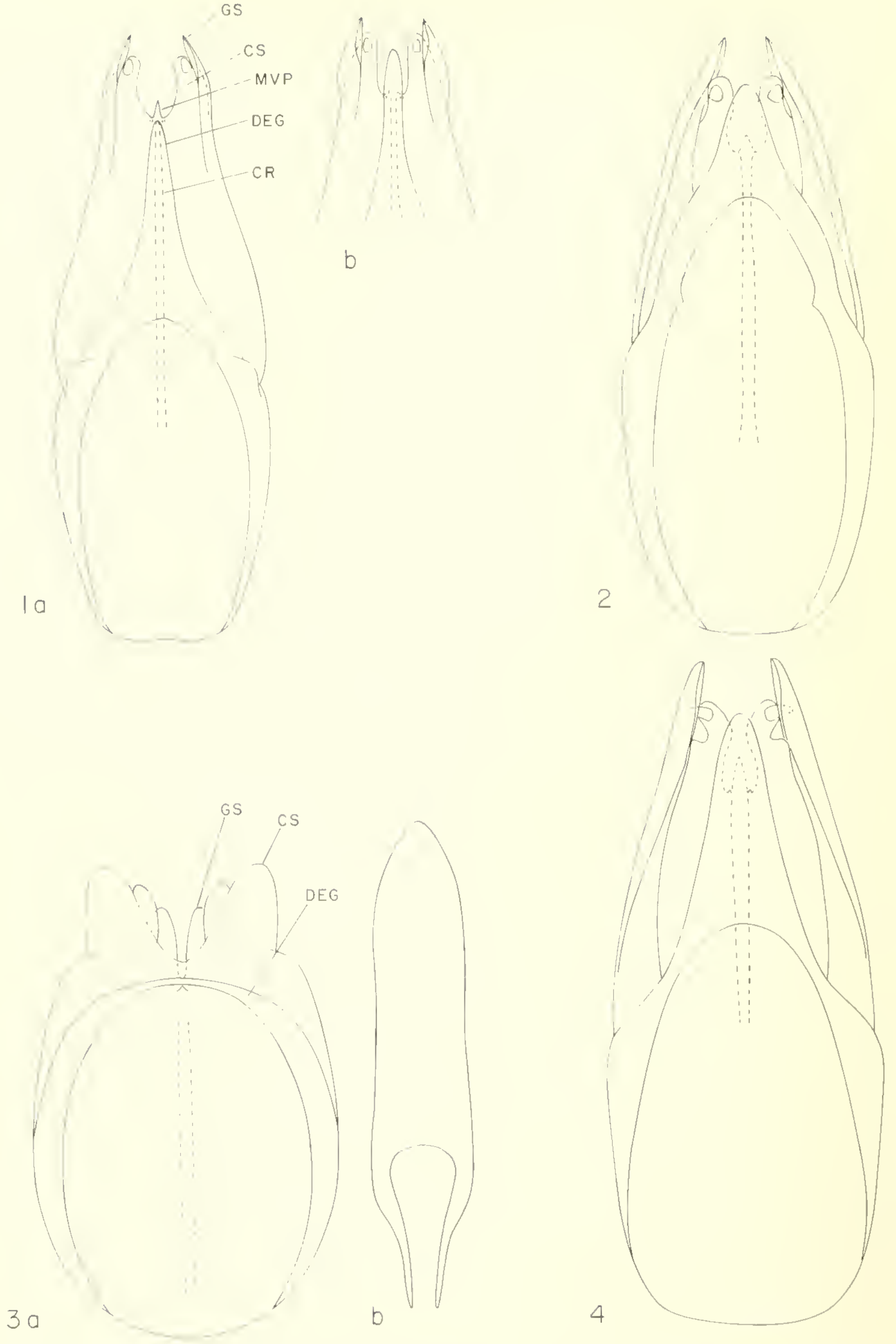
Female.—*Ovipositor:* 0.77 ± 0.01 (0.7–0.8) (n = 5) as long as hind tibia.

Type information.—Holotype ♂ and allotype ♀ from CALIFORNIA, San Joaquin Co., Linden; ex. undetermined Noctuidae egg on *Malva parviflora* L.; 10 September 1978; E. R. Oatman, collr.

Geographic distribution.—California and Texas, USA.

Records.—UNITED STATES. *California:* Colusa Co., ex. *Heliothis zea* eggs on tomato. Riverside Co., Menifee Valley, hills on west end, 24/29 October 1981, in pan trap. San Luis Obispo Co., Paso Robles, ex. undetermined Noctuidae eggs on *Malva parviflora*, 22 September 1981. San Joaquin Co., Linden ex. undetermined Noctuidae eggs on *M. parviflora*, 10 September 1978; Stockton, ex. *Vanessa* sp. eggs on *M. parviflora*, 12 September 1978. Yuba Co., Marysville, ex. *Vanessa* sp. egg on *M. parviflora*, 7 June 1983. *Texas:* Castro Co., ex. *Diatraea grandiosella* eggs on corn, 3 August 1982.

Remarks.—*Trichogramma thalense* is similar to several other species characterized by a narrow, elongate DEG. It differs from the three Hawaiian species with this trait (*T. vargasi* Oatman & Platner, *T. perkinsi* Girault, and *T. higai* Oatman & Platner) in several respects (see Oatman et al., 1982) but most conspicuously by the longer male flagellum (as long or longer than hind tibia). Also,



Figs. 1–4. Male genitalia of *Trichogramma* spp. (dorsal view). 1a, *T. thalense*, Linden, CA (length = 0.12 mm); 1b, same, Castro Co., TX. 2, *T. browningi* (length = 0.12 mm). 3a, *T. nomlaki* (genital capsule, length = 0.10 mm); 3b, same, aedeagus. 4, *T. offella*, (length = 0.11 mm). GS = gonostyli; CS = chelate structures; MVP = median ventral projection; DEG = dorsal expansion of gonobase; CR = chitinized ridge.

the flagellar setae of *T. higai* and *T. perkinsi* are shorter than those of *T. thalense* (less than 2× the maximum width of flagellum).

Males of other similar species are separated from *T. thalense* as follows: *T. lacustre* Sorokina (1978) by the less abruptly narrowed and much longer DEG, the lack of a constriction at the base of the gonostyli, and by the much shorter flagellum; *T. principia* Sugonjaev & Sorokina (1976) by the shorter flagellar setae (only 2× as long as flagellar width), uniquely shaped genital capsule, and longer apodemes of the aedeagus; *T. raoi* Nagaraja (1973) by the much longer flagellar setae (4× greater than flagellar width), inconspicuous MVP, and the broader genital capsule which lacks a constriction at the base of the gonostyli; *T. parkeri* Nagarkatti (1975) by the more elongate genital capsule (ca. 0.25 as wide as long) and the longer aedeagus (subequal to hind tibial length); *T. pintoi* Voegele (1982) (*T. euproctidis* of Nagarkatti & Nagaraja, 1971) by the triangular DEG, and more elongate genital capsule (ca. 0.28 as wide as long); *T. brassicae* Voegele by the shorter flagellar setae (ca. 1.5× greatest flagellar width), and the shorter and broader DEG.

Specimens of *T. thalense* from California and Texas are similar except for the length of the DEG. In California material the apex of the posterior extension of the DEG approximates the base of the MVP (Fig. 1a); in material from Castro Co., Texas it extends to a point ca. half the distance from the base of the MVP to the apex of the gonostyli (Fig. 1b). Also, we have been able to maintain the Texas population in culture on *T. ni* eggs, whereas all California populations were lost after a few generations. Therefore, cross-breeding studies could not be conducted between California and Texas material.

Etymology.—"Of the Valley." Thal is of German origin.

Trichogramma browningi **Pinto & Oatman, New Species**

Fig. 2

Description based on culture material originating from all locales noted in Records (below); material reared on *Trichoplusia ni* eggs at 23–27°C and ca. 50% R.H.

Color.—Based on specimens mounted in Hoyer's medium. Both sexes dark brown except antenna, hind portion of thorax, fore and middle legs, and tibiae and tarsi of hind leg paler.

Male.—*Length:* 0.5–0.7 mm. *Antenna:* Flagellum elongate, broadly arcuate at basal half, 6.79 ± 0.40 (6.3–7.6) (n = 12) as long as wide, 1.09 ± 0.03 (1.06–1.11) (n = 12) as long as hind tibia; setae moderately long, tapering gradually to apex, length of longest seta 3.15 ± 0.13 (2.9–3.3) (n = 12) maximum width of flagellum, ca. 39–46 in number. *Forewing:* Vein tracts well defined, area between 4th and 5th tracts with 22–50 setae; length of longest seta on post-apical margin ca. 2× maximum width of hind tibia and 0.2 maximum width of wing. *Hindwing:* Posterior vein tract of 5–9 setae, extending from 0.4–0.8 length of middle tract; anterior tract absent or with no more than 2 setae. *Mesoscutellum:* Anterior pair of setae varying from 0.2–0.6 length of posterior pair. *Genital capsule:* Moderately broad, 0.41 ± 0.01 (0.38–0.44) (n = 12) as wide as long; gonostyli from apex to base of MVP comprising ca. 0.2 length of genital capsule; DEG broadly subtriangular, not notched or lobed at base or only slightly so, subapical width ca. 0.6 distance between apex of gonostyli, apex attaining 0.91 ± 0.01 (0.88–0.93) (n =

12) length of genital capsule: MVP short, subtriangular apex anterior to that of DEG and CS, attaining 0.82 ± 0.01 (0.80–0.84) (n = 12) length of genital capsule; CS attaining 0.91 ± 0.01 (0.87–0.93) (n = 12) length of genital capsule, occupying ca. 0.6 distance from base of MVP to apex of gonostyli; CR extending ca. 0.5 distance from MVP to base of genital capsule. *Aedeagus:* 0.62 ± 0.03 (0.57–0.67) (n = 12) as long as hind tibia, ca. same length as genital capsule, apodemes comprising 0.55 ± 0.02 (0.50–0.55) total length of aedeagus.

Female.—*Ovipositor:* 0.87 ± 0.06 (0.8–1.0) (n = 4) as long as hind tibia.

Type information.—Holotype ♂ and allotype ♀ from CALIFORNIA, Riverside Co., Riverside (University of California campus), ex. *Agraulis vanillae* L. (Nymphalidae) egg on *Passiflora* sp.; 12 July 1980; H. Browning, collr.

Geographic distribution.—Southern California.

Records.—UNITED STATES. *California:* Kern Co., Arvin, ex. *Trichoplusia ni* eggs on *Sonchus* sp., 16 September 1980; Tehachapi, ex. *Vanessa* sp. eggs on *Malva parviflora*, 16 September 1980. Riverside Co., Riverside, ex. *Agraulis vanillae* eggs on *Passiflora* sp., 12 July 1980.

Remarks.—*Trichogramma browningi* resembles other species that have a relatively broad, subtriangular DEG. These include the Old World species *T. chilotraeae* Nagaraja & Nagarkatti (1969), *T. kalkae* Schulten & Feijen (1978), *T. ostriniae* Pang & Chen (1974), *T. pinneyi* Schulten & Feijen (1978), *T. mwanzai* Schulten & Feijen (1982), and the North American *T. brevicapillum* Pinto & Platner (Pinto et al., 1978). The short MVP, however, separates it from all except *T. brevicapillum* from which it is distinguished primarily by the much longer flagellar setae, incomplete anterior and posterior vein tracts on the hindwings, and the less densely setate forewings.

Etymology.—Named for Dr. Harold Browning, the first collector of this species.

Trichogramma nomlaki **Pinto & Oatman, New Species**

Fig. 3a, b

Description based on a single male collected by screen sweeping in Glenn County, California. The genitalic structure of this species is the most highly modified yet reported in *Trichogramma*.

Color.—Based on unique male mounted in Hoyer's medium. Uniformly dark brown except tibiae, tarsi and antennae distinctly lighter.

Male.—*Length:* 0.75 mm. *Antenna:* Flagellum elongate, broadly arcuate at basal half, 5.4 as long as wide, equal in length to hind tibia; setae moderately long, tapering abruptly at apex, length of longest seta 2.20 maximum width of flagellum, 40 in number. *Forewing:* Numerous setae between moderately well defined vein tracts, area between 4th and 5th tracts with 43 setae; length of longest postapical seta 0.17 greater than maximum width of hind tibia, 0.10 maximum width of wing. *Hindwing:* Posterior vein tract with 8 short setae, extending 0.5 length of middle tract; anterior tract of six setae, subequal in length to posterior tract. *Mesoscutellum:* Anterior pair of setae very long, subequal in length and width to posterior pair. *Genital capsule:* Unique for genus, with gonostyli, DEG and MVP highly reduced, CS strongly and uniformly sclerotized, apparently bilobed, consisting of a large subconical lobe with a smaller appendage ventromedially, lacking apical spine; CS extending further posteriorly than all other genital structures. Genital capsule broad, 0.65 as wide as long; gonostyli ventral to CS, attaining

0.93 length of genital capsule, distance from apex to base of MVP 0.18 the distance to base of genital capsule; DEG arcuate, not lobed or notched at sides, narrowing medially and lacking the usual posteromedial extension, attaining 0.77 length of genital capsule; MVP obsolescent, distance from obsolescent MVP to apex of CS 0.28 length of genital capsule; CR very well developed, extending from MVP to just short of genital capsule base. *Aedeagus:* Short and broad, only 0.49 as long as hind tibia, ca. same length as genital capsule, apodemes comprising 0.33 total length of aedeagus.

Female.—Unknown.

Type information.—Holotype, unique ♂, from CALIFORNIA, Glenn Co., Stony Creek, 5 mi. N. Elk Creek; screen sweeping riparian vegetation; 9 June 1983; J. D. Pinto, collr.

Geographic distribution.—Known only from the type locality in northern California.

Remarks.—*Trichogramma nomlaki* differs dramatically from all known congeners. It is the only species lacking a posteromedial extension of the DEG and with uniquely modified CS that extend further posteriorly than the gonostyli. The very large anterior mesoscutellar setae distinguish *T. nomlaki* from all species except *T. semifumatum* (Perkins) (see Oatman et al., 1982). Although not readily comparable to any other species, the male genitalia in *T. nomlaki* are most similar to those of *T. atopovirilia*, recently described from Guatemala and Mexico (Oatman & Platner, 1983). In the latter, the DEG is produced posteromedially but only slightly so. Also, as in *T. nomlaki*, the genital capsule is rather broad. The dorsal CS relative to the gonostyli is a trait shared with both *T. atopovirilia* and *T. drepanophorum*, new species (see below).

The gonostyli and CS are so greatly modified in *T. nomlaki* that there is some question whether homologies have been determined correctly. We have identified these structures primarily by their relative position and their relationship to the aedeagus. The presumptive CS are distinctly dorsal to the presumptive gonostyli, and the aedeagus rests between the CS and the DEG. This structural relationship also occurs in *T. drepanophorum* and *T. atopovirilia*. The gonostyli are lateral to the CS in most *Trichogramma*. We are not aware of any species with gonostyli dorsal to the CS which would be the other possible interpretation of homologies in *T. nomlaki*.

Although the male genitalia of *T. nomlaki* are exceptional for *Trichogramma*, all other features examined are typical of the genus.

Etymology.—Nomlaki is the name of the Indian people indigenous to the type locality and surrounding area.

***Trichogramma offella* Pinto & Oatman, New Species**

Fig. 4

Description based on P_1 material from the type locality.

Color.—Based on specimens mounted in Hoyer's medium. Both sexes dark brown except antennae, head above eyes, tibiae, tarsi, and propodeal area paler.

Male.—*Length:* 0.5–0.7 mm. *Antenna:* Flagellum elongate, broadly arcuate at base, 6.30 ± 0.45 (5.8–6.9) (n = 5) as long as wide, 1.17 ± 0.02 (1.15–1.20) (n = 5) as long as hind tibia; setae elongate, tapering gradually to apex, length of longest seta 3.43 ± 0.14 (3.2–3.5) (n = 5) maximum width of flagellum, ca. 40 in number.

Forewing: Vein tracts well defined, area between 4th and 5th tracts with 16–24 setae; length of longest postapical seta on margin ca. 1.6 maximum width of hind tibia and 0.2 greatest width of wing. *Hindwing:* Posterior vein tract of 5–7 setae, extending 0.3–0.7 length of middle tract; anterior tract absent. *Mesoscutellum:* Anterior pair of setae short, fine, ca. 0.2 length of posterior pair. *Genital capsule:* Moderately broad, subrhomboidal in shape, sides anterior and posterior to widest point straight, gradually convergent, 0.43 ± 0.01 (0.41–0.45) (n = 5) as wide as long; gonostyli (from apex to base of MVP) ca. 0.2 length of genital capsule; DEG and CS extending to a similar level considerably beyond MVP; DEG not lobed or notched basally, rather abruptly narrowed posterior from widest point and then more gradually so to apex, posterior extension lingulate, subapical width ca. 0.5 distance between gonostyli, attaining 0.91 ± 0.01 (0.90–0.93) (n = 5) length of genital capsule; MVP short, narrowly triangular, apex anterior to that of CS and DEG, attaining 0.85 ± 0.01 (0.84–0.87) (n = 5) length of genital capsule; CS subsinuate, abruptly and asymmetrically narrowed at center, attaining 0.94 ± 0.01 (0.92–0.95) length of genital capsule; CR extending ca. 0.5 the distance from MVP to base of genital capsule. *Aedeagus:* 0.80 ± 0.03 (0.76–0.83) (n = 5) as long as hind tibia; ca. same length as genital capsule, apodemes comprising ca. 0.5 total length of aedeagus.

Female.—*Ovipositor:* Of different length in the two females in type series; 0.22 mm (1.15 length of hind tibia) in one, and 0.17 mm (0.88 length of hind tibia) in the other.

Type information.—Holotype ♂ from LOUISIANA, Crowley; ex. *Chilo plejadellus* Zincken (Pyralidae) egg on rice; 10 September 1978; S. V. Rama Rao, collr. Allotype not designated.

Geographic distribution.—Known only from the type locality in southern Louisiana.

Remarks.—The subsinuate chelate structures which closely approach the gonostyli combined with the relatively short MVP, the relatively narrow DEG, and the long flagellar setae characterize *T. offella.* The male genitalia of this species are most similar to that of *T. polychrosis* Chen & Pang (1981). The latter differs, however, by the longer chitinized ridge which extends to the base of the genital capsule, the much shorter flagellar setae (only ca. 2.4 × maximum flagellar width) and its paler coloration. *Trichogramma flandersi* Nagaraja and Nagarkatti has similarly shaped CS but in that species the DEG is extremely long and wide, and the MVP is inconspicuous. Although asymmetrical CS also occur in *T. atopovirilia* and *T. drepanophorum* they are quite different in shape in both.

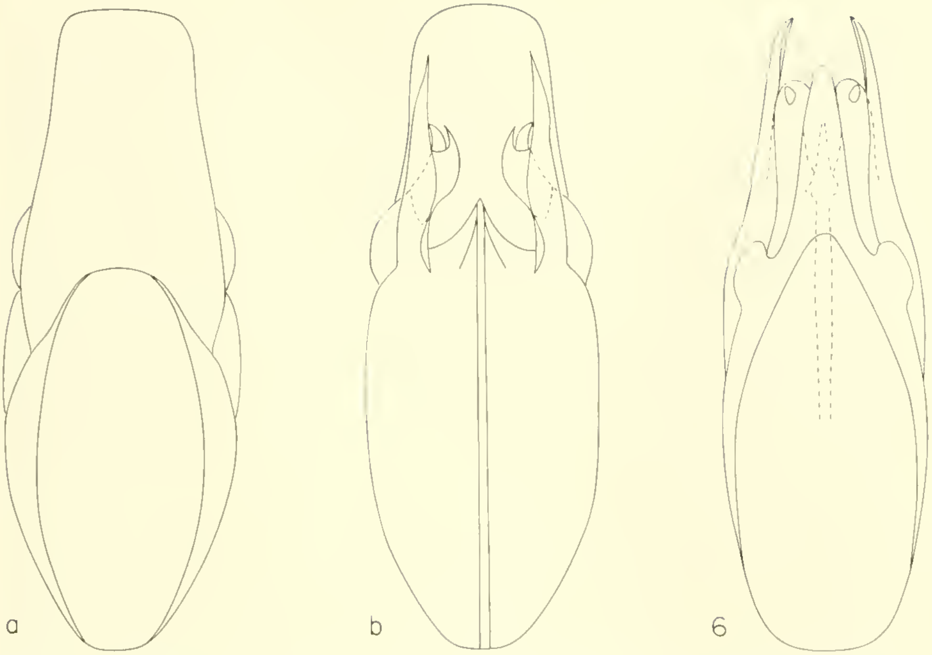
Etymology.—Offella is a Latin noun meaning "little bit."

Trichogramma drepanophorum **Pinto & Oatman, New Species**

Fig. 5a, b

Description based on original P_1 material, and F_1 material reared on eggs of *Trichoplusia ni* at 23–27°C and ca. 50% R.H.

Color.—Based on specimens freshly killed in 70% ethanol. Sexes similar. Head yellow above eyes, fumate to black in front of, between and below eyes; thorax, abdomen, coxae and femora black tinged with yellow, most yellow along sutures and intersegmentally. Antennae, tibiae and tarsi pale yellow; antenna fumate basally in most females.



Figs. 5–6. Male genitalia of *Trichogramma* spp. 5a, *T. drepanophorum* (dorsal view, length = 0.12 mm); 5b, same (ventral view). 6, *T. inyoense* (dorsal view, length = 0.16 mm).

Male.—*Length:* Ca. 0.7 mm (F_1 material). *Antenna:* Flagellum elongate, broadly arcuate at base, 5.82 ± 0.18 (5.5–6.0) (n = 5) as long as wide; 1.09 ± 0.03 (1.06–1.12) (n = 5) as long as hind tibia; setae moderately long, tapering abruptly at apex, length of longest seta 2.42 ± 0.10 (2.3–2.6) (n = 5) as long as maximum flagellar width, ca. 50 in number. *Forewing:* Vein tracts well defined, a moderate number of setae between tracts, area between 4th and 5th tracts with 16–25 setae; length of longest postapical seta on margin ca. 1.3 maximum width of hind tibia and 0.10 maximum width of wing. *Hindwing:* Posterior vein tract of 5–8 setae, extending ca. 0.5 length of middle tract; anterior tract consisting of only 1 seta. *Mesoscutellum:* Anterior pair of setae moderately long, varying from 0.3–0.5 length of posterior pair. *Genital capsule:* Moderately narrow, 0.35 ± 0.001 (0.34–0.35) (n = 5) as wide as long, DEG broadly notched at base, very broad and elongate, extending well beyond apex of gonostyli, subapical width greater than distance between apex of gonostyli and slightly greater than 0.5 the maximum width of genital capsule; gonostyli very attenuate apically, attaining 0.91 ± 0.02 (0.89–0.93) (n = 5) length of genital capsule, distance from apex to base of MVP ca. 0.3 the distance to base of genital capsule; MVP moderately long, broadly subtriangular, projecting somewhat posteroventrally, apex anterior to that of CS, attaining 0.75 ± 0.01 (0.7–0.8) (n = 5) the length of genital capsule; CS highly modified, positioned dorsal to gonostyli, apical 0.67 very well sclerotized and falcate in shape, apex directed laterally, attaining 0.86 ± 0.01 (0.85–0.87) (n = 5) length of genital capsule; CR very well developed, extending from MVP to base of genital capsule. *Aedeagus:* Relatively short, 0.58 ± 0.03 (0.5–0.6) (n = 5) as long as hind tibia and ca. 0.8 as long as genital capsule, apodemes not readily distinquishable under light microscope, comprising ca. 0.5 ? the total length.

Female.—*Ovipositor:* 1.16 ± 0.04 (1.1–1.2) (n = 4) length of hind tibia.

Type information.—Holotype ♂ and allotype ♀ from MISSISSIPPI, Hattiesburg; ex. *Limenitis archippus* (Cramer) (Nymphalidae) egg on *Salix* sp.; 23 September 1983; E. R. Oatman & J. D. Pinto, collrs. Types represent F_1 culture material.

Geographic distribution.—Southeastern Mississippi, USA.

Records.—UNITED STATES. *Mississippi.* Hattiesburg, ex. *Limenitis archippus* and unidentified Sphingidae eggs on *Salix* sp., 23 September 1983.

Remarks.—*Trichogramma drepanophorum* is one of the most distinctive species in the genus. The highly sclerotized, falcate digit of the CS separates it from all known congeners. The well developed CR, which totally bisects the genital capsule below the MVP, and the greatly enlarged DEG are additional distinguishing features. In *T. hesperidis* Nagaraja, *T. flandersi* Nagaraja & Nagarkatti, and *T. lingulatum* Pang & Chen, the DEG extends beyond the apex of the gonostyli as in *T. drepanophorum* but it is narrower in these species. A similarly broad but shorter DEG is found in *T. fasciatum* (Perkins) (see Pinto et al., 1978) and *T. cephaliciae* Hochmut & Martinek (1963). The dorsal position of the CS relative to the gonostyli also occurs in *T. atopovirilia* Oatman & Platner, and *T. nomlaki,* new species (see above). Although *T. drepanophorum, T. atopovirilia,* and *T. nomlaki* are very distinctive, all three have highly modified, dorsally positioned CS and very well developed CR.

Etymology.—Greek: "sickle bearer"; in reference to the sickle-like chelate structures.

Trichogramma inyoense Pinto & Oatman, New Species

Fig. 6

Description based on culture material reared on *Trichoplusia ni* at 23–27°C and ca. 50% R.H.

Color.—Based on specimens mounted in Hoyer's medium. Both sexes dark brown except antennae, head, tibiae, tarsi and propodeal area paler.

Male.—*Length:* ca. 0.7 mm. *Antenna:* Flagellum elongate, arcuate at base, 6.73 ± 0.17 (6.5–6.9) (n = 4) as long as wide, 1.09 ± 0.04 (1.05–1.14) (n = 4) as long as hind tibia; setae long, gradually tapering to apex, length of longest 3.50 ± 0.18 (3.3–3.8) (n = 4) maximum width of flagellum, ca. 50 in number. *Forewing:* Vein tracts well defined, with numerous setae between, area between 4th and 5th tracts with 26–49 setae; length of longest postapical seta on margin ca. 1.6 maximum width of hind tibia and 0.1 maximum length of wing. *Hindwing:* Posterior vein tract of 8–9 setae, extending 0.4–0.6 length of middle tract; anterior tract of 4–7 setae, only slightly shorter than posterior tract, extending 0.4–0.5 length of middle tract. *Mesoscutellum:* Anterior pair of setae short, fine, only 0.1–0.2 length of posterior pair. *Genital capsule:* Moderately elongate, 0.33 ± 0.02 (0.31–0.35) (n = 4) as wide as long; gonostyli (from apex to base of MVP) comprising ca. 0.25 length of genital capsule; DEG elongate, with large posteriorly projecting lateral lobes, posterior extension lingulate, subapical width ca. 0.5 distance between apex of gonostyli, apex attaining 0.93 ± 0.004 (0.90–0.93) (n = 3) length of genital capsule; MVP elongate, narrowly triangular, apex anterior to that of DEG and CS, attaining 0.85 ± 0.02 (0.84–0.88) (n = 4) length of genital capsule; CS apex at similar level as that of DEG, attaining 0.92 ± 0.01 (0.90–0.93) (n = 3) length of genital capsule; CR extending ca. 0.5 distance from MVP to base of genital capsule. *Aedeagus:* 0.84 ± 0.03 (0.8–0.9) (n = 4) as long as hind tibia, and ca. 0.9 as long as genital capsule, apodemes comprising 0.51 ± 0.02 (0.48–0.52) (n = 4) its total length.

Female.—*Ovipositor:* 1.15 ± 0.03 (1.1–1.2) (n = 4) as long as hind tibia.

Type information.—Holotype ♂ and allotype ♀ from CALIFORNIA, Inyo Co., Independence Creek, ca. 6 mi. W. Independence (ca. 6000 ft. elev.); ex. undetermined Lepidoptera egg on *Salix* sp.; 25 August 1972; E. R. Oatman, collr.

Geographic distribution.—Known only from the type locality in east central California.

Remarks.—This species differs from *T. pretiosum* Riley, perhaps its closest relative, by the well defined, posteriorly projecting lateral lobes of the DEG, and its darker coloration.

Etymology.—Inyo is the name of the county of the type locality.

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LITERATURE CITED

Chen, T. and X. Pang. 1981. *Trichogramma polychrosis*, a new species of Trichogrammatidae (Hymenoptera). Zool. Res. 2: 333–335.

Hochmut, R. and V. Martinek. 1963. Beitrag zur Kenntnis der mitteleuropäischen Arten und Rassen der Gattung *Trichogramma* Westw. (Hymenoptera, Trichogrammatidae). Z. Angew. Entomol. 52: 255–274.

Nagaraja, H. 1973. On some new species of Indian *Trichogramma* (Hymenoptera: Trichogrammatidae). Orient. Insects 7: 275–290.

Nagaraja, H. and S. Nagarkatti. 1969. Three new species of *Trichogramma* (Hymenoptera: Trichogrammatidae) from India. Entomophaga 14: 393–400.

Nagarkatti, S. 1975. Two new species of *Trichogramma* (Hym.: Trichogrammatidae) from the U.S.A. Entomophaga 20: 245–248.

Nagarkatti, S. and H. Nagaraja. 1971. Redescriptions of some known species of *Trichogramma* (Hym., Trichogrammatidae), showing the importance of the male genitalia as a diagnostic character. Bull. Entomol. Res. 61: 13–31.

Oatman, E. R., J. D. Pinto, and G. R. Platner. 1982. *Trichogramma* (Hymenoptera: Trichogrammatidae) of Hawaii. Pac. Insects 24: 1–24.

Oatman, E. R. and G. R. Platner. 1983. A new species of *Trichogramma* (Hymenoptera: Trichogrammatidae), with notes on other species collected in Guatemala. Proc. Entomol. Soc. Wash. 85: 710–713.

Pang, X. and T. Chen. 1974. *Trichogramma* of China (Hymenoptera: Trichogrammatidae). Acta Entomol. Sin. 17: 441–454.

Pinto, J. D., G. R. Platner, and E. R. Oatman. 1978. Clarification of the identity of several common species of North American *Trichogramma* (Hymenoptera: Trichogrammatidae). Ann. Entomol. Soc. Am. 71: 169–180.

Schulten, G. G. M. and H. R. Feijen. 1978. Two new species of *Trichogramma* (Hymenoptera: Trichogrammatidae) from Malawi; egg parasitoids of *Diopsis macrophtalma* Dalman (Diptera: Diopsidae). Entomol. Ber. (Amst.) 38: 25–29.

———. 1982. A new species of *Trichogramma* (Hymenoptera: Trichogrammatidae) from Malawi, parasitizing eggs of *Chilo diffusilineus* (de Jaonnis). Entomol. Ber. (Amst.) 42: 142–144.

Sorokina, A. 1978. New data on taxonomy and biology of the genus *Trichogramma* (Hymenoptera, Chalcidoidea). Zool. Zh. 57: 1442–1444. (In Russian).

Sugonjaev, E. S. and A. P. Sorokina. 1976. New species of the genus *Trichogramma* (Hymenoptera, Chalcidoidea) from Middle Asia and Altai. Zool. Zh. 55: 777–779. (In Russian).

Voegele, J. 1982. Découverte et description de deux nouvelles espèces de Trichogrammes du groupe Euproctidis, *Trichogramma brassicae* et *T. pintoi* (Hym. Trichogrammatidae). Ann. Soc. Entomol. Fr. (N.S.) 18: 163–166.

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CONFIRMATION OF THE NEOTROPICAL COCKROACH *PLECTOPTERA PICTA* SAUSSURE AND ZEHNTNER IN THE UNITED STATES (BLATTODEA; BLATTELLIDAE)

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Abstract.—*Plectoptera picta* is a small neotropical cockroach reported to have been introduced to the United States prior to 1917. Because the specimens were only partially labelled, the United States record was discounted. However, recent collections have verified its presence in Texas, Louisiana, Virginia, and North Carolina. It is easily distinguished from *P. poeyi,* a south Florida species, by its darkly colored pronotum and its reddish-brown face with a horizontal ivory colored band between the eyes.

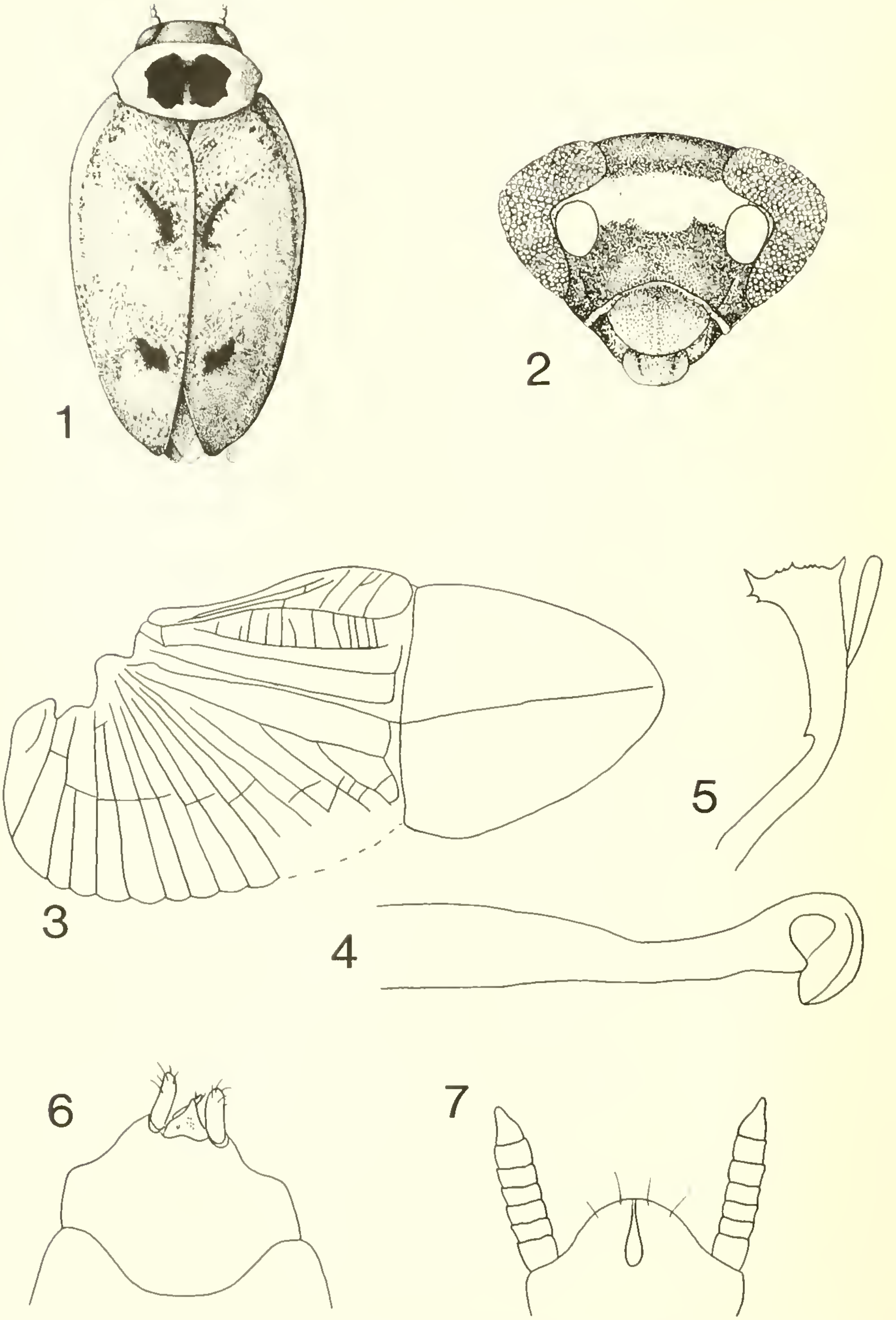
Plectoptera picta Saussure and Zehntner is a small, distinctly marked cockroach that has been collected only rarely. It was described by Saussure and Zehntner (1894) from Veracruz, Mexico. Rehn (1903) subsequently reported it from Costa Rica. It was also reported from Texas and Virginia (Caudell, 1913), but its occurrence in the United States was later questioned and discounted (Hebard, 1917; Princis, 1965), because of partial or incomplete labeling of the specimens.

Recently several additional specimens have come to our attention, which demonstrate that *P. picta* is in fact established in two disjunct areas of the United States. In 1971 a male *picta* was collected on the campus of Louisiana State University, Baton Rouge, La., and sent to A. B. Gurney for identification. At about the same time Gurney received several specimens of the same species collected in light traps in North Carolina. Since that time five additional specimens have been collected in Louisiana and North Carolina, prompting us to present the following diagnosis to facilitate identification of this species.

Plectoptera picta (Fig. 1) is a small cockroach, about 5.5–6.5 mm long. It is silvery-gray with an overlying reddish mottled pattern on the tegmina. The pronotum is dark reddish brown or black with an irregular white or buff border. The head and body are dark brown; a distinctive buff colored band extends across the face from the compound eyes to the midpoint of the antennal sockets (Fig. 2).

The tegmina barely overlap, presenting more the appearance of beetle elytra than dictyopteroid tegmina. The resemblance is so close that the collector (a coleopterist) of the most recently collected specimen presumed that he had collected a small hydrophilid beetle. The apex of the hindwing (Fig. 3) has a large intercalated triangle composed of two large cells occupying nearly half the area of the hindwing (exclusive of the anal lobe).

To establish the identity of this species, we compared the genitalia of the holotype of *P. picta* with males from Texas and North Carolina. The right phal-



Figs. 1–7. Morphological features of *Plectoptera picta*. 1, Habitus, dorsal view (specimen from Bertie Co., NC. Scale is 2 mm). 2, Head of same specimen, frontal view. 3–6, Holotype. 3, Right hindwing. 4, Right phallomere (R2). 5, Left phallomere (L2d). 6, Subgenital plate. 7, Female subgenital plate of specimen from Bertie Co., NC.

lomere (R2, see McKittrick, 1964) of the holotype (Fig. 4) bears a stout subapical lobe; the inflated apex of R2 recurves strongly to this lobe. The apex of the left phallomere, L2d, is broadly truncate, armed along the apical margin with about 11 spines, those at the edges being longer and stouter than the more centrally located spines. The shapes of the subgenital plates of the male and female are as in Figs. 5 and 6. Externally all specimens agree in general with the holotype, differing mainly in degree of pigmentation of the overall body markings and in the degree of spination of the left phallomere.

There are numerous species of *Plectoptera* in Central America. The species *pulicera* Saussure and Zehntner, *circumdata* Saussure and Zehntner, and *circumcincta* Saussure and Zehntner are figured in Saussure and Zehntner (1894), and their color patterns are distinctly different from *picta.* The holotype of the Costa Rican species *hastifera* Rehn—a male, not a female as Rehn stated (1903:281)—also differs markedly in color from *picta.*

There are 11 West Indian species of *Plectoptera*: *dominicae* Rehn and Hebard, *dorsalis* (Burmeister), *infulata* Rehn and Hebard, *insularis* Princis, *lacerna* Rehn and Hebard, *perscita* Rehn and Hebard, *poeyi* Saussure, *porcellana* (Saussure), *pygmaea* (Palisot de Beauvois), *rhabdota* Rehn and Hebard, and *vermiculata* Rehn and Hebard. All of these species have different color patterns from *picta.*

The only other species of *Plectoptera* occurring in the United States is *poeyi,* which is limited to Key West, Florida, and Cuba (Rehn and Hebard, 1927). This is a glossy, uniformly translucent yellowish species which because of its color is unlikely to be confused with *picta* (Zayas, 1974). Candidates more likely to be confused with *picta* are *Compsodes schwarzi* (Caudell), *Chorisneura texensis* (Saussure and Zehntner) (see Helfer, 1963: 58–59), and another recently introduced cockroach, *Ectobius sylvestris* (Poda) (Hoebeke and Nickle, 1981). *Compsodes schwarzi* and *E. sylvestris* also have a dark pronotal disc with pale, lightly colored margins. *E. sylvestris* also shares the well-developed intercalated triangle of the hindwing but lacks the light colored facial band. *Chorisneura texensis* has a smaller intercalated triangle and is uniformly glossy yellow, lacking the dark brown pronotum found in *picta.*

Whether *picta* is an uncommonly collected native species or a recent adventive introduction into the United States cannot be determined for certain, but, considering its occurrence in Costa Rica and Mexico and its apparent disjunct distribution in the United States, it seems more likely to be an introduction. *Plectoptera picta* is an outdoor species and, so far as known, is unlikely to be a domiciliary pest.

Specimens examined. 7 ♂, 5 ♀. Holotype, ♂: MEXICO: Veracruz, Atoyac [BMNH]. COSTA RICA: Cartago, Turrialba (Tristan) 1 ♀ [NMNH]; Tucurrique (Schild & Burgdorf) 1 ♀ [ANSP]. UNITED STATES: LOUISIANA: West Baton Rouge Par., Baton Rouge IX-1971 (Elaine Cox) LA-72 1 ♂ [LSU]; St. John the Baptist Par., Edgard VIII-26-1975 (V. Brou) 2 ♂ [NMNH, FSCA]; NORTH CAROLINA: Edgecombe Co., Tarboro, at Tar R. IX-18-1982 (W. E. Steiner) 1 ♀ [NMNH]; Bertie Co., Lewiston IX-8-1971 (light trap) (W. R. Baker, Jr.) 1 ♂, 1 ♀ [NCS, NMNH]; Warren Co., E. of Ridgeway, road 158 field W-5 NW Dare soybeans VIII-30-1979 (W. C. Warrick) (sweeping soybeans) 1 ♂ [NMNH]; VIRGINIA: "Virginia only" 1 ♀ [ANSP]; TEXAS: "Texas only" 1 ♂ [NMNH].

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The authors thank David R. Ragge, British Museum (Natural History), London [BMNH], for the loan of the holotype, and Joan B. Chapin, Louisiana State University, Baton Rouge [LSU], R. E. Woodruff, Florida State Collection of Arthropods, Division of Plant Industry, Gainesville [FSCA], Dan Otte, Academy of Natural Sciences of Philadelphia [ANSP], and H. H. Neunzig, North Carolina State University, Raleigh [NCS] for the loan of additional specimens. We appreciate the suggestions of the following individuals who reviewed the manuscript: T. J. Spilman and A. S. Menke, SEL, USDA, and Frank Fisk, Ohio State University, Columbus, Ohio. The figures were rendered by Ms. Kate M. Conway and Michelle Miller.

LITERATURE CITED

Caudell, A. N. 1913. Notes on nearctic orthopterous insects. I. Nonsaltatorial forms. Proc. U.S. Nat. Mus. 44: 595–614.

Hebard, M. 1917. The Blattidae of North America north of the Mexican Boundary. Mem. Am. Entomol. Soc. No. 2. 284 pp.

Helfer, J. 1963. How to know the grasshoppers, cockroaches, and their allies. Wm. C. Brown Co., Dubuque, Iowa. 353 pp.

Hoebeke, E. R. and D. A. Nickle. 1981. The forest cockroach, *Ectobius sylvestris* (Poda), a European species newly discovered in North America (Dictyoptera: Blattodea: Ectobiidae). Proc. Entomol. Soc. Wash. 83: 592–595.

McKittrick, F. A. 1964. Evolutionary studies of cockroaches. Cornell Univ. Agric. Exp. Sta. Mem. 389. 197 pp.

Princis, K. 1965. Blattariae: Subordo Blaberoidea. Part 7. *In* M. Beier (ed.), Orthopterum Catalogus. W. Junk. The Hague. pp. 285–400.

Rehn, J. A. G. 1903. Studies in American Blattidae. Trans. Am. Entomol. Soc. 29: 259–290.

Rehn, J. A. G. and M. Hebard. 1927. The Orthoptera of the West Indies. Number 1. Blattidae. Bull. Am. Mus. Nat. Hist. 54: 1–320.

Saussure, H. and L. Zehntner. 1894. Biologia Centrali Americana, Insecta, Orthoptera, 1: 198 pp.

Zayas, F. de. 1974. Entomofauna Cubana III. Inst. Cubano del Libro. Havana, Cuba. 130 pp.

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 191–201

TWO NEW SPECIES, LARVAL DESCRIPTIONS, AND LIFE HISTORY NOTES OF SOME PANAMANIAN SAWFLIES (HYMENOPTERA: ARGIDAE, TENTHREDINIDAE)

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Abstract.—Larvae are described and biological notes and hosts are presented for five species of Symphyta from Panama, two of which are new. Four species are argids: *Didymia* ***unifasciata*** Smith, n. sp. (on *Rouria glabra*), *Manaos* ***kimseyae*** Smith, n. sp. (on *Inga phagifolium*), *Sericoceros gibbus* (Klug) (on *Coccoloba manzanillensis*), and *Ptilia concinna* (Klug) (on *Cnestidium rufescens*). One species is a tenthredinid: *Erythraspides interstitialis* (Cameron), n. comb. (originally in *Monophadnus*) (on *Hamelia patens*). The larvae of each species and the adult characters for the two new species are illustrated.

Host plants and larvae of very few Neotropical sawflies are known. Four argids and one tenthredinid species were reared by the senior author from woody plants on Barro Colorado Island in the Zona del Canal, Panama. The larvae are described and available biological information on them is noted. The reared adults were identified by the junior author, who describes the two new species and supplies all the taxonomic information.

All specimens, except for a few paratypes, are deposited in the Entomology Museum of the University of California, Davis, and the National Museum of Natural History, Washington, D.C.

Argidae

The following two new species are remarkably similar in general appearance and coloration, but belong to different genera. The length of the antenna will readily separate the two genera, that of *Manaos* being long, slender, tapering toward its apex, and its length more than twice the head width, and that of *Didymia* being short, mostly of uniform width throughout, with its length less than 1.5× the head width. Other differences between the two genera are as follows: the shape of the last closed cubital cell of the forewing, which is nearly square or slightly longer on the cubitus than on the radius in *Manaos*, and much longer on the radius than on the cubitus in *Didymia*; the sharp interantennal carina in *Manaos* and the rounded interantennal carina in *Didymia*; and the absence of or very short accessory vein at the apex of the radial cell in the forewing in *Manaos* and the long accessory vein in *Didymia*, which is nearly one-fifth the length of the radial cell. Both genera are separated from others in the Argidae by the following:

hindtibia without a preapical spine; tarsal claw simple; no intercostal vein in the forewing; radial cell of forewing closed at apex; anal cell present in hindwing; high interantennal carina present; and eyes large, converging below with the lower interocular distance less than the eye length.

Didymia unifasciata **Smith, New Species**

Figs. 1–5, 11–19

Female.—Length, 7.0–9.5 mm. Antenna yellow, 3rd segment gradually changing to brown toward apex. Head black, area between and below antennae, clypeus, and mouthparts yellow; apex of mandible dark reddish. Thorax yellow, mesosternum black with yellow line at center; mesonotum black with prescutum laterally, lateral margins of lateral lobes, and posterior ⅓–¾ of scutellum yellow. Abdomen yellow with apical 3 segments and sheath black. Legs yellow with hindtarsus black and sometimes apical 2–3 segments of fore- and midtarsi brownish. Forewing and hindwing black at base and apex, with broad yellow band at center; stigma and veins yellow in yellow portion, veins black in black areas.

Antenna length 1⅓× head width; 1st segment nearly 2× longer than broad; 2nd segment slightly longer than broad; 3rd segment of nearly uniform width throughout, slightly tapering to rounded apex, in cross-section laterally flattened with indistinct carina on outer margin. Malar space linear; clypeus very shallowly circularly emarginated at center, labrum subtruncate; eyes large and converging below, lower interocular distance about ⅘ eye length; maxillary palpus about 1⅖ eye length; distances between lateral ocellus and eye, between lateral ocelli, and between lateral ocellus and hindmargin of head in ratio of 0.8:1.0:0.7; interantennal carina high and sharp, bisecting about upper ⅓ of supraclypeal area; each mandible simple. Tarsal claw simple; hindbasitarsus slightly longer than remaining tarsal segments combined. Forewing with 3 cubital cells, last closed cell longer on radius than on cubitus, vein 3r-m strongly curved; accessory vein at apex of radial cell long, more than ⅕ length of radial cell. Anal cell of hindwing about ½ as long as petiole. Sheath (Figs. 2, 3) with blunt scopae; lancet in Fig. 1.

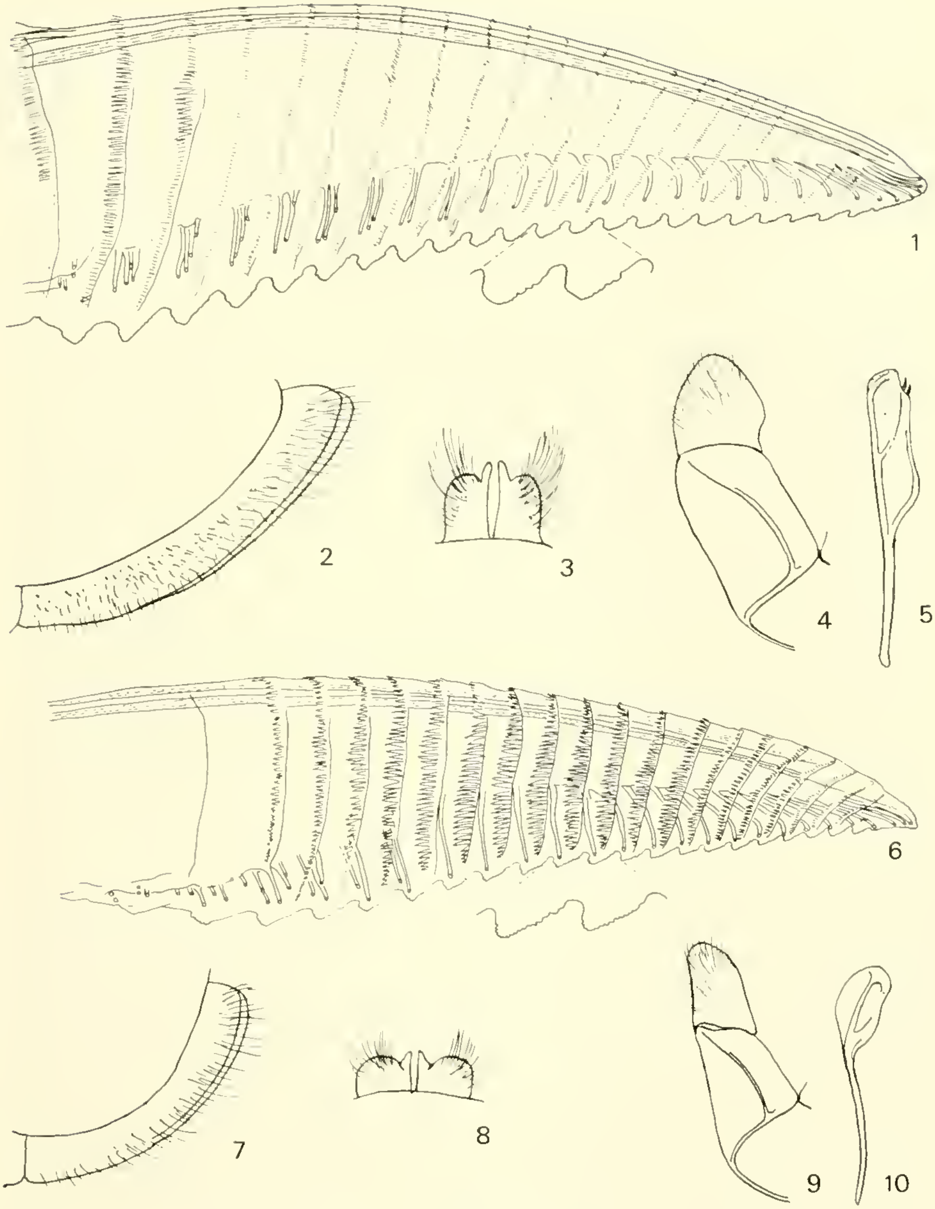
Male.—Length, 7.0 mm. Color and structure similar to female, except antennal length nearly 2× head width and 3rd antennal segment furcate. Genitalia as in Figs. 4, 5.

Larva (ultimate instar).—Length, 16.0–17.0 mm. Head blackish, body pale yellow with long black tubercles, leg segments black.

Head with scattered short setae, becoming longer and more numerous between eyespot and mandible (Fig. 14); antenna a single, flat, circular segment; clypeus with 2 lateral setae; labrum emarginate medially, with 2 lateral setae; epipharynx with 10–13 setae in arcuate row on each lobe (Fig. 15); maxillary palpus 3-segmented, 1st segment with 1 seta, palpifer with 1 seta, lacinia with 2 apical setae (Fig. 16); labial palpus 2-segmented, prementum asetose; left mandible with 5 sharp teeth on outer cutting edge and large truncate cusp on inner cutting edge (Fig. 18); right mandible with 5 teeth on outer cutting edge and ridge on inner cutting edge (Fig. 19); each mandible with a single seta on outer surface.

Thorax strongly tuberculate (Figs. 11, 12); thoracic legs 5-segmented, with scattered setae on each segment. Midtarsal claw as in Fig. 17.

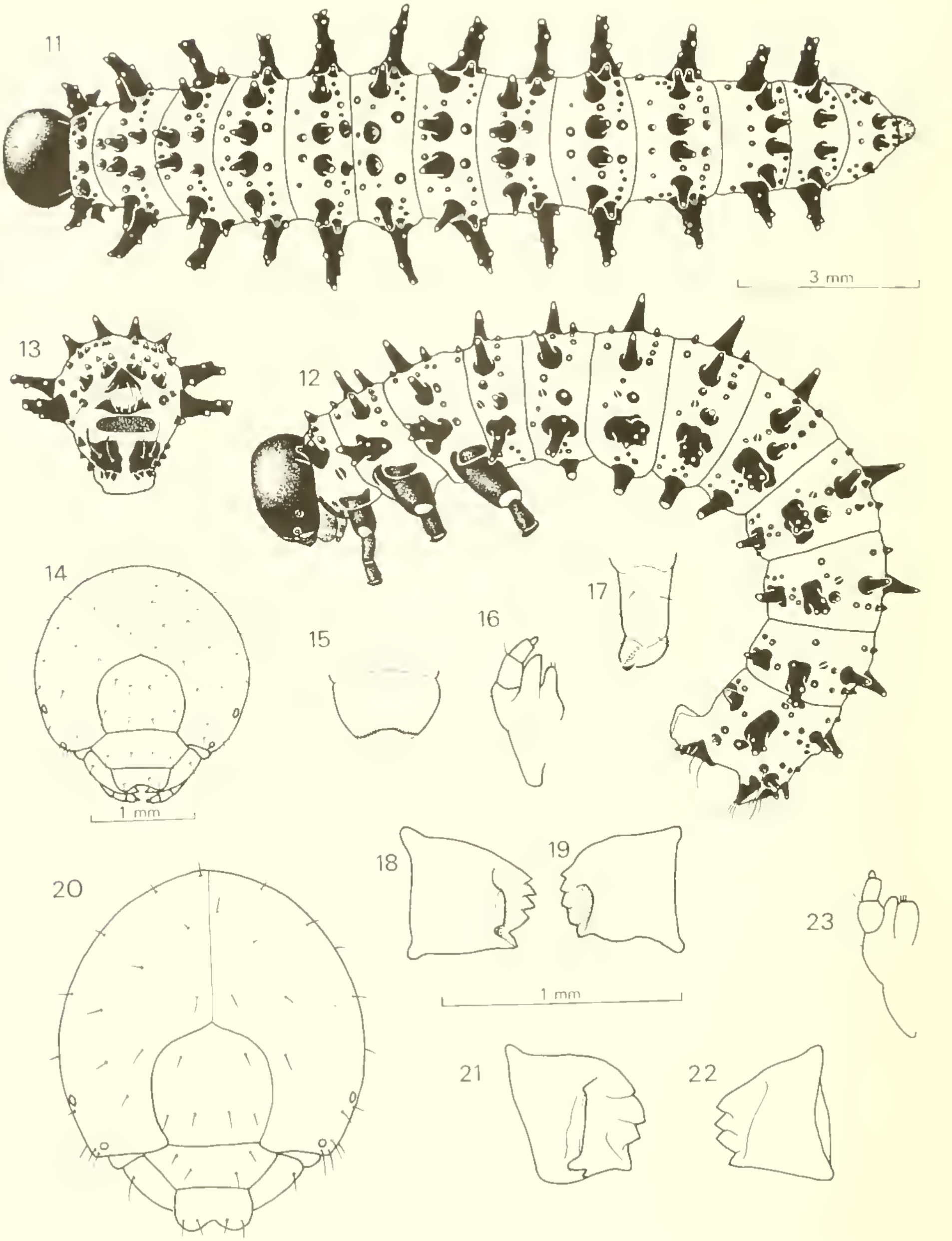
Abdominal segments 1–9 each with 3 faint annulets, tuberculate as in Figs. 11, 12; enlarged ventral tubercles in place of prolegs on segments 2–9; segment 10



Figs. 1–10. 1–5, *Didymia unifasciata*. 6–10, *Manaos kimseyae*. 1, 6, Female lancet. 2, 7, Female sheath, lateral views. 3, 8, Female sheath, dorsal views. 4, 5, 9, 10, Male genitalia. 4, 9, Left half of genital capsule, ventral view. 5, 10, Aedeagus.

produced into conical projection with triangular dorsal plate and 3 posterior plates, 4 apical tubercles in dorsal view (Fig. 13).

Holotype.—Female, from Panama, labeled "Trinidad Rio, Pan., 17 March 1912, A. Busck, coll." In the National Museum of Natural History.



Figs. 11–23. 11–19, *Didymia unifasciata*, ultimate larva. 11, Body, dorsal view. 12, Body, lateral view. 13, Abdomen, posterior view. 14, Head, front view. 15, Epipharynx. 16, Left maxilla. 17, Midtarsus and claw. 18, Left mandible, inner surface. 19, Right mandible, inner surface. 20–23, *Ptilia concinna*, ultimate larva. 20, Head, front view. 21, Left mandible, inner surface. 22, Right mandible, inner surface. 23, Left maxilla.

Paratypes.—PANAMA: Same data as holotype (1 ♂); same data as holotype but 23 March 1912 (1 ♀), 19 March 1912 (1 ♀), 2 Jan. 1912 (2 ♀); Canal Zone Barro Colorado Is., 3 March 1963, C. W. and M. E. Rettenmeyer, taken in Malaise trap

(1 ♀); Decora B-O, 13 May 1953, Shannon traps, V. Alvarez (1 ♀); Barro Colorado Is. (BCI), Canal Zone, 10–12 May 1926, C. T. Greene (1 ♀); BCI, 12 Feb. 1929, S. W. Frost (1 ♀); BCI, 12 Feb. 1936, F. E. Lutz (1 ♀), same data except 9 Feb. 1936 (1 ♀); BCI, 24 July 1924, N. Banks (1 ♀); BCI, 2 April 1981, R. B. and L. S. Kimsey, ex *Rouria* sp. (1 ♀), same except 26 March 1981 and without host (1 ♀). Deposited in the National Museum of Natural History; University of California, Davis; American Museum of Natural History, New York; and Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

Host and life history.—Larvae were observed feeding singly on seedlings of *Rouria glabra* (Connaraceae) between April and August, 1981. The larvae fed primarily on the new flush leaves. Six individuals were reared; the period from cocoon formation to eclosion was 20 days at 23°C. The tachinid, *Vibrissina* sp., was reared from four cocoons.

Discussion.—The yellow coloration with most of the head, mesosternum, and apex of the abdomen black, and the bicolored wings with the single, broad, central yellow band are unique. This coloration and comparison of the lancet and genitalia with Figs. 1, 4, and 5 will distinguish this new species from other species of *Didymia*. Most other species are all orange or yellow, some have an entirely black abdomen, and most have uniformly blackish wings. The few species that do have bicolored wings have black at the base, center, and apex, with two yellow bands in between.

Didymia includes about 12 species and occurs from Panama to southern Brazil. Larvae and hosts of the other species are not known.

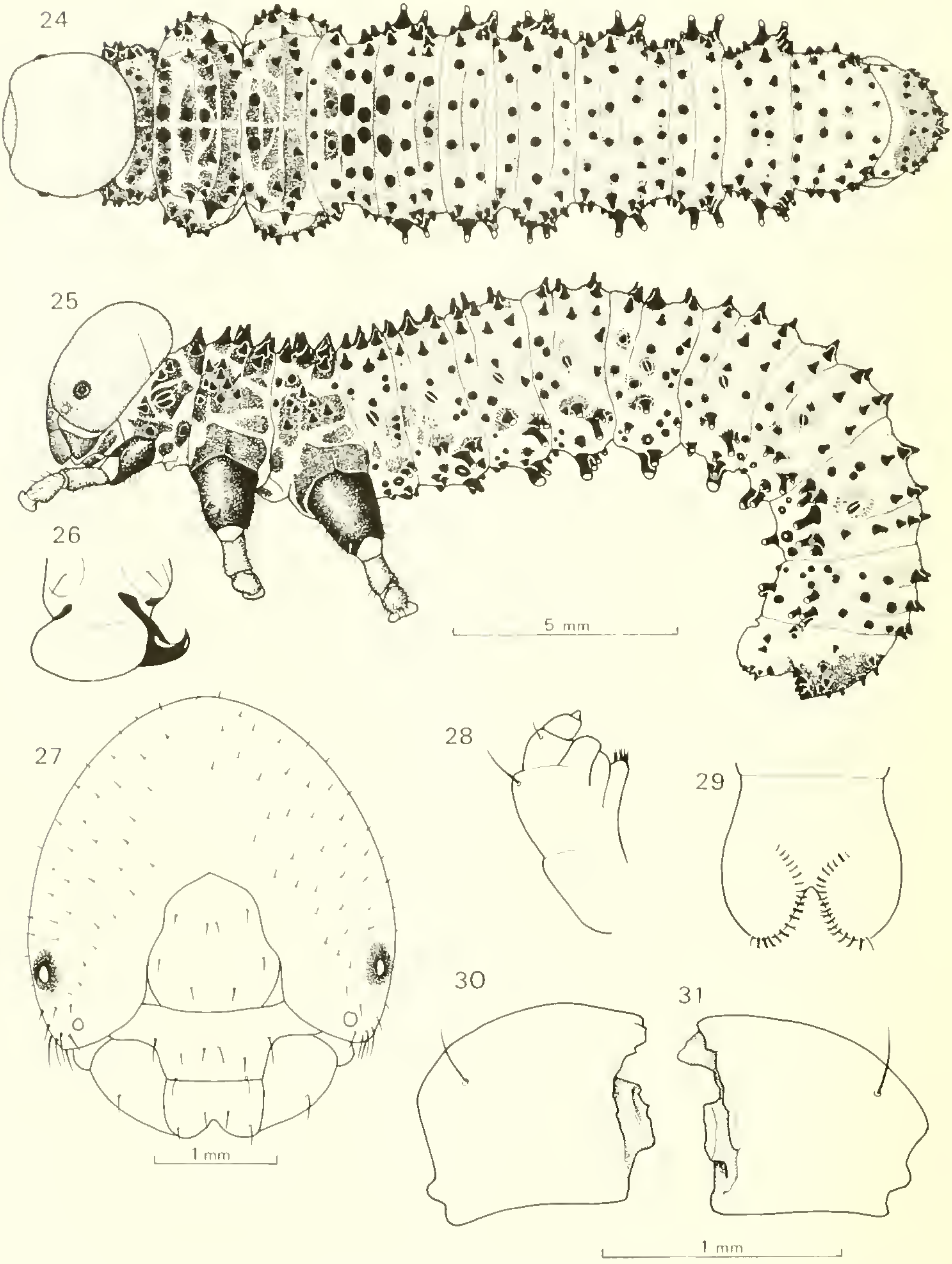
The species epithet alludes to the single yellow band of the forewing, from the Latin "unus" meaning one and "fascia" meaning band.

Manaos kimseyae **Smith, New Species**

Figs. 6–10, 32–39

Female.—Length, 7.0–8.0 mm. Antenna yellow, 3rd segment changing to brownish near center and to black on apical ½. Head black, area between and below antennae, clypeus, and mouthparts yellow; apex of mandible dark reddish. Thorax yellow, mesoscutum sometimes with 2 large or small black areas, mesonotum mostly black with prescutum laterally (entirely in 1 specimen) and extreme apex of scutellum black. Abdomen yellow with apical 3 segments and sheath black. Legs yellow with apical ⅓ of hindtibia and all hindtarsus black; sometimes apical 3 segments of fore- and midtarsi black. Forewing and hindwing black at base and apex with broad yellow band at center; stigma and veins yellow in yellow portion, veins black in black portion.

Antenna length 2⅓× head width; 1st segment 2× longer than broad; 2nd segment as long as broad; 3rd segment usually curved and tapering toward apex, round to oval in cross-section. Malar space linear; clypeus and labrum truncate; eyes large and converging below, lower interocular distance ⅗ eye length; maxillary palpus long, 1⅗ eye length; distances between lateral ocellus and eye, between lateral ocelli, and between lateral ocellus and hindmargin of head in ratio of 1.0:0.8:0.7; interantennal carina high, rounded, not bisecting supraclypeal area; each mandible simple. Tarsal claw simple; hindbasitarsus subequal to length of following segments combined. Forewing with 4 cubital cells, last closed cell longer



Figs. 24–31. *Sericoceros gibbus,* penultimate larva. 24, Body, dorsal view. 25, Body, lateral view. 26, Midtarsus apex and claw. 27, Head, front view. 28, Left maxilla. 29, Epipharynx. 30, Left mandible, inner surface. 31, Right mandible, inner surface.

on cubitus than on radius; small basal anal cell present; apex of radial cell without accessory vein or with very short stub. Hindwing with anal cell longer than its petiole. Sheath short, with stout laterally expanded scopae (Figs. 7, 8). Lancet as in Fig. 6.

Male.—Length, 6.1–7.0 mm. Color and structure similar to female except 3rd antennal segment furcate. Genitalia as in Figs. 9, 10.

Larva (penultimate instar).—Length, 16 mm. Head tan, eyespot pale, mandible darker; body yellowish, tubercles only slightly darker, coxae with dark brown medial stripe.

Head with scattered short setae, only slightly more numerous between eyespot and mandible (Fig. 34); antenna a single, round, flattened segment; clypeus with 2 lateral setae; labrum slightly indented medially, with 2 lateral setae; epipharynx with 8 spines in an arcuate pattern on each lobe (Fig. 37); maxillary palpus 3-segmented, segments without setae, palpifer large, palpifer and stipes each with 1 seta; lacinia with 5 spines (Fig. 35); labial palpus 2-segmented, prementum without setae; right mandible with 4 teeth on outer cutting edge and 2 on inner edge (Fig. 39); left mandible similar to right (Fig. 38); each mandible with 1 seta on outer surface.

Thorax strongly lobate, tuberculate as in Figs. 32, 33; legs short and somewhat reduced, 5-segmented; midtarsal claw as in Fig. 36.

Abdominal segments 1–9 each with 3 indistinct tuberculate annulets, appearing winged in dorsal view (Figs. 32, 33); short rounded prolegs on segments 2–7, all about same size; tergum 10 with 10 tubercles around apical margin.

Holotype.—Female, Panama, labeled "Canal Zone, Pan., Barro Colorado I., IX-1-1981, R. B. and L. S. Kimsey," "Larva collected: *Inga phagifolium*, pupation VIII-17-1981, eclosion VIII-31-1981." At the University of California, Davis.

Paratypes.—PAMANA: Same data as holotype (3 ♂); BCI, 12 May 1981, R. B. and L. S. Kimsey (1 ♀), BCI, 21 Sept. 1976 (1 ♀); Panama Prov., Cerro Jefe, 18 Sept. 1976, R. B. and L. S. Kimsey (1 ♀); BCI, 24 July 1968, D. Q. Cavagnaro and M. E. Irwin (1 ♀); BCI, 7 Jan. 1929, C. H. Curran (1 ♀); BCI, 14 March 1929, S. W. Frost (1 ♀); Cabima, 24 May 1911, A. Busck (1 ♀). Deposited in the University of California, Davis; California Academy of Sciences, San Francisco; American Museum of Natural History, New York; and National Museum of Natural History.

Host and life history notes.—Four larvae were reared from *Inga phagifolium* (Leguminosae) in August, 1981. Approximately 20 larvae were observed feeding singly on the younger leaves of a 0.5 m tall seedling. Mature larvae construct fuzzy, loosely spun, amber-colored cocoons on small stems on the plant. Eclosion occurred in 14 days at 23°C.

Discussion.—The bicolored wings, the yellow and black color pattern (black on the head, mesonotum, mesosternum, and apex of the abdomen), and lancet and genitalia (Figs. 6, 9, 10) will distinguish this new species. Most other species of *Manaos* are entirely orange, or have a different orange and black color pattern, and have uniformly blackish wings.

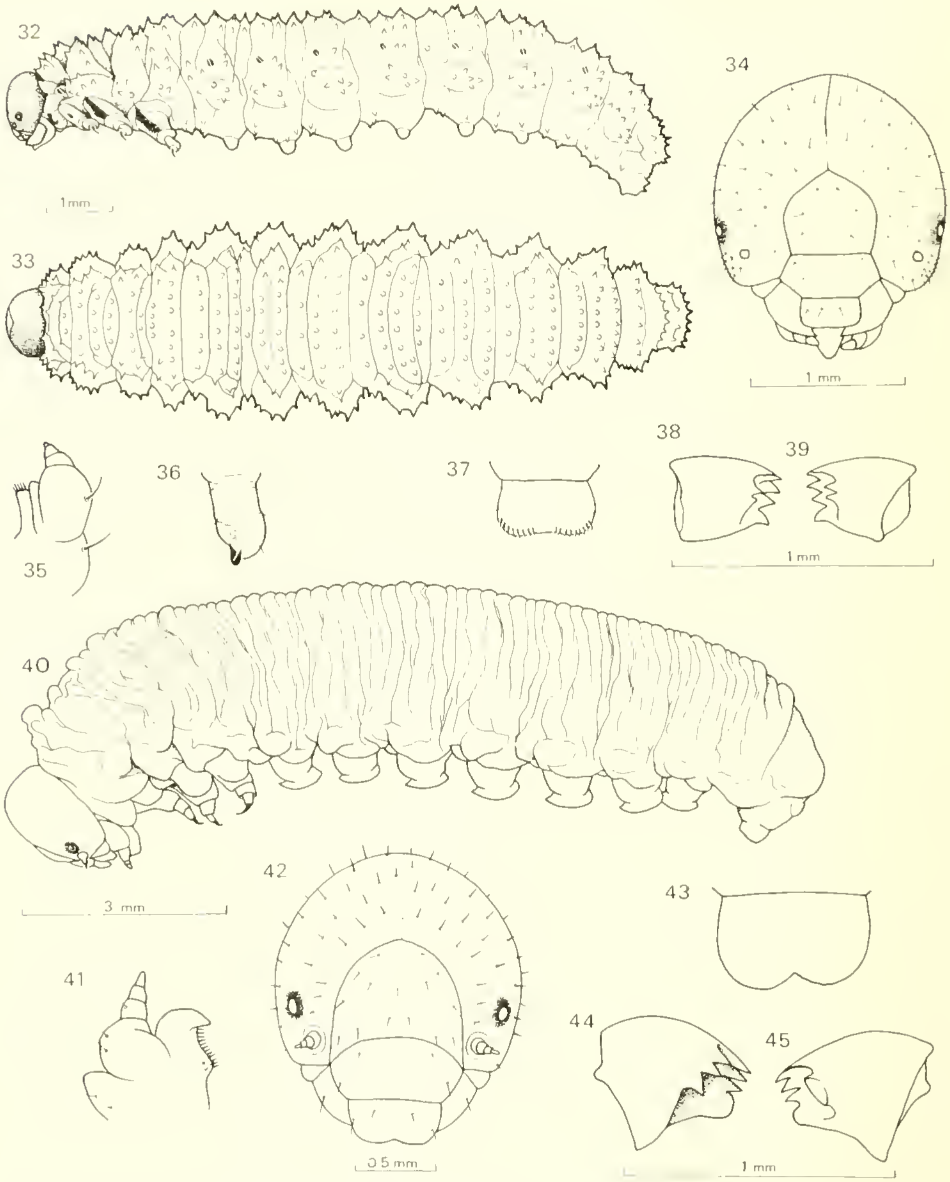
Species of *Manaos* occur from southern Mexico to northern Argentina. Most of the 13 described species are from the Amazon Basin of Brazil and Peru. Larvae and hosts are not known for other species.

The species is named for Lynn Kimsey who collected and reared the species.

Sericoceros gibbus **(Klug)**

Figs. 24–31

Larva (penultimate instar).—Length, 25–26 mm. Head dark brown, eyespot and clypeus black, mandible black with pale medial spot; body greenish, with dark plates and black tubercles; femora blackish.



Figs. 32–45. 32–39, *Manaos kimseyae*, penultimate larva. 32, Body, lateral view. 33, Body, dorsal view. 34, Head, front view. 35, Right maxilla. 36, Midtarsus apex and claw. 37, Epipharynx. 38, Left mandible, inner surface. 39, Right mandible, inner surface. 40–45, *Erythraspides interstitialis*, ultimate larva. 40, Body, lateral view. 41, Left maxilla. 42, Head, front view. 43, Epipharynx. 44, Left mandible, inner surface. 45, Right mandible, inner surface.

Head with scattered short setae, longer and more numerous between eyespot and mandible (Fig. 27); antenna a single, round, flat segment; clypeus with 4 lateral setae; labrum strongly emarginate medially, with 2 lateral setae; epipharynx with 19 apically bifurcate spines arranged in an arcuate row on each lobe (Fig. 29); maxillary palpus 3-segmented, 1st segment and palpifer each with 1 seta;

lacinia with 3 apically bifurcate spines (Fig. 28); labial palpus 2-segmented, prementum with 3 setae; left mandible badly worn, with apparently 2 apical teeth on outer cutting edge and large truncate cusp on inner edge (Fig. 30); right mandible with 2 teeth on outer cutting edge and large cusp in inner edge (Fig. 31); each mandible with a single seta on outer surface.

Thorax strongly tuberculate (Figs. 24, 25); thoracic legs large, each 5-segmented, with scattered setae on each segment. Midtarsal claw as in Fig. 26.

Abdominal segments 1–9 each with 3 annulets, tuberculation as in Figs. 24, 25; ventral tubercles enlarged with white tips, in place of prolegs on segments 2–9; tergum 10 with about 10 tubercles around edge of dark dorsal plate.

Host and life history notes.—Ten larvae were reared on *Coccoloba manzanillensis* (Polygonaceae) in July 1979, and 18 in August 1981. One clump of 13 eggs in a loose cluster was found attached to the under surface of a new leaf. Unlike *S. krugii* (Cresson), no female was observed guarding the eggs (Martorell, 1941). Larval feeding took 33 days and eclosion took 21 days. They fed gregariously along the leaf margin, holding the abdomen erect, away from the leaf margin. This posture has led to the Panamanian name of "Rabo al Honbro." When disturbed they either waved the abdomen or curled it down against the leaf and secreted droplets of fluid from the coxal bases. The last larval instar was slightly smaller than the penultimate instar and had red thoracic segments. Larvae entered the leaf litter and constructed a thick brown silk pupal case attached to twigs and dried leaves. Mature male larvae are slightly smaller than mature female larvae and drop to the ground a week earlier.

Discussion.—*Sericoceros* includes about 15 species and occurs from the West Indies and Mexico south to Argentina. *Sericoceros gibbus* occurs from Mexico south to Brazil and Bolivia. Hosts and larvae are known for only two other species of *Sericoceros*, *S. krugii* from Puerto Rico and *S. edwardsii* (Cresson) from Honduras, both of which also feed on species of *Coccoloba* (Martorell, 1941; Smith, 1972). The larva of *S. krugii* differs from *gibbus* by having a broad black stripe on the head extending from the occiput to the clypeus, and the larva of *S. edwardsii* differs by having paler body tubercles more concolorous with the rest of the body.

***Ptilia concinna* (Klug)**

Figs. 20–23

Larva (ultimate instar, shed skin).—Length about 16 mm. Head blackish, body pale yellow with long black tubercles; leg segments black.

Head with scattered short setae, becoming slightly more numerous between eyespot and mandible (Fig. 20); antenna a single, round, flat segment; clypeus with 2 lateral setae; labrum deeply emarginate medially, with 2 lateral setae; epipharynx with about 8 setae in arcuate pattern on each lobe; maxillary palpus 3-segmented, 1st segment and palpifer each with 1 seta, lacinia with 3 setae (Fig. 23); labial palpus 2-segmented, prementum of labium apparently without setae; left mandible with 4 teeth on outer cutting edge and truncate cusp on inner surface (Fig. 21); right mandible with 4 teeth on outer cutting edge, inner cutting edge simple (Fig. 22); each mandible with 1 seta on outer surface.

Thorax strongly tuberculate, closely resembling that of *Didymia kimseyae*; thoracic legs 5-segmented.

Abdominal segments 1–9 each with 3 faint annulets, tuberculations and anal plate closely resembling those of *Didymia kimseyae.*

Host and life history notes.—Four larvae were collected feeding singly on the new flush leaves of a seedling of *Cnestidium rufescens* (Connaraceae).

Discussion.—About 7 species of *Ptilia* are known from Mexico south to Brazil. *Ptilia concinna* occurs from Costa Rica to Brazil. Hosts and larvae for other species are not known.

TENTHREDINIDAE

BLENNOCAMPINAE

Erythraspides interstitialis **(Cameron), NEW COMBINATION**

Figs. 40–45

Monophadnus interstitialis Cameron, 1883: 24. ♀.

Larva (ultimate instar).—Length, 12–13 mm. Head whitish, body bluish gray becoming abruptly pale yellow ventrally. Penultimate instar: head tan, body dark gray above, pale yellow below.

Head with short scattered setae; antenna 4-segmented; clypeus with 2 lateral setae (Fig. 42); labrum medially emarginate, with 2 lateral setae; epipharynx apparently asetose (Fig. 43); maxillary palpus 3-segmented, 1st segment with 1 seta, stipes and palpifer each with 2 setae, lacinia with 13 spines (Fig. 41); labial palpus 3-segmented, prementum of labium with setae; left mandible with 3 sharp teeth and 1 rounded one on outer cutting edge, and 3 sharp teeth on inner edge (Fig. 44); right mandible with 3 sharp teeth and 1 rounded one on outer cutting edge, and truncate cusp on inner edge (Fig. 45); each mandible with 1 seta on outer surface.

Thoracic legs normal, 5-segmented.

Abdominal segments 1–9 each with 6 annulets, without setae or tubercles; tergum 10 without dark plate (Fig. 40).

Host and life history notes.—Eight larvae were reared from *Hamelia patens* (Rubiaceae). A female was observed ovipositing on a single leaf, inserting the eggs under the epidermis on the surface. After hatching, the larvae fed gregariously, starting at the tip of the leaf and working toward the petiole. They fed on the leaf blade but did not consume the midrib or other large veins. When not feeding, the larvae remained together in a cluster on the underside of the leaf. In the laboratory, last instar larvae were placed in a soil-filled petri dish where they burrowed in the soil and formed smooth-walled, silk-lined cocoons in the soil. At 25°C the period from hatching to cocoon formation was 15 days; adults emerged after 10 days.

Discussion.—*Erythraspides* includes about 10 species and is found from Canada to Central America. Hosts for only the two Nearctic species are known, *E. carbonarius* (Cresson) on *Oenothera* sp. and *E. vitis* (Harris) on *Vitis* sp. Only the larva of *E. vitis* has been described (Smith, 1969), and it differs from *interstitialis* by the long, conical, dark tubercles on the upper surface of the body. The identification and new combination are based on a study of Cameron's type in the British Museum (Natural History), London., by the junior author. The type is from "Panama, Volcan de Chiriqui, 2000 to 3000 feet."

ACKNOWLEDGMENTS

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LITERATURE CITED

Cameron, P. 1883. Hymenoptera, Tenthredinidae-Chrysididae. *In* Godman and Salvin, Biologia Centrali-Americana, Vol. 1, 486 pp.

Martorell, L. F. 1941. Biological notes on the sea-grape sawfly, *Schizocera krugii* Cresson, in Puerto Rico. Caribb. For. 2(3): 141–144.

Smith, D. R. 1969. Nearctic sawflies. I. Blennocampinae: Adults and larvae (Hymenoptera: Tenthredinidae). U.S. Dep. Agric. Tech. Bull. 1397, 179 pp., 19 pls.

———. 1972. North American sawfly larvae of the family Argidae (Hymenoptera). Trans. Am. Entomol. Soc. 98: 163–184.

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A LIST OF THE ALEYRODIDAE OF THE ISLAND OF RÉUNION

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Abstract.—Collection data are given for 15 described and five undescribed species of Aleyrodidae and for six collections of early stage Aleyrodinae. Citations are given to 21 publications that contain references to the Aleyrodidae of Réunion. Parasites and/or predators of four species of Aleyrodidae are indicated.

This list of the Aleyrodidae of the Island of Réunion is the first to be published on the aleyrodid fauna of a Mascarene Island. The article lists 21 species of Aleyrodidae, six of which apparently are undescribed, and six collections of unidentified larvae, with collection data. The species belong in the Aleyrodinae except for one, indicated in the list, which is placed in the Aleurodicinae. Parasites and/or predators of four aleyrodid species are listed. The collections were made by J. Etienne except as noted, and the specimens are in the U.S. National Museum of Natural History, Washington, D.C.

The aleyrodids are reported from 31 plant genera belonging to 20 families and from several unidentified plants. Eleven genera and seven families are recorded, for the first time, as hosts of Aleyrodidae in Réunion. The botanical names appearing herein have been checked in Hortus Third (Staff of the L. H. Bailey Hortorium, Cornell University, 1976) and/or Index Kewensis and Supplements (various compilers, 1855–1974). Family names of plants are given only once, the first time a host plant is listed.

Literature citations are given for all the articles we have found that have scientific names of Aleyrodidae reported from Réunion.

ALEYRODIDAE OF RÉUNION

Acutaleyrodes palmae Takahashi.

Recorded by Takahashi (1960b) on *Acanthophoenix rubra* (Palmae), Saint-Philippe, XII-1925, R. Paulian. Re-recorded by Mound and Halsey (1978).

Aleurocanthus hibisci Corbett.

On *Hibiscus liliiflorus* (Malvaceae), Saint-Denis, 19-XI-1976.

On *Cassia siamea* (Leguminosae), Saint-Denis, 7-V-1978.

Eretmocerus sp. (Aphelinidae) is a parasite of *A. hibisci* in Réunion.

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Aleurodes trachoides Pack! (= Aleurotrachelus trachoides (Back)).

Recorded by Luziau (1953b) and by Plenet (1960b, 1965) on *Casuarina equisetifolia* (Casuarinaceae). Orian (1972) referred to Luziau's record but questioned the identification of *trachoides*. Mound and Halsey (1978) referred to Orian's report. We think it is unlikely that *trachoides* occurs in Réunion on *Casuarina*.

Aleuroplatus evodiae Takahashi.

Recorded by Takahashi (1960a) on *Evodia* sp. (Rutaceae), Plaine d' Affouches, V-1957, J. Bosser. Re-recorded by Mound and Halsey (1978).

Aleuroplatus subrotundus Takahashi.

Recorded by Takahashi (1960a) on *Eugenia Jambos* (= *Syzygium Jambos*) (Myrtaceae), Bois de Nèfles near Saint-Denis, V-1957, J. Bosser. Re-recorded by Mount and Halsey (1978).

Aleuroplatus sp. (undescribed).

On unidentified plant, Forêt de Bébour, 20-XI-1975.

Aleurothrixus floccosus (Maskell).

Recorded by Mound and Halsey (1978) without host plant or locality.

Recorded by Etienne (1978) and by Etienne and Vilardebó (1978) on *Citrus* sp. (Rutaceae); and by Etienne (1978) on *Calophyllum* sp. (Guttiferae), *Eugenia pimenta* (= *Pimenta dioica*) (Myrtaceae), and *Psidium cattleianum* (Myrtaceae).

On *Citrus* sp., Cambai, 25-III-1975, B. Aubert, from Y. Ben-Dov and 10-VII-1975, from J. Onillon; Tampon, 5-X-1976; Sainte-Anne, 28-X-1976; La Bretagne, 27-IX-1977.

On *Calophyllum* sp., La Possession, 9-XII-1976.

Accidentally introduced, *A. floccosus* was the most serious pest of citrus in Réunion before 1975. Predators belonging to the Coccinellidae, Chrysopidae, and Miridae did not maintain a low level population of the whitefly. In 1976 *Cales noacki* Howard (Aphelinidae) was introduced and within two years after its release, the *floccosus* population was reduced sufficiently to make chemical control of the aleyrodid unnecessary.

Aleurotrachelus pauliani Takahashi.

Recorded by Takahashi (1960b) on unidentified plant, Cilaos, XII-1955, R. Paulian. Re-recorded by Mound and Halsey (1978).

Aleurotrachelus reunionensis Takahashi.

Recorded by Takahashi (1960b) on unidentified plant, Cilaos, XII-1955, R. Paulian. Re-recorded by Mound and Halsey (1978).

Bemisia elliptica Takahashi.

Recorded by Takahashi (1960b) on unidentified plant, Cilaos, XII-1955, R. Paulian. Re-recorded by Mound and Halsey (1978).

Bemisia sp.

On *Manihot utilissima* (= *M. esculenta*) (Euphorbiaceae), Mouffia, 25-XI-1976.

Bemisia tabaci (Gennadius).

Recorded by Bouriquet (1938) as *Bemisia manihotis* Frappa ". . . au Jardin Colonial de St. Denis et au Piton St. Leu . . ." Recorded by Luziau (1953a) as *Bemisia maniotis*! Frappa on manioc.

Dialeurolonga simplex Takahashi.

Recorded by Etienne (1978) and by Etienne and Vilardebó (1978) on *Citrus* sp. On *Citrus* sp., Entre-Deux, V-1972, H. D. Catling; Tampon, 5-X-1976, 10-X-

1976; Sainte-Anne, 21-X-1976, 28-X-1976; Gol-les-Hauts, 4-XI-1976; Saint-Philippe, 10-XI-1976; La Bretagne, 27-IX-1977.

On *Calophyllum* sp., Le Tremblet, 11-IX-1975.

Dialeurolonga sp. (undescribed).

On *Citrus* sp., Haut de Bras Panon, 25-III-1975, B. Aubert, from Y. Ben-Dov.

Neomaskellia bergii (Signoret).

Recorded by Guérin-Meneville (1868, 1869), by Signoret (1869), and by Bordage (1900) on sugarcane (Gramineae). Recorded by Williams and Mamet (1954, 1962) and by Plenet (1960a, 1965) on *Saccharum officinarum* (Gramineae).

On *Saccharum officinarum*, Petite-Ile, 2-XI-1976 and La Bretagne, 25-XI-1976.

On *Pennisetum purpureum* (Gramineae), La Bretagne, 16-XII-1976.

Stenaleyrodes vinsoni Takahashi (Aleurodicinae).

Recorded by Takahashi (1938) on palm (Palmae), Saint-Denis, X-1937, J. Vinson. Re-recorded by Mound and Halsey (1978). Recorded by Mamet (1952) as "fairly troublesome" on *Chrysalidocarpus lutescens* (Palmae), *Cocos nucifera* (Palmae), and *Oreodoxa regia* (=*Roystonea regia*) (Palmae), Saint-Denis, 19–21-VII-1951, J. R. Williams. Recorded by Plenet (1960b, 1965) as a parasite of *Aspidiotus destructor* Signoret (Diaspididae) on *Cocos nucifera*. We do not think this aleyrodid was a parasite of a diaspidid (Coccoidea), but that the two occurred together on *Cocos*.

On palm, Saint-Denis, 14-X-1963, J. G. Pointel, from G. Remaudière.

On *Chrysalidocarpus lutescens*, Saint-Denis, 4-XI-1976.

On *Cocos nucifera*, Saint-Denis, 7-XII-1976.

Clitostethus arcuatus (Rossi) (Coccinellidae) is a predator of *S. vinsoni* in Réunion.

Tetraleurodes sp. (undescribed).

On *Citrus* sp., Plaine des Palmistes, 2-X-1976.

Tetraleurodes sp. (undescribed).

On *Ocotea* sp. (Lauraceae), Les Makes, 23-II-1978.

Trialeurodes elaphoglossi Takahashi.

Recorded by Takahashi (1960a) as *Trialeurodes elaphroglossi*! on *Elaphroglossum*! sp. (Polypodiaceae), Plaine des Caffres, VI-1957, J. Bosser. Re-recorded by Mound and Halsey (1978).

Trialeurodes vaporariorum (Westwood).

Recorded by Etienne and Roura (1976) on *Sechium edule* (Cucurbitaceae), Cilaos; *Cucumis sativus* (Cucurbitaceeae), Saint-Pierre; *Curcubita pepo* (Cucurbitaceae), Saint-Pierre and Plate; *Gerbera* sp. (Compositae), La Bretagne; *Lycopersicon esculentum* (= *L. Lycopersicum*) (Solanaceae), Sainte-Marie; *Pelargonium capitatum* (Geraniaceae), Colimaçons and Tampon; *Phaseolus* sp. (Leguminosae), Colimaçons and La Bretagne.

On *Hibiscus* sp., La Bretagne, 16-IV-1975.

On *Pelargonium capitatum*, Les Colimaçons, 2-X-1975 and 28-X-1976, Trois Bassins, 7-XI-1976.

On *Lycopersicon esculentum* (= *L. Lycopersicum*), Saint-Louis, 1-XI-1975.

On *Phaseolus* sp., La Bretagne, 24-XI-1975 and Les Colimaçons, 28-X-1976.

On *Mussaenda arcuata* (Rubiaceae), Saint-Philippe, 11-XII-1975.

On yellow plate, Saint-Philippe, Forêt de la Mare Longue, 14-IV-1976.

On *Sechium edule,* Cirque de Cilaos, 29-XI-1976 and Cilaos, 26-1-1978.

On *Nasturtium officinale* (Cruciferae), Cirque de Cilaos, 29-XI-1976.

On *Siegesbeckia orientalis* (Compositae), Entre-Deux, 23-VI-1977.

T. vaporariorum, a polyphagous species, was first collected in Réunion in January 1975 (Etienne and Roura, 1976). It became established and was soon recognized as a serious pest of horticultural crops. *Encarsia formosa* Gahan and *E. tricolor* Foerster (Aphelinidae) were introduced from France in 1977 to control the whitefly. The recovery of *E. formosa* in 1980 at Les Colimaçons, three years after its release, indicates that the parasite was established on the island. At the present time, however, we do not know whether *vaporariorum* is being efficiently controlled by *E. formosa.*

Aleyrodinae (undescribed genus and species).

On unidentified plant, Forêt de Bébour, 20-XI-1975.

Aleyrodinae (immature).

On *Tambourissa* sp. (Monimiaceae), Forêt de Bébour, 13-XI-1975.

On *Nuxia verticilla* (Loganiaceae), Forêt de Bébour, 20-XI-1975.

On *Ficus mauritiana* (Moraceae), Route de Salazie, near Pont de l'Escalier, 10-XII-1975.

On *Takamaka inophyllum* (Guttiferae), Saint-Philippe, 14-IV-1976.

On *Citrus* sp., Entre-Deux 25-III-1975, B. Aubert from Y. Ben-Dov; Plaine des Palmistes, 2-X-1976.

LITERATURE CITED

Bordage, E. 1900. Sur les principaux parasites animaux et végétaux de la canne a sucre aux iles Mascareignes. Compt. Rend. VI. Congr. Int. Agric. Paris 2: 321–327.

Bouriquet, G. 1938. Note concernant les maladies des plantes cultivées à la Réunion. Rev. Agric. Réunion 43 (n.s.): 33–38.

Etienne, J. 1978. Introduction à la Réunion de *Cales noacki* How. (Hymenopt. Aphelinidae) pour lutter contre *Aleurothrixus floccosus* (Maskell) (Homopt. Aleurodidae). Fruits 33: 883–886.

Etienne, J. and A. Roura. 1976. Insectes nuisibles nouveaux pour la Réunion. Ann. Rpt. IRAT. Réunion, pp. 43–44.

Etienne, J. and A. Vilardebó. 1978. Notes sur les principaux ravageurs des agrumes de l'ile de la Réunion. Fruits 33: 873–876.

Guérin-Meneville, F. E. 1868. Études sur les insectes, considérés comme la cause de la maladie des cannes à sucre, dans les îles Maurice et de la Réunion. Rev. Mag. Zool. 20 (ser. 2): 123–127.

———. 1869. Ibidem. Ann. Entomol. Soc. France 9 (ser. 4): 89–92.

Luziau, R. 1953a. Contribution a la prospection phytosanitaire de l'ile de la Réunion. Phytoma 6 (46): 16–21.

———. 1953b. Ibidem. Phytoma 6 (47): 13–19.

Mamet, R. 1952. A note on *Stenaleyrodes vinsoni* Takahashi (Hemiptera: Aleyrodidae). Proc. R. Entomol. Soc. Lond. (B) 21 (pts. 9–10): 134.

Mound, L. A. and S. H. Halsey. 1978. Whitefly of the world. British Museum (Nat. Hist.), 340 pp.

Orian, A. 1972. The Psylloidea of Mauritius with a description of Trioza eastopi *sp. nov.* Fauna of Mauritus. Insecta-Homoptera 1 (1): 1–6.

Plenet, A. 1960a. Parasites animaux des principales plantes cultivées à la Réunion (1 ère pt.). Rev. Agr. Réunion 60 (n.s.): 79–86.

———. 1960b. Ibidem (2 ème pt.). Rev. Agr. Réunion 60 (n.s.): 167–181.

———. 1965. Parasites animaux des principales plantes cultivées a la Réunion. Congr. de la protection des cultures tropicales. Compt. Rend. des travaux, Chambre Comm. Industr. Marseille, pp. 203–216.

Signoret, V. 1869. Quelques observations sur les cochenilles connues sous le nom de pou à poche blanche qui ravagent les plantations des cannes a sucre a l'ile Maurice et a l'ile de la Réunion. Ann. Soc. Entomol. Fr. 9 (ser. 4): 93–96.

Takahashi, R. 1938. A new genus and species of Aleyrodidae from the Island of Réunion (Homoptera). Trans. Nat. Hist. Soc. Formosa 28: 269–271.

———. 1960a. Three species of Aleyrodidae from Réunion Island (Homoptera). Nat. Malgache 12: 139–143.

———. 1960b. Some species of Aleyrodidae from Réunion Island (Homoptera). Nat. Malgache 12: 145–153.

Williams, J. R. and J. R. Mamet. 1954 Insects and other invertebrates which feed upon sugar cane in Mauritus and Réunion, and their natural enemies. Bull. Dep. Agr. Mauritius 89: 1–19.

———. 1962. The insects and other invertebrates of sugar cane in Mauritius and Réunion. Mauritius Sugar Ind. Res. Inst. Occas. Pap. 8: 1–23.

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BIOLOGY AND IMMATURE STAGES OF *THECESTERNUS HIRSUTUS* PIERCE (COLEOPTERA, CURCULIONIDAE) IN NORTH-EASTERN MEXICO

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Abstract.—*Thecesternus hirsutus* Pierce (Thecesterninae) was studied in north-eastern Mexico as a biocontrol agent against *Parthenium hysterophorus* L. (Asteraceae), an introduced weed pest in Australia, and field and laboratory observations on the previously little-known biology of this weevil are reported. There is one generation per year. The larval stage overwinters. Larvae hatch from eggs laid in the soil surface, burrow down to the host's roots, on which they feed externally, causing a gall-like swelling at each feeding-site, and construct earthen cells around themselves and the feeding-sites. Although its host range is highly specific, including only a few closely related species of *Parthenium*, *T. hirsutus* does not seem promising as a biocontrol agent because larval feeding does not cause significant damage to the plants. Larvae and pupae are described for the first time for the Thecesterninae and larval morphology clearly places this group in the section Phanerognatha of the Curculionidae.

The Thecesterninae are a small North American subfamily of large weevils whose biology has been little studied and whose immature stages have never been reported. The subfamily contains one genus, *Thecesternus*, with seven species (O'Brien and Wibmer, 1982), and the adults are characterized structurally by their unlobed tarsi, the short, broad rostrum which fits into a deep emargination in the prothorax, and the triangular form of the prosternum which lies posterior to this emargination (Kissinger, 1964). Blatchley and Leng (1916) quoted a report by [C. V.] Riley (no reference cited) of the adults cutting off grape blossoms, while Kissinger (loc. cit.) states that they are to be found under stones and dried cow dung. Apart from these references there seems to be virtually no published information on the biology of the group.

From 1978 to 1983 one of us (McClay) was engaged in studies of the natural enemies of the annual weed *Parthenium hysterophorus* L. (Asteraceae) in north-eastern Mexico on behalf of the Department of Lands of Queensland, Australia. This plant, native to the neotropics, was introduced into Australia in the 1950's, and since 1973 has become a serious problem in cattle-raising areas of central Queensland (Haseler, 1976). The studies in Mexico were aimed at identifying potential biocontrol agents for use against it in Queensland, and were carried out from a base at Monterrey, Nuevo Leon.

During these studies, large curculionid larvae were found feeding externally on the roots of *P. hysterophorus*. Adults reared from these larvae were identified by D. R. Whitehead of the Systematic Entomology Laboratory, IIBIII, USDA, in Washington, D.C. as *T. hirsutus* Pierce. While this species was being evaluated as a possible biocontrol agent for *P. hysterophorus*, observations were made of its life-history, habits and host-specificity, and larvae and pupae were collected for detailed morphological study.

Collections were made at a number of sites in the vicinity of Monterrey. *Thecesternus hirsutus* was found to be locally common, favoring dry, stony, well-drained sites subject to little disturbance. It was collected mainly as larvae, which when collected partly-grown could be reared through to pupation in the laboratory on an artificial diet (Harley and Willson, 1968). Adults were rarely found in the field.

Although the evaluation suggested that *T. hirsutus* was not a promising biocontrol agent for *P. hysterophorus*, material has been sent for further study to the Department of Lands laboratories at Sherwood, Queensland. If it is confirmed to be sufficiently host-specific, this species may eventually be released onto infestations of *P. hysterophorus* in Queensland.

The descriptions of the immature stages presented here will help future investigators to identify larvae and pupae of this genus and to establish the correct systematic position of the subfamily Thecesterninae within the Curculionidae.

Life History

Information on the life history was derived mainly from observations on weevils kept in an open insectary on potted plants of *P. hysterophorus* under ambient conditions.

The eggs are laid in the soil surface either at the base of the host plant or within the area of the root system, and covered with a few mm of soil. If oviposition is not completed, the site appears as a small conical pit in the soil surface. Females observed ovipositing adopted a characteristic "head-up" position with the tip of the abdomen inserted in the soil surface and being moved back and forth to excavate the oviposition hole. The egg is smooth and pale yellow, ovoid, approximately 1.40 × 1.04 mm in size. Owing to the concealed oviposition site, the duration of the egg stage is not known exactly.

The newly-hatched larva burrows down into the soil from the oviposition site and begins to feed externally on either a tap-root or a lateral root. A gall-like swelling soon begins to form at the feeding site, resulting from a proliferation of the cortical tissue of the root. The stele is little affected by the gall formation or the feeding of the larva. As the larva grows it forms around itself an earthen cell, which is attached around the edge of the feeding site on the gall. At first the cell is fairly fragile but later becomes reinforced by an interior layer of a dark brown papery material that gives it considerable toughness. Larvae feeding on artificial diet in the laboratory were observed taking drops of excreta from the anus into the mouthparts and spreading them on the surface of the diet block. This behavior is probably responsible under natural conditions for the formation of the reinforcing layer of the feeding cell.

The gall may be as large as 10 mm in diameter, and in the field up to 12 nearly-mature larvae have been found feeding on the roots of a single plant. Their feeding does not seem to have any significant detrimental effect on the growth of the plant. The normal duration of the larval stage in the field appears to be about 6 months. Larvae are often found on the roots of *Parthenium* plants growing several m from their nearest neighbors of the same species, indicating that the adults, although flightless, have a well-developed searching ability for the host plant.

Pupation takes place in the feeding cell. The duration of the pupal stage of individuals that were fed on the laboratory diet varied from 16 to 20 days. Detailed morphological descriptions of the larva and pupa are given below.

After eclosion the teneral adult remains in the cell for several days to harden up before cutting a hole in the cell and tunnelling up to the soil surface. Adults which emerged in the laboratory did not begin to feed until 14 to 24 days after eclosion. When maintained on potted plants of *P. hysterophorus*, they fed somewhat sparingly on the foliage, cutting pieces out of the edges of the leaves. Their mottled gray coloration provides a very effective disguise on the soil surface. Feeding, mating, oviposition and locomotion were all observed during daylight, but on some occasions the weevils were inactive during the day in cracks in the soil or in the corners of the cage. The adults are long-lived, some surviving for at least 10 months.

PHENOLOGY

From January to December of 1982, a site near the village of Dr. Gonzalez, about 54 km north-east of Monterrey, was visited at approximately monthly intervals in order to determine the seasonal occurrence of the different stages of the life-cycle. From these observations it is apparent that *T. hirsutus* has a mainly univoltine life-cycle, with the main period of oviposition occurring in September when the late summer rains lead to a flush of growth of *P. hysterophorus*. The larvae then feed over the autumn and early winter, ceasing to feed when they reach full development some time between December and February. Pupation occurs in early April and the adults emerge in April or May to feed over the summer and oviposit in September. The finding of a few early-instar larvae from May onwards, and of some pupae in September and October, suggests that some adults may oviposit in the spring, giving rise to a partial second generation over the summer. The timing of oviposition is probably influenced by the availability of the host plant in a suitable condition. In the insectary, adults which had emerged the previous year oviposited from February onwards.

HOST-SPECIFICITY

Larvae were found in the field on roots of both *P. hysterophorus* and *P. confertum* DC. One larva found on *P. bipinnatifidum* Villanova near San Luis Potosi, SLP, was similar to those found on *P. hysterophorus* and *P. confertum*, but was not reared to the adult stage. Examination of the roots of other Asteraceae growing in the vicinity of *P. hysterophorus*, mainly at the Dr. Gonzalez site showed no larvae feeding on *Melampodium cinereum* DC, *Viguiera dentata* (Cav.) Spreng., *Ambrosia confertiflora* DC, *Dyssodia micropoides* (DC) Loes., *D. pentachaeta* (DC) Robins or *Chaetopappa* sp.

Host-specificity tests were also carried out in the insectary, in multiple-choice cages in which potted plants of *P. hysterophorus* and other species of Asteraceae were exposed to the adult weevils. The design of the test cages was such that the weevils could move freely from one plant to another and had access to both the plants and the soil surface in the pots. In this way both feeding and oviposition preferences could be studied. Five to seven weeks after setting up a test, the roots of all test plants were carefully cleaned of soil and checked for the presence of larvae. The other test plants used were *P. argentatum* Gray (the guayule rubber plant), *Helianthus annuus* L., *Ambrosia confertiflora* DC, *Bidens pilosa* L., *Xanthium* sp., *Lactuca sativa* L., *Cichorium intybus* L., and ornamental cultivars of coreopsis, zinnia and dahlia.

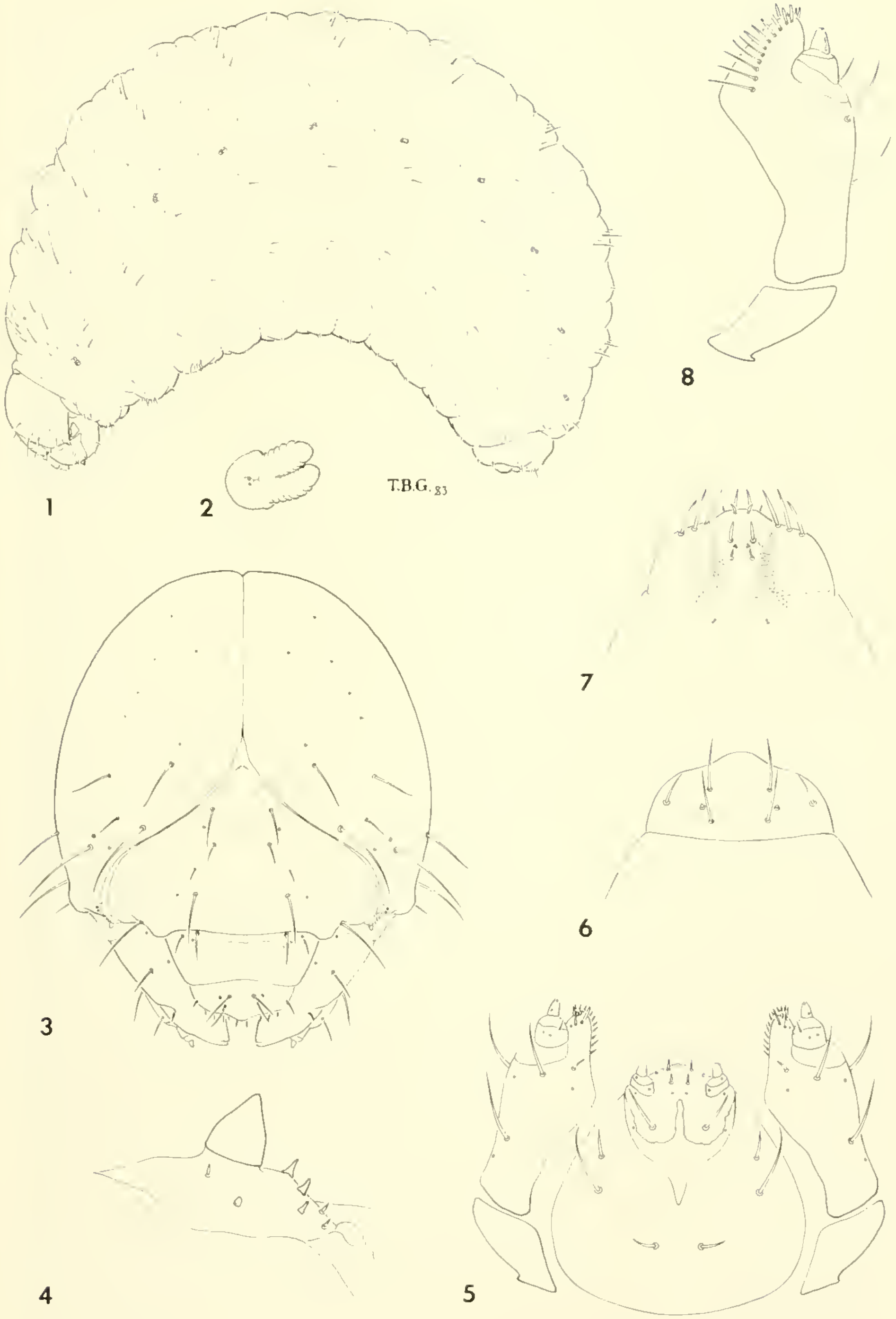
In these tests extensive feeding occurred on foliage of *P. hysterophorus,* while feeding was zero or negligible on all other test plants. Oviposition behaviour was seen frequently in the pots containing *P. hysterophorus,* but was never observed in those containing other test plants. Examination of the roots showed a mean of 9.7 larvae per plant of *P. hysterophorus* (range 0–24), while none were found on the roots of any other test plant.

DESCRIPTIONS OF IMMATURE STAGES

Larva.—The following description is based upon a series of 10 mature (final instar) larvae, of which 3 were dissected, collected at Garza Garcia, N.L., Mexico, Nov. 10, 1981, on roots of *P. confertum* by A. S. McClay and H. Miranda. Unless noted otherwise, the terminology used follows that of Anderson (1947).

Body: Stout, C-shaped, tapered at both ends (Fig. 1). Maximum length of entire specimens: 10.62 mm. Body white, with pale brown or unpigmented setae and tiny unpigmented asperities.

Head (Figs. 3–8): Convex dorsally, unretracted, slightly longer than wide; width of 8 measured: 1.40–1.60, mean 1.49 mm. Epicranium and frons light orange-brown, darkest dorsolaterally and around mouthframe. Epicranial suture slightly more than half length of epicranium. Five pairs of dorsal epicranial setae (des) present; des 3 and 5 longest, more than twice the length of des 4. Three pairs of dorsal epicranial sensilla present. Four pairs of minute posterior epicranial setae present. Two pairs of lateral epicranial setae present, subequal in length. Frontal sutures distinct, slightly sinuate, not reaching articulating membrane of mandible at anterior extremities. Frons with 5 pairs of setae (fs) and 2 pairs of sensilla; fs 4 and 5 subequal and distinctly longer than fs 1, 2, and 3. Endocarinal line distinct for approximately ⅓ length of frons. Two pairs of ventral epicranial setae present, subequal in length. Anterior ocellus present, its lens flat and its pigment divided into 2 equal spots; posterior ocellus vaguely indicated by a small subcutaneous pigment spot. Clypeus with 2 pairs of moderately long setae and 1 pair of basal sensilla. Labrum with 3 pairs of setae (lms) of which the inner 2 pairs (lms 1 and 2) are subequal, longer than lms 3, and with 2 basal sensilla but no median sensillum. Maxilla bearing 1 dorsal and 2 ventral setae on the stipes, a row of 10 or 11 dorsal malar setae, a group of 5 ventral malar setae of which 2 are short, 3 subequal to dorsal malar setae, and 4 ventral sensilla. Maxillary palpus of 2 articles, the first distinctly larger than the second and bearing 1 short ventral seta. Dorsal surface of maxilla partly covered with rows of microspicules. Premental sclerite of labrum trident-shaped with a pointed posteromedian process and an elongate anteromedian process. Labial palpi of 2 articles, the first distinctly broader than the second. Ligula bearing 2 pairs of short setae and 1 pair of rod-like sensilla. Three pairs of postmental setae (pms) present, of which pms 1 are more



Figs. 1–8. *Thecesternus hirsutus*, larva. 1, Entire larva, lateral view. 2, Abdominal spiracle. 3, Head, front view. 4, Antenna, dorsal view. 5, Labium and maxillae, ventral view. 6, Labrum, dorsal view. 7, Epipharynx, ventral view. 8, Right maxilla, dorsal view.

closely spaced than pms 2 or pms 3. Premental setae shorter than pms 2, subequal to pms 1 and 3. Hypopharyngeal bracon present, with a pair of pigmented spots near the center. Epipharynx with 3 pairs of anterolateral setae, 6 anteromedian setae, and 2 pairs of median setae (spines of Anderson, 1947), of which the anterior pair are longest. Labral rods (tormae) dark, elongate, slightly convergent posteriorly. Two pairs of sensilla clusters present on epipharynx; anterior pair, of 3 sensilla per cluster, posterior to 1st pair of median setae; posterior pair, of 2 sensilla per cluster, located posterior to labral rods. Asperities of epipharynx condensed into 2 paramedian stripes which converge anteriorly. Antenna a single membranous basal article bearing a subconical accessory sensory appendage (sensory cone) and 7 smaller processes. Mandibles stout, bifid at tips, orange-brown in basal ⅔, becoming dark brown at tips. Mandibular seta 1 more than twice the length of 2.

Thorax (Fig. 1): Pronotum lightly pigmented, bearing 11 setae on each side of midline. Spiracle bicameral; air tubes oriented dorsally, approximately as long as diameter of peritreme. Pleura bearing 2 setae on prothorax, 1 seta on meso- and meta-thorax. Alar areas both with 1 seta. Spiracular area of meso- and meta-thorax with 1 long and 1 short seta. Epipleura with 1 seta. Pedal areas with 8 setae, of which 3 are longer than the rest and 1 is minute. Sternal setae of medium length. Prodorsal folds of meso- and meta-thorax with 1 pair of median dorsal setae and 2 pairs of minute lateral setae. Postdorsal folds of meso- and meta-thorax with 4 pairs of setae, of which the second pair are short, the rest moderately long.

Abdomen (Figs. 1, 2): Eight pairs of lightly pigmented bicameral spiracles present, located laterally, with air tubes oriented posterodorsally. Segments 1–7 with 3 dorsal folds (folds II–IV) plus a small auxiliary fold behind fold IV; fold I developed laterally on segments 2–7. Prodorsal folds on segments 1–7 with 1 pair of dorsal setae and 1 pair of minute lateral setae. Five pairs of postdorsal setae (pds) present on segments 1–8, pds 1, 2 and 4 short, 3 and 5 long. Three pairs of pds on segment 9, the middle seta long, the others short. Epipleura and pleura on segments 1–8 with 2 setae of which 1 is short, the other of medium length. One short pedal seta and 2 pairs of short eusternal setae present on segments 1–9. Sternellum absent on all segments. Anus terminal, surrounded by 4 distinct lobes, the 2 lateral lobes bearing 1 short and 1 minute seta.

Alimentary canal (Figs. 9, 10): Terminology from May (1977): Proventriculus distinct but not expanded. Five or 6 large subglobular mycetomes encircling the constriction marking the cardiac valve. Anterior ventriculus large, deeply folded transversely at regular intervals. Posterior ventriculus with an anterior transverse twist followed by a longitudinal coil, on which the gastric caeca are arranged in an irregular row of 6 on each side. Six Malpighian tubules present, grouped 2 and 4 at origin, reinserted into a moderately developed cryptonephridium on the hindgut. Rectal bracon marked by an external constriction but membranous and difficult to discern.

No significant difference (other than size) was observed between the mature larvae described here and a series of 5 larvae (same collection data) that were clearly in an earlier instar, but no 1st instar larvae were available for study. Thus, it may be possible to identify most larvae of this species with the aid of the description and illustrations provided here, but if the 1st instar larva differs from later instars, as it does in some weevil genera, it may be difficult to identify.

Pupa.—The following description is based upon 4 pupae, of which 3 were reared from larvae collected at Dr. Gonzalez on Jan. 12, 1982, and 1 field collected at the same site between August and October, 1982. The terminology used here follows Burke (1968).

Body (Figs. 11, 12): Robust in form, white, with brown attenuate setae arising from tubercles of varying height. Length of 4 specimens: 8.72–11.62, mean 9.94 mm.

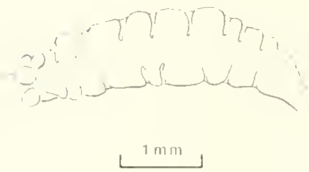
Head (Fig. 11): Convex dorsally, with impressed median ecdysial line. Rostrum very short, stout, untapered. Antennae thick, inserted at base of rostrum. Eyes not visible externally. Mandibles very stout, convex, 2-toothed, bearing 1 short seta. One pair of frontal setae, 3 pairs of supraorbital setae (1 pair short), 3–4 pairs of basirostral setae, and 3 pairs of distirostral setae present. Some tiny auxillary setae sometimes present on the rostrum.

Thorax (Figs. 11, 12): Prothorax slightly broader than long, convex dorsally and laterally; setae moderately long and slightly curved, borne on tubercles of moderate height, including 2 pairs of widely separated anteromedian setae, 2 pairs of posteromedian setae slightly anterior to middle of pronotum, 3 pairs of anterolateral setae, and 2 pairs of posterolateral setae. Ocular lobes well developed. Three pairs of mesonotal and metanotal setae present. No anteronotal setae present on meso- or metanotum. Elytral pads thick, convex, and distinctly striate externally, apices nearly reaching tips of hind femora. Hindwing pads very short, hidden by elytral pads. Forecoxae subglobose, approximate, concealing most of prosternum. Midcoxae separated by a distinctly protuberant mesosternum. Hindcoxae widely separated by the metasternum.

Abdomen (Figs. 11, 12): Convex dorsally, slightly swollen through middle segments and slightly wider at that point than broadest width of prothorax. Segments 1–7 each bearing 4 pairs of discotergal setae, of which the innermost pair are short, and 1 pair of laterotergal setae, all of which increase progressively in length and tubercle height posteriorly, becoming prominent on segments 5–7. Eighth segment bearing 1 pair of discotergal and 1 pair of laterotergal setae on prominent tubercles. Anal segment bearing 2 pairs of setae of which 1 pair arise from tips of short, curved posterior processes. Two pairs of very short laterosternal setae present on all but the anal segment. Spiracles nearly round to oval, distinct on segments 1–7. Sternopleural area longitudinally wrinkled on all segments. Sexes are separable, females having a distinct pair of lobes anterior to the anus, but males with a single plate bearing 4 short setae in that area.

DISCUSSION

The life cycle of *T. hirsutus* is well adapted to that of its host, *P. hysterophorus*, an opportunistic annual plant growing in an area of low and very seasonal rainfall. Where this insect was studied in Mexico, periods of highest rainfall occur on average in June and September, and each such period leads to a flush of growth of the plant. Adults emerging in early summer can thus usually build up reserves by feeding on the plants of the first flush, enabling them to survive until the plants of the second flush are available for oviposition. Larvae then develop on the roots



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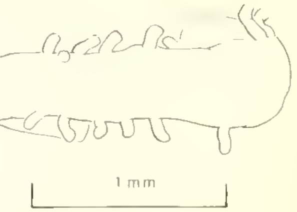

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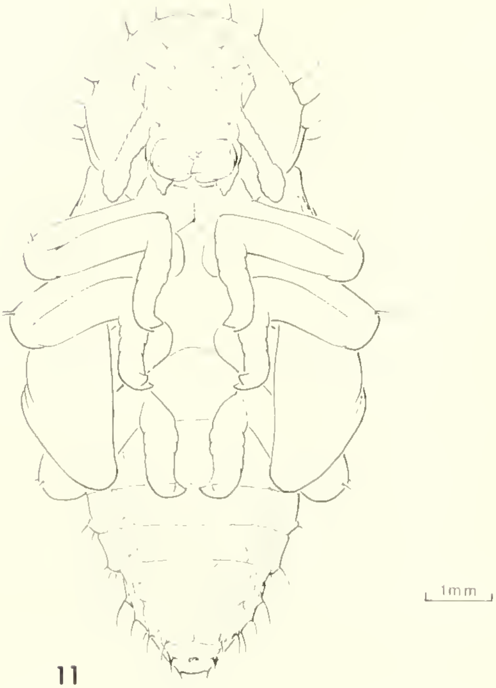

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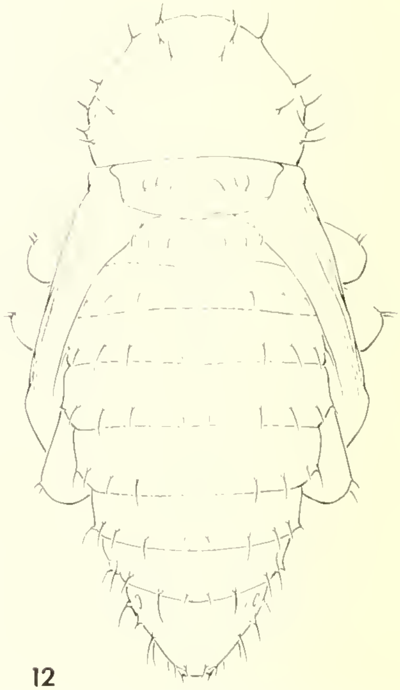

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Figs. 9–12. *Thecesternus hirsutus*. 9–10, Larva, alimentary canal. 9, Proventriculus and anterior ventriculus, with their juncture marked by rounded mycetomes. 10, Posterior ventriculus, ventral view, with gastric caecae attached laterally. 11–12, Pupa. 11, Ventral view. 12, Dorsal view.

of these plants and, by the time plant growth ceases due to the cooler, dryer winter conditions, many of these will have developed sufficiently to enable them to pupate the following spring. The life cycle seems sufficiently flexible to allow a summer generation to occur if plants are available for oviposition.

Both the field and insectary observations indicate a high degree of host-specificity, feeding and larval development being restricted among the Asteraceae to *P. hysterophorus*, *P. confertum* and probably *P. bipinnatifidum*. These species are closely related, being grouped by Rollins (1953) in the section *Argyrochaeta* of the genus *Parthenium*, and they resemble each other closely in their general morphology. The gall-forming response of the roots to larval feeding is indicative of a close biochemical or physiological adaptation of this insect to its host, and is thus further evidence of specificity.

Thecesternus hirsutus does not cause serious damage to its host plant, and does not appear to be a promising biocontrol agent. Defoliation caused by the adults is light, and the fact that larval feeding is confined to the cortical tissue of the root means that it is unlikely to affect the plant's water uptake. However, its host specificity seems to be such that it could be released without causing damage to other plants.

No comparison of the larvae of *T. hirsutus* with those of other weevil genera will be attempted here, except to note that the incomplete frontal sutures, elongate sensory appendage of the antenna, and 3 distinct dorsal folds in typical abdominal segments clearly place this larva in the Phanerognatha as defined by van Emden (1952). However, it seems possible that further comparison of this larva with those of other weevils may help to establish the phylogenetic position of the genus *Thecesternus* to a greater extent than has been possible on the basis of adult specimens alone.

Acknowledgments

The biological observations on *T. hirsutus* were made by one of us (McClay) while employed by the Commonwealth Institute of Biological Control for studies of the natural enemies of *P. hysterophorus* in Mexico, funded by the Queensland Department of Lands. We are grateful to Dieter Enkerlin and the Instituto Tecnologico y de Estudios Superiores de Monterrey for providing facilities for this work, to D. R. Whitehead for the identification of *T. hirsutus,* to C. W. O'Brien for information on the genus *Thecesternus,* and to Hugo J. Miranda for technical assistance. We also thank T. Britt Griswold for his painstaking preparation of the illustrations. R. D. Gordon and E. W. Baker, Systematic Entomology Laboratory, USDA, and W. E. Clark, Auburn University, kindly reviewed and made helpful comments on the manuscript.

Literature Cited

Anderson, W. H. 1947. A terminology for the anatomical characters useful in the taxonomy of weevil larvae. Proc. Entomol. Soc. Wash. 49: 123–132.

Blatchley, W. S. and C. W. Leng. 1916. Rhynchophora or weevils of North Eastern America. Nature Publishing Co., Indianapolis. 682 pp.

Burke, H. R. 1968. Pupae of the weevil tribe Anthonomini (Coleoptera: Curculionidae). Technical Monograph 5, Texas Agric. Expt. Sta., Texas A&M University. 92 pp.

Emden, F. I. van 1952. On the taxonomy of Rhynchophora larvae: Adelognatha and Alophinae (Insecta: Coleoptera). Proc. Zool. Soc. Lond. 122: 651–795.

Harley, K. L. S. and B. W. Willson. 1968. Propagation of a cerambycid borer on a meridic diet. Can. J. Zool. 46: 1265–1266.

Haseler, W. H. 1976. *Parthenium hysterophorus* L. in Australia. PANS 22: 515–517.

Kissinger, D. G. 1964. Curculionidae of America north of Mexico. A key to the genera. Taxonomic Publications, S. Lancaster, MA. v + 143 pp.

May, B. M. 1977. Immature stages of Curculionidae: larvae of the soil-dwelling weevils of New Zealand. J R. Soc. N. Z. 7: 189–228.

O'Brien, C. W. and G. J. Wibmer. 1982. Annotated checklist of the weevils (Curculionidae *sensu lato*) of North America, Central America, and the West Indies (Coleoptera: Curculionoidea). Mem. Am. Entomol. Inst. 34. ix + 382 pp.

Rollins, R. C. 1950. The guayule rubber plant and its relatives. Contr. Gray Herb. Harvard Univ. 172: 1–72.

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SITONA LINEATUS (L.), THE PEA LEAF WEEVIL: FIRST RECORDS IN EASTERN NORTH AMERICA (COLEOPTERA: CURCULIONIDAE)

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Abstract.—The pea leaf weevil, *Sitona lineatus* (L.), a common pest of legumes in Europe, has been known from the Pacific Northwest (British Columbia, California, Idaho, Oregon, and Washington) since the mid 1930's. Recent collections from Virginia (Cheriton, Northampton Co. and Newport News) indicate that *S. lineatus* is established in eastern North America. North American interception records, host plants, economic importance, seasonal history, and habits are summarized for populations in Europe and the Pacific Northwest. An adult diagnosis and habitus allow separation of *S. lineatus* from the clover root curculio, *S. hispidulus* (F.), and other *Sitona* species known to occur in eastern North America.

Sitona lineatus (L.), a well-known pest of leguminous crops, is widely distributed through Europe (including the British Isles) and northern Africa (Morocco). In North America it is known from the Pacific Northwest. It was first detected in North America in 1936 when specimens were taken under codling moth bands at Royal Oak near Victoria, Vancouver Island, British Columbia (Downes, 1938). *S. lineatus* is now widespread in the coastal regions west of the Cascade mountain range in Oregon (Willamette River Valley) and Washington, and reaches the western end of the Fraser River Valley in British Columbia (Prescott and Reeher, 1961); it also occurs in central and northern California and northern Idaho (see map in U.S. Dept. Agric., 1970:58).

We provide here the first records of this introduced weevil in eastern North America (Virginia); review North American interception data for the species; summarize what is known of its food plants, habits, and seasonal history; and give characters for separating it from native and introduced species of *Sitona* occurring in eastern North America.

Detection.—A recent collecting trip by the authors to the Tidewater area and the Eastern Shore of Virginia produced the first confirmed records of the pea leaf weevil, *S. lineatus* (L.), in eastern North America. Specimens were swept from vegetation along railroad tracks at two sites in coastal Virginia: Northampton County, Cheriton, 26 May 1984, E. R. Hoebeke and A. G. Wheeler, Jr., colls.; Newport News, 26 May 1984, ERH and AGW. On a second trip to the Cheriton site, on 2 June 1984, AGW collected 74 specimens from hairy vetch (*Vicia villosa* Roth).

Interception records.—Each year from 1940 to 1963, specimens of *S. lineatus* were intercepted at ports of entry along the eastern seaboard. These records are from List of Intercepted Plant Pests, 1940–1963, compiled by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine programs. Most specimens apparently were associated with cut flowers originating from the Netherlands, Denmark, England, Germany, and Bermuda, and destined for New York, New Jersey, Pennsylvania, and Massachusetts.

The interception records from Bermuda are of particular interest. If *S. lineatus* is established in Bermuda (as the interception data would suggest), this then would be a likely source area of immigration into the mid-Atlantic states, perhaps more so than Europe or the West Coast. The field sites where we collected specimens (railroad right-of-ways and yards) at Cheriton and Newport News are near the expansive naval facilities of the Norfolk area. Reed (1964) listed several exotic weeds of European and South American origin that have been introduced with commerce to the port of Newport News. D. R. Whitehead (Systematic Entomology Laboratory, USDA, Washington, DC) has suggested that the Norfolk area, because of its naval facilities and proximity to Bermuda, might be a plausible (and relatively recent) focus of infestation (*in litt.*).

Host plants and damage.—Plants of the family Fabaceae (= Leguminosae) are the primary hosts of adult *S. lineatus* and represent the sole food source for the larvae. In the Pacific Northwest, the principal host plants are peas and vetch (Prescott and Reeher, 1961). Adults, however, also will cause severe feeding injury to alfalfa (*Medicago sativa* L.) and red clover (*Trifolium pratense* L.). In Great Britain, the food plants include peas, broadbeans, alfalfa, black medic (*Medicago lupulina* L.), all species of clover, tare (*Vicia sativa* L.), and wild vetches (*Vicia* spp.) (Jackson, 1920). When the principal leguminous food plant is in limited abundance, adults may feed on plants in various families (see Prescott and Reeher, 1961).

Adult feeding damage is characteristic, consisting of subcircular or U-shaped notches in the leaf margins, cut in close sequence and producing a scalloped effect (Prescott and Reeher, 1961). Severe ragging of the leaves or complete defoliation can occur in heavy infestations. Although the most obvious injury is done by the adults, larvae can severely damage and destroy the nitrogen root nodules of peas and vetch.

Seasonal history and habits.—In Europe, the biology of *S. lineatus* has been well studied and documented by several workers, including Andersen (1931) and Hans (1959). The seasonal history outlined below is drawn largely from Prescott and Reeher's (1961) studies in the Pacific Northwest, and Jackson's (1920) studies in Great Britain. Because of the relatively moderate climate of the coastal region of the Pacific Northwest, both the weevil and host plants develop 1–2 months earlier than in Great Britain and Europe.

Adults leave their overwintering sites and usually start flying about the middle of March in the Pacific Northwest, as temperatures approach 60°F, and move rapidly onto leguminous crops. By mid-March, adults have mated and begun laying eggs. Eggs are generally scattered singly on the soil surface near hosts but occasionally are laid on the plants. Females are capable of depositing large numbers of eggs over an extended period. Eggs begin hatching in mid- to late April and continue to hatch into late June. Newly hatched larvae move through the soil and

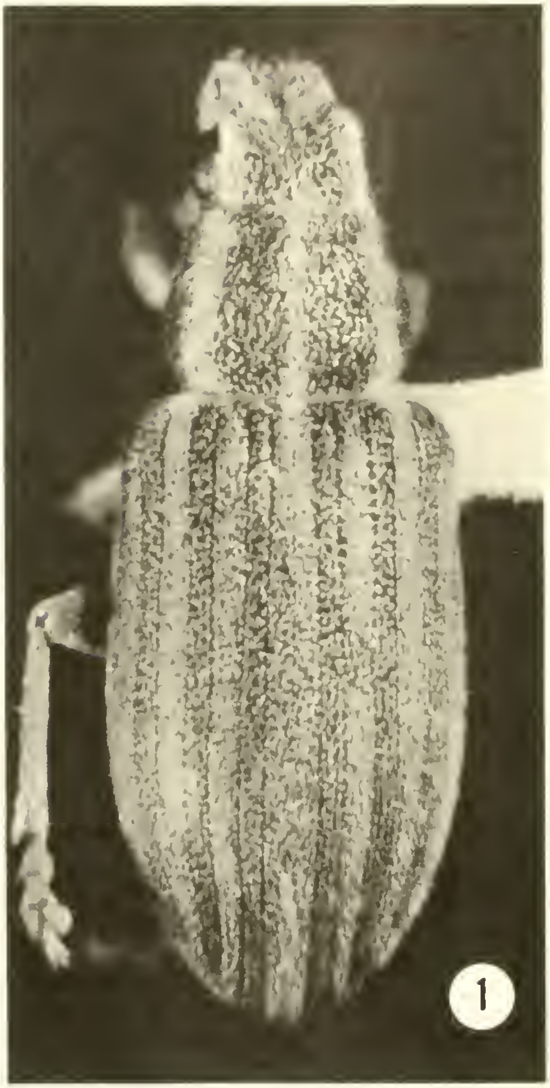

Fig. 1. *Sitona lineatus* (L.), the pea leaf weevil. Adult habitus, dorsal.

make contact with root nodules of the host plant. Young larvae feed on nodules by chewing a hole through one end and consuming the contents. In Europe, it has been noted that larvae also will feed on roots (Baranov, 1914). Mature larvae vacate the nodules and pupate in the soil. By early June, new adults begin to emerge from the soil, reaching peak levels from late June to mid-July. New adults fly intensively for several weeks, then disperse widely in search of alfalfa and red clover. From late summer through most of the fall, new adults enter a period of estivation, seeking refuge among roadside litter, grass clumps, and fence rows. In the Pacific Northwest, weevils become active again by mid-October and resume feeding on legumes.

In North America, there is one generation annually (Prescott and Reeher, 1961).

The newly emerged, sexually immature, adults do not begin to lay eggs until the following spring (Jackson, 1920). In Europe, the number of generations produced annually may vary. Molz and Schröder (1914) recorded 2 generations in Germany, and Rostrup (1915) lists the same in Denmark. In Sweden, Kemner (1917) mentioned only a single generation, as did Baranov (1914) for Russia.

The longevity of overwintered adults is approximately 2–3 months. Duration of the life stages in the Pacific Northwest, according to Prescott and Reeher, 1961, are as follows (numbers in parentheses refer to European populations): egg, 18 days (20–21); larva, 35 days (42–49); and pupa, 15 days (21).

Recognition features.—Adults of *S. lineatus* (Fig. 1) can be readily separated from other *Sitona* species occurring in eastern North America by the following combination of characters: Length 3.9–5.0 mm, form slender, elongate; body (devoid of scales) black, with antennae, tibiae and tarsi brownish red; dorsal scales brownish ochreous or greyish ochreous, interspersed with flat setae; pale scales tending to form median and sublateral stripes on the head and pronotum; scales of the elytra (Fig. 1) frequently arranged in alternate light and dark stripes; rostrum with a central furrow extending behind level of hind margin of eyes; and anterior margin of procoxae very narrowly or not at all separated from the transverse subapical furrow that traverses the ventral surface of the prothorax.

Larvae of *S. lineatus* have been described and illustrated in detail by Jackson (1920) and van Emden (1952). Prescott and Anderson (1961) gave characters and illustrations by which *S. lineatus* can be separated from the clover root curculio, *S. hispidulus*.

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LITERATURE CITED

Andersen, K. T. 1931. Der linierte Graurüssler oder Blattrandkäfer (*Sitona lineata* L.). Monogr. Pflanzenschutz 6: 1–88. (In German.)

Baranov, A. D. 1914. Pests of field crops. Materials for the study of the injurious insects of the government of Moscow. Moscow, V, 112–130. (In Russian.)

Downes, W. 1938. The occurrence of *Sitona lineatus* L. in British Columbia. Can. Entomol. 70: 22.

Hans, H. 1959. Beiträge zur Biologie von *Sitona lineatus* L. Z. Angew. Entomol. 44(4): 343–386. (In German.)

Kemner, N. A. 1917. Ärtviveln (*Sitona lineatus* L.). Centralanstalten för Jordbruksförsök, Flygblad Nr. 63. (In Swedish.)

Jackson, D. J. 1920. Bionomics of weevils of the genus *Sitones* injurious to leguminous crops in Britain. Ann. Appl. Biol. 7: 269–298.

Molz, E. and D. Schröder. 1914. The life cycle of *Sitona lineata* in Germany. Z. wiss. Insektenbiol., Berlin, X, nos. 8–9, pp. 273–275. (In German.)

Prescott, H. W. and W. H. Anderson. 1961. Characters for separating larvae of *Sitona lineata* (L.) and *Sitona hispidula* (Coleoptera: Curculionidae). Ann. Entomol. Soc. Am. 54: 465–466.

Prescott, H. W. and M. H. Reeher. 1961. The pea leaf weevil, an introduced pest of legumes in the Pacific Northwest. U.S. Dept. Agric. Tech. Bull. 1233. 12 pp.

Reed, C. F. 1964. A flora of the chrome and manganese ore piles at Canton, in the Port of Baltimore, Maryland and at Newport News, Virginia, with descriptions of genera and species new to the flora of eastern United States. Phytologia 10: 321–406.

Rostrup, S. 1915. Some observations concerning *Sitona lineatus*. Entomol. Medd. Entomol. Foren., X, 6, pp. 258–259. (In Danish.)

U.S. Dept. Agric. 1970. Distribution of Pea Leaf Weevil (*Sitona lineatus*). Coop. Econ. Ins. Rpt. 20(5): 58.

van Emden, F. I. 1952. On the taxonomy of Rhynchophora larvae: Adelognatha and Alophinae. Proc. Zool. Soc. Lond. 122: 651–795.

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A NEW SPECIES OF *STENOTABANUS* (*BRACHYTABANUS*) (DIPTERA: TABANIDAE) WITH A KEY TO THE SPECIES OF THE SUBGENUS[1]

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Abstract.—*Stenotabanus* (*Brachytabanus*) ***sphaeriscapus*** Wilkerson, new species, from Bolivia is described and figured. A key is provided for comparison to the other two species of the subgenus, *S.* (*B.*) *longipennis* Kröber and *S.* (*B.*) *platyfrons* Fairchild.

The subgenus *Brachytabanus* was proposed by Fairchild (1942) to accommodate *Stenotabanus longipennis* Kröber. Subsequently, 2 other species, *S.* (*B.*) *platyfrons* Fairchild and *S.* (*B.*) *sphaeriscapus* Wilkerson new species, have been discovered. *Brachytabanus* may be defined as follows: female eyes bare, green with 3 purple bands; frons very broad, frontal index less than 2.0; basal callus protuberant, wider than high, not touching sides of frons; a shiny spot at vertex but no vestiges of ocelli; anterior tentorial pits dark and shiny; antennal annuli quite short, often only 3 annuli in evidence; and wing with a short appendix on R_{4+5} or none.

The above differs somewhat from Fairchild's (1942) definition of the subgenus because of characters on the species described here. The most diagnostic characters are the broad frons, round or oval protuberant basal callus, bare tentorial pits and reduced antennal annuli. See Fairchild (1969) for a discussion of and a key to the genus *Stenotabanus* and its subgenera.

KEY TO FEMALE *STENOTABANUS* (*BRACHYTABANUS*)

1. Basal callus about ¾ or more of basal width of frons. Frons narrower, frontal index 1.7–1.9. Antennal flagellum relatively short, 0.4–0.6 as long as basal plate (Costa Rica, Panamá, Colombia, Venezuela) ..... *longipennis*
– Basal callus about ½ or less of basal width of frons. Frons broad, frontal index 1.5 or less. Antennal flagellum longer, about ¾ as long as basal plate 2
2. Antennal scape inflated, nearly spherical, shiny yellowish brown. Basal plate about as wide as long (Bolivia) .... *sphaeriscapus* n. sp.
– Antennal scape normal, not spherical, partially shiny yellowish brown. Basal plate distinctly longer than wide (1.3–1.4 times longer than wide) (N Argentina) .... *platyfrons*

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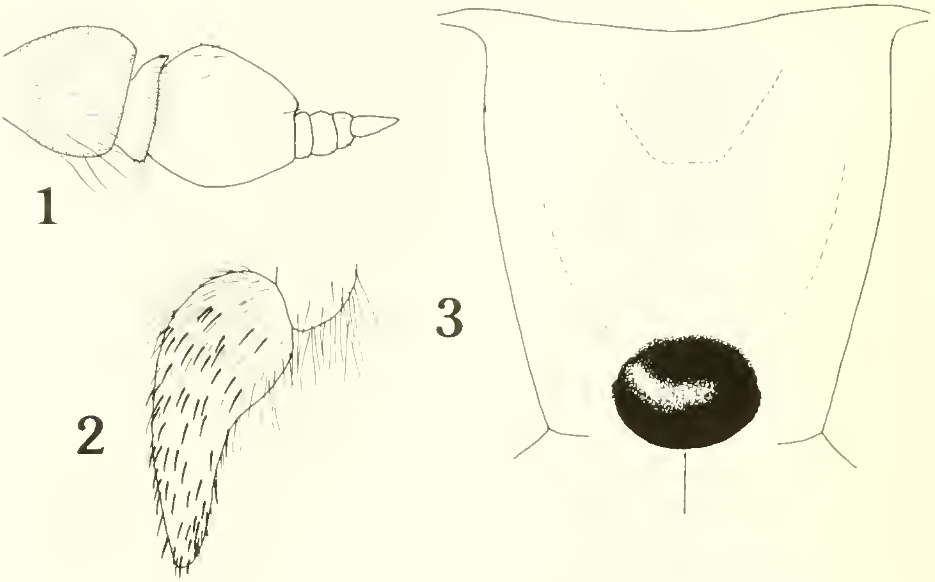

Figs. 1–3. Female, *Stenotabanus* (*Brachytabanus*) *sphaeriscapus.* 1, Antenna. 2, Palpus. 3, Frons.

***Stenotabanus* (*Brachytabanus*) *sphaeriscapus* Wilkerson NEW SPECIES**

Figs. 1–3

A small pale yellowish species with a very broad frons and protuberant black basal callus. Antennal scape shiny and spherical; basal plate and annuli short and compact; basal plate as long as wide. Abdomen above nearly black, with a broad middorsal pale stripe.

Female holotype.—Length: body 8.5 mm; wing 8 mm. Head structures in figures 1–3. Frontal index 1.5. Frons convergent below, width at vertex/width at base = 1.5. Frons pale yellow pollinose with sparse short black hairs and sparse yellow recumbent, scale-like hairs. Area near vertex slightly raised with a central shiny yellow patch. Remnants of ocelli not evident. Basal callus black, protuberant. Central area of frons slightly concave. Eye color and pattern not noted. Subcallus, gena and frontoclypeus pale yellow pollinose. Genal hairs and hairs of beard short and pale yellow except for a few black hairs on upper gena. Frontoclypeus sparsely short pale yellow haired. Anterior tentorial pits shiny black. Antennal scape nearly spherical, shiny yellowish brown, pedicel and flagellum pale yellow and pale yellow pollinose. Antennal hairs pale yellow. Palpus yellow, pale yellow and black haired as in Fig. 2. Proboscis pale yellowish brown, without shiny sclerotized areas; short, less than head height; labella relatively large, a little longer than palpal length.

Scutum and scutellum yellowish brown pollinose, pilosity a mixture of black hairs and yellow scale-like hairs. Scutum very faintly striped with a faint bluish cast anteriorly. Pleuron pale yellowish gray pollinose and sparsely pale yellow haired. Legs mostly yellowish brown and pale yellow haired. Foretibia darkened apically and mostly black haired. Mid- and hindtibiae with a few apical black hairs. Wing, including costal cell, glass-clear; venation normal, vein R_{4+5} (fork of 3rd vein) with a short appendix. Basicosta bare. Halter pale yellowish brown.

Abdomen above with a middorsal, nearly parallel sided pale yellowish brown and pale yellow haired stripe; on either side of this stripe, and about equal in width to it, are dark brown and black haired stripes; lateral areas and posterior borders of tergites 4–6 pale yellowish brown, and pale yellow haired. Abdomen ventrally pale yellow and pale yellow haired except for sternite 1 and anterior portion of 2 which have black integument showing through sparse pale yellow pollinosity.

Holotype.—♀, Bolivia, Cochabamba Dept., Villa Tunari, 240 m elev, 5-IX-1983, R. Wilkerson. To be deposited in the Florida State Collection of Arthropods (FSCA), Gainesville, Florida.

Discussion.—*Stenotabanus* (*B.*) *sphaeriscapus* n. sp. is quite similar to *S.* (*B.*) *platyfrons* but differs by having a shiny, nearly spherical antennal scape (thus the name), and by having a basal plate as wide as long (1.3 and 1.4 times longer than wide in *S.* (*B.*) *platyfrons*). In addition, the frons of *S.* (*B.*) *sphaeriscapus* is more convergent below (width at vertex/width at base 1.5 vs 1.3 and 1.2) than that of *platyfrons,* and the basal callus occupies a larger proportion of the basal width of the frons (0.50 vs 0.40 and 0.46). I believe the antennal characters are quite distinctive but the frontal characters may prove to be variable as more specimens become available.

***Stenotabanus* (*Brachytabanus*) *longipennis* Kröber**

Stenotabanus longipennis Kröber 1929: 125, holotype, ♀, Vienna.
Stenotabanus (*Brachytabanus*) *longipennis*: Fairchild 1942: 300–301. Fairchild 1964: 175, ♂. Wilkerson 1979: 219–220.

Fairchild (1942) proposed the subgenus *Brachytabanus* for *S. longipennis* Kröber. I have seen Panamá material as follows: Panamá Prov, 1 ♂, Las Cumbres, 9-VI-1958 (G. B. Fairchild coll) (in coll G.B.F.); 1 ♀, Las Cumbres, 22-VI-1966 (G. B. Fairchild) (R.C.W.). Darién Prov, 1 ♀, Río Paya, 2-VI-1969 (G. B. Fairchild) (G.B.F.); 1 ♀, Río Imamado, Río Jaque, 17-IV-1947 (A. Wetmore) (G.B.F.); 1 ♀, Río Tacarcuna, 1900 ft (575 m), 9-VII-1963, compared with type of *S. longipennis* by G. B. Fairchild, Vienna, 1964, with good agreement (G. B. Fairchild) (G.B.F.). I also have before me the following specimens collected in Colombia by M. A. Tidwell (all in FSCA): 18 ♀, Antioquia Dept, Río Arquia, Pto Palacio, 9-IX-1977 (17) and 14-II-1978 (1) biting man; 1 ♀, Valle Dept, Bajo Calima, 6-II-1979. In addition there are records from the literature as follow: Fairchild (1942), 1 ♀, Venezuela, XI-1936; 14 ♀, Colombia, Muzo and Villavicencio; 1 ♀, Panamá, Gamboa, C.Z., 9-VII-1924; 2 ♀, Panamá, Utevey, near Pacora, 6-VIII-1941, on horse. Bequaert and Renjifo (1946), Colombia, Santander Dept, Bocas del Rosario, Río Magdalena; Colombia, "Upper Magdalena River." Lee et al. (1969), 1 ♀, Valle Dept, Río Raposo, 17-IX-1964. Hogue and Fairchild (1974), 1 ♂, Costa Rica, Puntarenas, Palmar.

See the key and discussion of *S.* (*B.*) *sphaeriscapus* for distinguishing characters. It is interesting to note that the presumed male of this species does not have shiny anterior tentorial pits but does have a pair of dark brown spots on the subcallus, these lacking in the female. Fairchild notes on 2 of the above female specimens that the eye pattern is glaucus green with 3 narrow reddish purple bands.

Stenotabanus (*Brachytabanus*) *platyfrons* Fairchild

Stenotabanus (*Brachytabanus*) *platyfrons* Fairchild 1964: 174, holotype, ♀, Argentina, Tucumán, CAS (examined); Coscarón 1975: 26–28, pl. 5, A–H.

In addition to the holotype I have before me a paratype from Argentina, Río Bermejo, XI-916. The holotype bears the date 16–19-I-1957. Another paratype is in the Museum of Comparative Zoology, from Argentina, Jujuy. Fairchild's (1964) figure proves to be of the paratype from Río Bermejo, not of the holotype. The basal callus of the holotype is without the upward extension shown in his figure. Coscarón (1975) redescribes this species and gives complete figures including female genitalia. Also, he saw 2 females from Argentina, Tucumán Prov, Río Viejo, 8-X-1943. *Stenotabanus platyfrons* has an eye pattern of 3 narrow dark lines on a light green background.

This species is quite close to *S.* (*B.*) *sphaeriscapus* n. sp. See the key and discussion section of *S.* (*B.*) *sphaeriscapus* for distinguishing features.

LITERATURE CITED

Bequaert, J. and S. Renjifo. 1946. The Tabanidae of Colombia (Diptera). Psyche 53: 52–86.

Coscarón, S. 1975. Notas sobre tabánidos Argentinos IX. Los generos *Stenotabanus* Lutz y *Myiotabanus* Lutz (Diptera: Insecta). Provincia de Buenos Aires, Comisión de Investigaciones Cienctíficas. Informes 16, 39 pp.

Fairchild, G. B. 1942. Notes on Tabanidae (Diptera) from Panama. IX. The genera *Stenotabanus* Lutz, *Lepiselaga* Macquart and related genera. Ann Entomol. Am. 35: 289–309.

———. 1964. Notes on Neotropical Tabanidae (Diptera). IV. Further new species and new records for Panama. J. Med. Entomol. 1: 169–185.

———. 1969. Notes on Neotropical Tabnidae. XII. Classification and distribution, with keys to genera and subgenera. Arq. Zool., São Paulo 17: 199–255.

Hogue, C. L. and G. B. Fairchild 1974. A revised checklist of the Tabanidae (Diptera) of Costa Rica. Rev. Biol. Trop. 22: 11–27.

Kröber, O. 1929. Die Stenotabaninae und die Lepiselaginae Sudamerikas. Encycl. Entomol. (B) Diptera 5: 101–154.

Lee, V. H., G. B. Fairchild. and P. Barreto 1969. Artrópodos hematófagos del Río Raposo, Valle, Colombia. III. Tabanidae. Caldasia 10: 441–458.

Wilkerson, R. C. 1979. Tábanos (Diptera; Tabanidae) de los Departamentos Colombianos del Chocó, Valle y Cauca. Cespedesia 8: 89–432.

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DESCRIPTION AND LIFE HISTORY OF A NEW SPECIES OF *NEMATUS* (HYMENOPTERA: TENTHREDINIDAE) ON *ROBINIA HISPIDA* (FABACEAE) IN NEW YORK

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Abstract.—*Nematus* ***hispidae*** Smith, n. sp., is described from a large series of adults reared from *Robinia hispida* in Ithaca, N.Y. Aspects of biology and life history are discussed and compared with that of *N. tibialis.* Notes on parasitism by *Cleptes semiauratus* (Hymenoptera: Chrysididae: Cleptinae) and the current distribution of this parasitoid in North America are presented.

The rose acacia, *Robinia hispida* L. (Fabaceae), is a widely planted ornamental shrub, native to southeastern U.S.A. In 1980 a large population of sawfly larvae was observed defoliating a stand of rose acacia on the Cornell University campus at Ithaca, N.Y. Discussions with Cornell's cooperative extension associates provided no insight into the identity of the sawfly. Apparently, sawflies attacking the rose acacia had attracted little attention in the past. A large series of larvae were collected and reared to adults. Specimens were sent to DRS for identification. When it became apparent that the species was either new to science or new to the U.S., more detailed biological studies were initiated by DCD. It was eventually determined that there are two species of *Nematus* feeding on *R. hispida,* one of which was undescribed. In this paper *Nematus hispidae* n. sp. is described and its life history is summarized and compared with *N. tibialis* Newman, the other species feeding on the rose acacia.

The sections on the taxonomy are by the junior author, those on the life history and parasitism are by the senior author.

Nematus hispidae Smith, New Species

Figs. 1–5, 9, 10

Female.—Length, 5.5–7.0 mm. Dark yellow with following black: Antenna (except anterior surface of scape), ocellar and postocellar areas with black expanded anteriorly in short armlike extensions one directed toward each antenna, large triangular spot on mesoprescutum, longitudinal broad stripe on each lateral lobe of mesonotum, posterior half or less of mesoscutellum with mesal stripe extending forward, mesopostergite, sometimes upper half of mesepimeron and extreme upper corner of mesepisternum, metascutellum and area surrounding cenchri, mesal portion of terga 1–8 appearing as a broad longitudinal dorsal stripe, hindtarsus, and sheath (except base); hindtibia darkened, increasingly dark to almost black toward apex; apex of mandible reddish brown; wings hyaline, veins brown, stigma amber.

Shining, covered with fine white pubescence. Antennal length about 2½ head width, in ratio of 6.0:2.3; 1st and 2nd segments each broader than long, segments 3–5 subequal in length, segments 6–9 slightly decreasing in length. Clypeus circularly emarginated for nearly ½ its medial length; malar space subequal to diameter of front ocellus; distances between eye and hindocellus, between hindocelli, and between hindocellus and posterior margin of head subequal. Hindbasitarsus shorter than length of following segments combined, as 2.0:2.7. Tarsal claw with long inner tooth. Sheath slender and tapering to pointed apex in dorsal view, in lateral view straight above, rounded below (Figs. 1, 2). Lancet with about 19 serrulae, each serrula flattened, separated by shallow circular notch, and with about 10 subbasal teeth on ventral margin; short intersegmental hairs present (Fig. 3).

Male.—Length, 5.0–6.0 mm. Coloration similar to that of female but black areas slightly more extensive: black in front of ocelli not always produced into armlike extensions, anterior margin of black straight or rounded, extending about halfway to antennae; mesonotum mostly black, at most with pale areas on sutures separating prescutum and lateral lobes; spots on meson of terga slightly broader. Structural characters as for female. Genitalia in Figs. 4, 5.

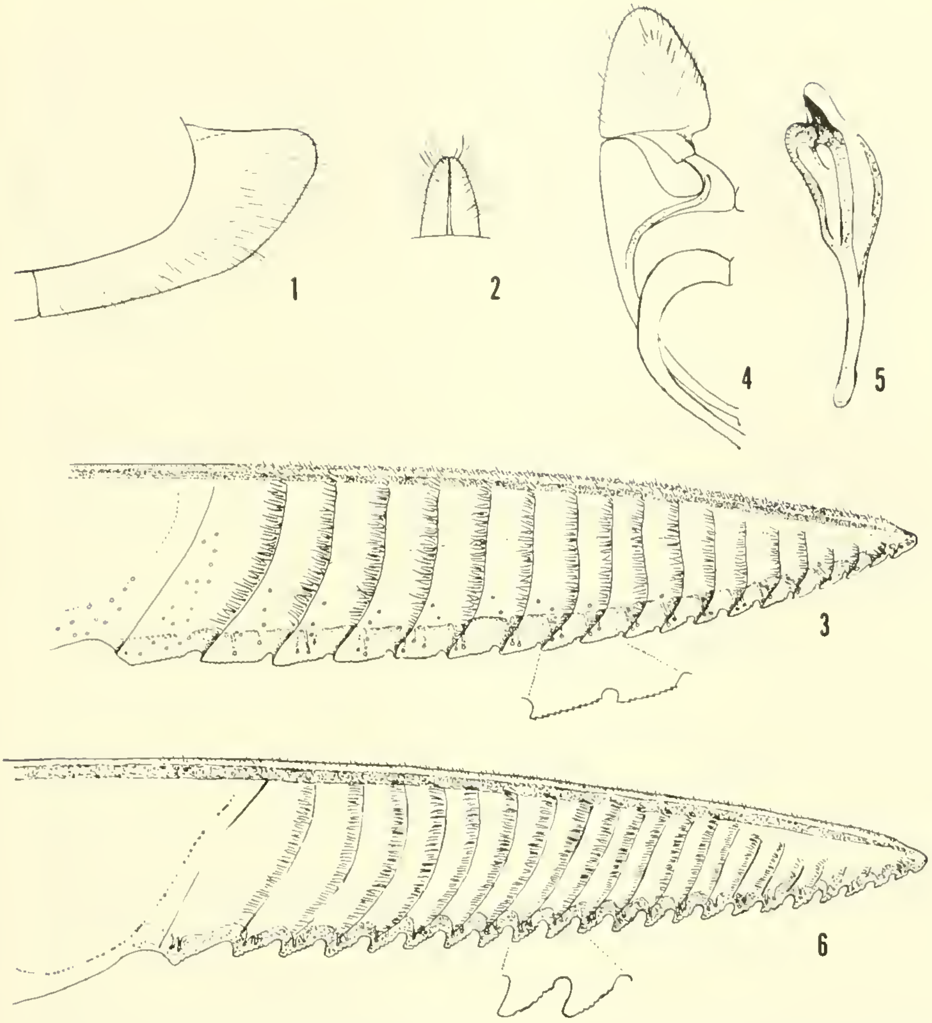
Holotype.—♀, New York, Tompkins Co., Ithaca, reared 80-05, D. C. Darling; defoliating *Robinia hispida*, Cornell campus, lab reared. Collected as late-instar larvae 10 June 1980, adult first emerged 30 June 1980. Deposited in Cornell University Insect Collection.

Paratypes.—14 ♀, 8 ♂, same data as for holotype. Deposited at Cornell, the National Museum of Natural History, Washington, D.C., the Canadian National Insect Collection, Ottawa, and Oregon State University Insect Collection, Corvallis.

Host.—*Robinia hispida.*

Larva.—Typical of the Nematinae and *Nematus*, with prolegs on abdominal segments 2–7 and 10, antenna conical, and 10th tergum with a pair of caudal protuberances. Early feeding stages dark blackish (Fig. 9). Late feeding stages green when alive, with head and 10th tergum amber and with black tubercles on body. Abdominal segments 1–8 apparently 5-annulate with black tubercles as follows (Fig. 10): 1st annulet with one small spot laterally; 2nd annulet with 2 large spots above spiracle; 3rd annulet with 2 small spots posterior to spiracle; 4th annulet usually with 4 spots, the upper 2 the largest; 5th annulet without spots; large spot on subspiracular lobe; 3 nearly confluent spots on surpedal lobe. Prepupa without spots, entirely green.

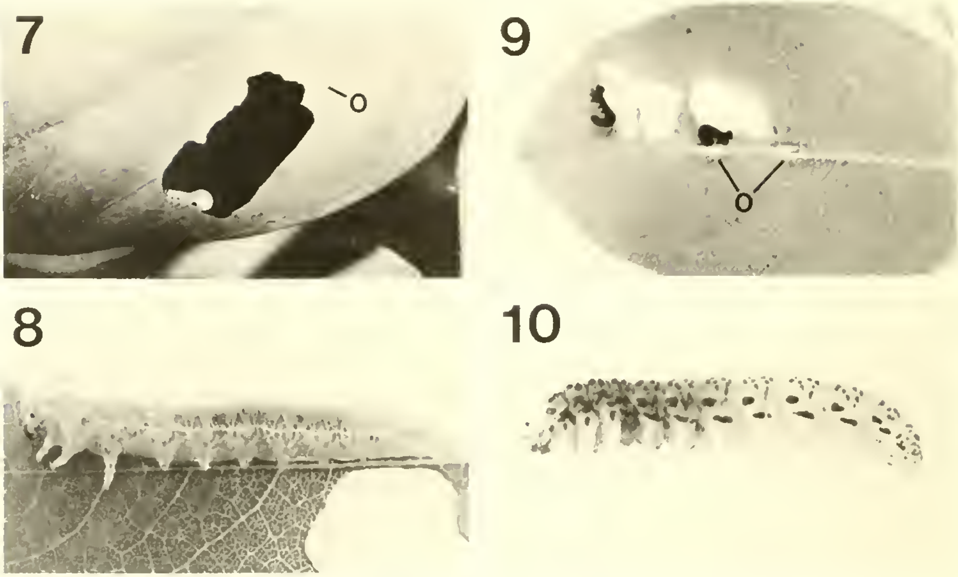
Remarks.—*Nematus hispidae* belongs in the *oligospilus* group of *Nematus* because of its long slender sheath and long lancet with intersegmental hairs; other groups may have the sheath apex expanded or have a very short sheath which is not longer than high and the lancet may be bare, with intersegmental spines, or be very short and triangular. Among species in the *oligospilus* group, structural characters and coloration place *hispidae* close to *tibialis* Newman, but it is separated from *tibialis* by the black or partly black meso- and metascutella (dark



Figs. 1–6. 1–5, *Nematus hispidae*. 1, Sheath, lateral view. 2, Sheath, dorsal view. 3, Lancet. 4, Harpe and parapenis, ventral view, left half. 5, Penis valve. 6, *Nematus tibialis*, lancet.

yellow in *tibialis*), the paler hindtibia (black in *tibialis*), and the flat serrulae of the lancet (deep and pointed with distinct anterior and posterior margins in *tibialis* (Fig. 6)). The male of *tibialis* is not known. The following characters will help distinguish *hispidae* from other members of the *oligospilus* group: short malar space (some species, like *oligospilus* Foerster, have a broad malar space, more than twice the diameter of an ocellus); flat serrulae (deeper and pointed in most other species); and mostly black dorsum (other species are not as extensively black or are all yellowish to orange). The male can be separated only by comparing the genitalia with the illustrations, Figs. 4–5. The larvae of *hispidae* differ from *tibialis* also, as will be discussed subsequently.

This new species was first expected to be *tibialis*, but after close examination it was evident that two species are involved. Since specimens could be masquer-



Figs. 7–10. 7, 8, *Nematus tibialis*. 7, Oviposition scar and first-instar larva. 8, Final instar larva. 9, 10, *Nematus hispidae*. 9, Oviposition scars and first-instar larvae. 10, Final instar larva. O = oviposition scar.

ading under *tibialis* in collections, all available collections of that species were checked, but no additional specimens of *hispidae* were found. It is possible that the species was adventive from the Old World, but I have checked many Palearctic species as well as keys to species of that region and have found nothing that resembles *hispidae*.

Larvae associated with *Robinia* in the USNM collection were checked, and I found a number that resemble the larvae of *hispidae* though none are with associated adults. These larvae are from the following: Pa., Perry Co., Toboyne Township, May 29, 1980, defol. black locust; Md., Caroline Co., Denton, May 23, 1973, on locust; S.C., Clemson, April 20, 1955, black locust; N.C., Mt. Mitchell, August 26, 1950, *Robinia hispida*; Mass., Eastham, June 12, 1957, *Robinia pseudoacacia*; Okla., Stillwater, May 4, 1965, on black locust. Though adults of *hispidae* are known only from the type-locality, these records of larvae indicate a wide distribution and the possibility that other species of *Robinia* may be hosts.

A Comparison of the Life History of *Nematus hispidae* and *N. tibialis*

Surveys were initiated in early May of 1981, 1982 and 1983, before the buds of *Robinia hispida* were opened. Eggs and first-instar larvae were first observed around the middle of May. Eggs could be found in two sites on the compound leaves of the plant and the associated first-instar larvae differed dramatically in color. The most abundant oviposition sites were blister-like swellings on the surface of the leaf (Fig. 7). All newly emerged larvae feeding in the vicinity of these oviposition sites were pale greenish-white with a brown head capsule (Fig. 7). Oviposition also occurred in the midribs (Fig. 9). First-instar larvae associated with this oviposition site were uniformly black (Fig. 9). In one instance, the emergence of an entirely black larva from a swelling in the midrib was observed in the laboratory. There were also two distinct types of later-instar larvae on *R. hispida*—uniform green (Fig. 8) and green with very prominent and contrasting black tubercles (Fig. 10). The blister-like oviposition scar, light green first-instar larva and final instar larva also of uniform color agree exactly with the descriptions provided by Comstock (1880) for *tibialis* (cited as *N. similaris* Norton) feeding on *Robinia pseudoacacia* (black locust) in Washington, D.C. The identity of these sawflies as *tibialis* is further supported by the results of oviposition observed under laboratory conditions in 1983. Field collected females were isolated with twigs of *R. hispida* that were determined to be free of eggs. Only blister-like oviposition scars were subsequently located and only uniformly green first-instar larvae emerged. Examination of the lancets of the females isolated with the twigs confirmed their identity as *tibialis.*

There also appear to be differences in the phenology of the two species of *Nematus* in Ithaca. *Nematus hispidae* directly developed to the adult stage and does not have an obligate diapause. Larvae were collected June 9 and 10, 1980 and pupation occurred between June 11 and 15. Adults emerged during the last week of June and first week of July. In 1981 and 1982 only *tibialis* was abundant in the study area. Individual larvae were reared to pupation. None emerged that summer, and the cocoons were overwintered at 5°C. Unfortunately, development did not resume the following spring. Consistent with these negative results and the seasonal abundance of the sawfly population, is the suggestion that *tibialis* is univoltine with an obligate diapause, probably mediated by photoperiod. This would explain my inability to break the diapause; photoperiod was not carefully regulated. Comstock (1880) states there are two and possibly 3 broods of *tibialis* in Washington, D.C.

Reproduction is also different in these two species. *Nematus tibialis* is parthenogenetic (thelytokous), whereas *hispidae* is bisexual, males and females occurring in approximately equal numbers.

PARASITISM OF *NEMATUS HISPIDAE*

In the early summer of 1981, the year following the defoliation of *R. hispida, Cleptes semiauratus* (L.) [Hymenoptera: Chrysididae: Cleptinae] was abundant in the study site. A one hour sampling period on June 11 produced approximately 25 specimens, and many more of the fast-flying wasps evaded capture. The wasps were observed on the leaves, areas frequented by the *Nematus* larvae.

Kimsey (1981) reviewed the Cleptinae of the New World and noted that *C. semiauratus* is "undoubtedly adventive" in eastern North America with the only previous records from New Jersey. This suggests the possibility that we were dealing with a recently introduced sawfly. Two factors suggest that *hispidae* is *not* recently introduced from the Palearctic. Firstly, both the sawfly (see "Remarks" section) and the parasitoid are known from many collecting localities in eastern North America. There is an additional specimen of *C. semiauratus* in the Cornell Collection [NY: Ludlowville, L. L. Pechuman, 30 June 1981] about 7 miles from type locality of *N. hispidae,* and also a specimen from Canada [Ontario: Hamilton, VI 19 1979, K. L. Bailey] in the University of Guelph collection. Secondly, the genus *Robinia,* the food plant of the sawfly, is restricted to the New World (Willis, 1973). It seems more likely that *hispidae* is an uncommon species endemic to the southern U.S., the range of its host plant, *R. hispida.* The planting of the ornamental rose acacia in northeastern U.S. provided an opportunity for *C. semiauratus* to parasitize *hispidae.*

I was also able to demonstrate parasitism in the laboratory. *Cleptes semiauratus* adults were brought back to the lab and a female was placed in a petri dish with a *Nematus* cocoon. The identity of the cocoon, *tibialis* or *hispidae,* was uncertain. The female immediately began to examine the cocoon and was left with the cocoon overnight. Cleptines chew a hole in the host cocoon and deposit an egg with the tubular ovipositor characteristic of Chrysididae. They then seal up the hole with masticated leaf litter (Clausen, 1940). This plug was observed the next day. The sawfly cocoon was dissected in mid-winter and the characteristic cleptine larvae was found in the cocoon. This specimen is deposited in the Cornell University Insect Collection, Lot #1123. Unfortunately, this experiment could not be replicated due to the small numbers of sawflies collected in 1981 and 1982.

Cleptes semiauratus was not observed in the study area in 1980, the year of peak abundance of *hispidae.* The marked increase in the numbers of the parasitoid was correlated with a drastic decline in the population of *hispidae.* Parasitism by *Cleptes semiauratus* may have been responsible for the dramatic decrease in the populations of *Nematus* on *Robinia hispida* in Ithaca, N.Y. This suggestion is supported by the documented ability of *C. semiauratus* to attack *Nematus* in North America and the host range of nematine tenthredinids attacked in Europe, *Nematus* spp., *Pachynematus* spp. and *Pristiphora abietina* (Christ) (see Gauss, 1964).

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LITERATURE CITED

Clausen, C. P. 1940. Entomophagous Insects. McGraw-Hill, New York. 688 pp.

Comstock, J. H. 1880. The locust sawfly, pp. 222–224. *In* Report of the Entomologist, 1879. U.S. Department of Agriculture, Washington, D.C. 621 pp.

Gauss, R. 1964. *Cleptes semiauratus* L. (Hym. Chrysididae) in Rahmen der Parasitenliste von *Pristiphora abietina* (Christ) (Hym. Tenthredinidae) in Sudwestdeutschland. Z. Angew. Entomol. 54: 225–232.

Kimsey, L. S. 1981. The Cleptinae of the western hemisphere (Chrysididae: Hymenoptera). Proc. Biol. Soc. Wash. 94: 801–818.

Willis, J. C. 1973. A dictionary of flowering plants and ferns. [Eighth Edition, Revised by H. K. Airy Shaw]. Cambridge University Press, London. 1245 pp.

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NEW SPECIES OF PHYCITINAE (LEPIDOPTERA, PYRALIDAE) FROM TEXAS, WITH DESCRIPTION OF A NEW GENUS

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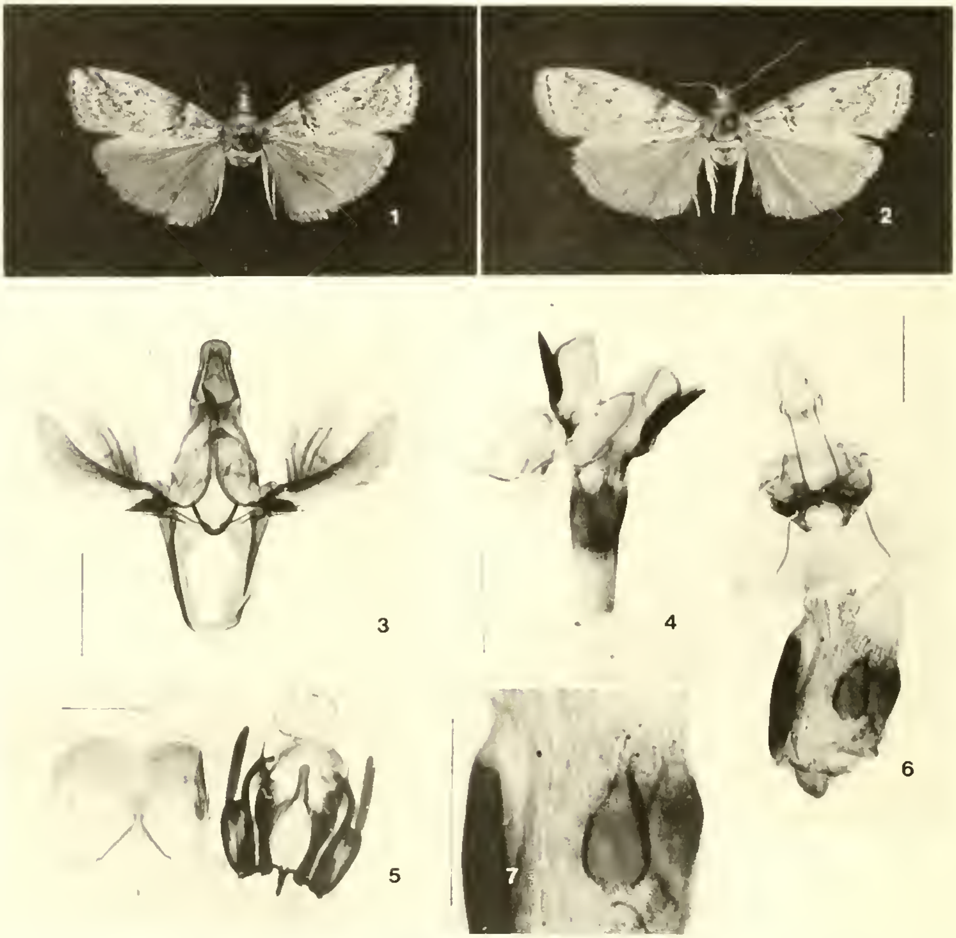
Abstract.—Meroptera anaimella, Melitara apicigrammella, and *Homoeosoma parvalbum* are described. A new genus, *Pseudocabotia,* is described, with *P. balconiensis* described as sole included species. Imagines, wing venation, and male and female genitalia are figured.

The following four new phycitine pyralids have resided for many years in the senior author's collection, but have recently been augmented by additional specimens collected by the junior author. All are known only from examples collected in Texas; the *Meroptera, Melitara,* and *Homoeosoma* from the Big Bend region; the *Pseudocabotia* from the Edwards plateau.

Meroptera anaimella Blanchard & Knudson, New Species
Figs. 1–7

Description.—*Head:* Front and vertex light orange brown. Maxillary palpi light orange brown aigrettes. Labial palpi upcurved, not quite reaching vertex, light orange brown. Antennae simple, pale ochreous dorsally, naked and minutely setose ventrally, male with sinus at base of shaft, containing 5 or 6 short, black, thorn-like processes, scale tuft pale ochreous. Chaetosema present. Collar light orange brown. *Thorax:* Patagia and mesonotum pale ochreous with black scaling anteriorly. *Abdomen:* Pale ochreous lightly sprinkled with black scales. *Forewing:* Ground color whitish ochreous lightly peppered with black scales over median area, mainly near costal margin. Antemedial band outwardly oblique from costa at ¼ the distance from base to dorsal margin at ⅓ the distance from base, consisting of a black outer line, broad at costa, diminishing beyond and not quite reaching dorsal margin, and a black inner line from dorsal margin to cell, separated by ground color. The basal space is suffused with light orange, appearing slightly paler than the remainder of the wing. Discal dots widely separated, black. Subterminal band faint, best defined near costal margin, with an inwardly directed cusp above cell and another over lower fold, weakly dentate between cusps. Outer and inner lines blackish, separated by ground color. Terminal dots confluent. Fringe pale ochreous. *Hindwing:* Pale ochreous, suffused with fuscous along outer margin, fringe whitish ochreous. *Length of Forewing:* Males: N = 8, 10.4–11.8 mm, average 11.0 mm. Females: N = 12, 10.1–12.0 mm, average 11.4 mm. *Male genitalia* (Figs. 3–5): Valva with short triangular clasper, about ¼ the length of the valva. Clasper with short spines on posterior surface and a single, larger



Figs. 1–7. *Meroptera anaimella.* Fig. 1, Holotype ♂. Fig. 2, Paratype ♀. Fig. 3, ♂ genitalia, on slide AB 5362 (by ECK), Presidio Co., Texas. Fig. 4, Aedeagus with inflated vesica, same specimen and slide as Fig. 3. Fig. 5, Sclerotization and tufts of 8th abdominal segment, same specimen and slide as Fig. 3. Fig. 6, ♀ genitalia, on slide ECK 845, K-Bar Research Station, Brewster Co., Texas. Fig. 7, Magnification of corpus bursae, showing signa, same specimen and slide as Fig. 6. Segments = 1 mm.

terminal spine. Aedeagus with two equal sized cornuti. *Female genitalia* (Figs. 6, 7): Sterigma with broad well sclerotized plate, bearing well sclerotized lateral arms projecting into ductus bursae. Corpus bursae with longitudinal ridges of scobinations and two opposed heavily scobinate patches.

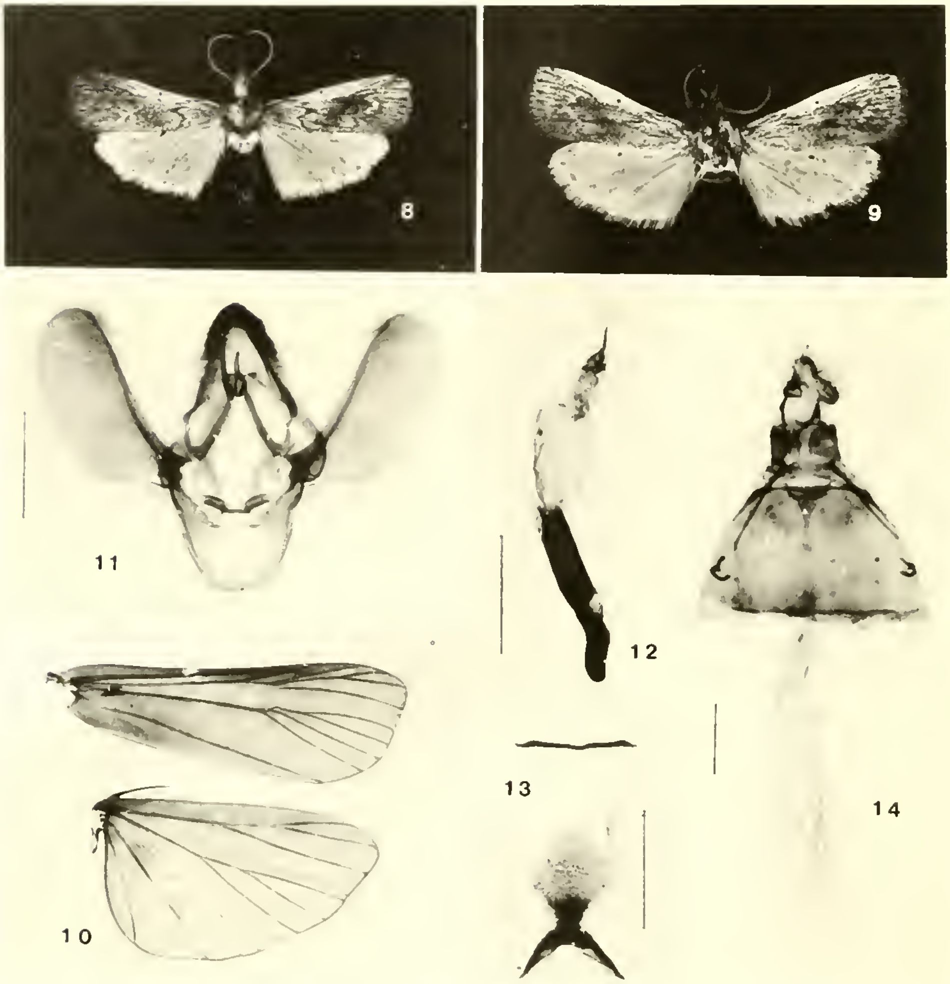
Holotype (Fig. 1).—♂, Shafter, Presidio Co., Texas, 9-VII-69, genitalia on slide AB 1750, A. & M. E. Blanchard collectors, deposited in the National Museum of Natural History. Paratypes.—Same locality as holotype, 9-IX-69, 1 ♂, 1 ♀; Presidio Co., Texas, Ruidosa Hot Spring, 8-VII-69, 1 ♂, collected by A. & M. E. Blanchard. Brewster Co., Texas, Big Bend Nat'l. Park, Dugout Wells, 13-IX-82, 1 ♀; K-Bar Research Station, 9-VIII-83, 1 ♀; Rio Grande Village, 6-IV-84, 5 ♂, 10 ♀, all collected by E. C. Knudson.

Remarks.—This new species is superficially indistinguishable from *Meroptera* *mirandella* Ragonot, and quite similar to *M. cviatella* Dyar. From both species, it differs in the shape of the clasper in the male, the larger, differently shaped, sclerotized plates on the corpus bursae, and the more strongly developed lateral arms of the sterigma in the female. The male genitalia are most similar to *M. abditiva* Heinrich, but *abditiva* has unequal sized cornuti in the vesica and it also differs in color and maculation. No other species of *Meroptera* is known from the Big Bend region of Texas, but *cviatella* occurs in the Texas panhandle. The host and early stages are unknown, but moths were collected in areas where both cottonwood and willow occur.

***Melitara apicigrammella* Blanchard & Knudson, NEW SPECIES**
Figs. 8–14

Description.—*Head:* Front gray, each scale narrowly white tipped. Vertex grayish white, darker gray posteriorly. Maxillary palpi squamous, gray dorsally, white ventrally, length equal to eye diameter. Labial palpi porrect, dark gray, exceeding front by 2½ eye diameters. Antennae bipectinate in male, shortly bipectinate in female, flagellum whitish, variably sprinkled with black scales. Collar gray. *Thorax:* Tegulae and patagia gray, mixed with a few white scales, each scale white tipped, mesonotum mainly whitish centrally, dark gray posteriorly. Ventral surface mainly whitish. *Abdomen:* Whitish, with a few black scales dorsally. First abdominal segment with white, paired lateral scale tufts. *Forewing:* Ground color light gray, heavily suffused with fuscous below costal margin over median area. Costal margin mainly grayish white, with scattered black scales. Antemedial line black, margined inwardly with white, sharply produced into two outwardly directed points above, and over cell and again produced to a longer outwardly directed point over median vein. Below median vein, the antemedial line forms a broad, inwardly directed point over lower fold. Single elongate discal spot obscured by fuscous suffusion. Subterminal band indistinct, angled inwardly from costal margin and moderately dentate, consisting of a pale gray central line flanked by dark gray inner and outer lines. Veins lightly black scaled over outer ⅓ of wing. Terminal intervenular dashes black, conspicuous. Fringe gray. Undersurface grayish, terminal dashes weakly indicated. *Hindwing:* White, lightly suffused with fuscous at apex in male; more heavily suffused in female. Terminal line narrow, fuscous. Fringe whitish. *Venation* (Fig. 10): Hindwing: Sc and Rs stalked for ⅓ their lengths, beyond cell; M3 and Cu1 stalked. *Length of Forewing:* Males: N = 11, 11.3–14.6 mm, average 13 mm. Females: N = 11, 13.3–17.7 mm, average 15.6 mm. *Male genitalia* (Figs. 11–13): Bifid apical processes of gnathos slender and pointed. Anellus with base well sclerotized, lateral arms weakly sclerotized. Aedeagus moderately long (length 7× width), vesica unarmed. *Female genitalia* (Fig. 14): Ostium funnel shaped, membranous. Ductus bursae and corpus bursae membranous, without signum. Holotype.—(Fig. 8). ♂, Terrel Co., Texas, Sanderson, 28-IX-80, collected by E. Knudson and deposited in the National Museum of Natural History. Paratypes.—Same data as holotype, 7 ♂; Brewster Co., Texas, Big Bend Nat'l. Park, K-Bar Research Station, 9-VIII-83, 1 ♀; Big Bend Nat'l. Park, Rio Grande Village, 6-IV-84, 2 ♂, 9 ♀, all collected by E. Knudson. Big Bend Nat'l. Park, Chihuahuan desert near Nugent Mt., 1-V-72, 2 ♂; Big Bend Nat'l. Park, Dugout Wells, 1 ♀, collected by A. & M. E. Blanchard.

Remarks.—This new *Melitara* is easily distinguished from the other species in



Figs. 8–14. *Melitara apicigrammella.* Fig. 8, Holotype ♂. Fig. 9, Paratype ♀, K Bar Research Station Brewster Co., Texas. Fig. 10, Wing venation of ♂ paratype, on slide ECK 830 (by AB), same data as holotype. Fig 11, ♂ genitalia of paratype, on slide ECK 827, same data as holotype. Fig. 12, Aedeagus and inflated vesica of paratype, on slide ECK 838, same data as holotype. Fig. 13, Sclerotization of 8th abdominal segment of ♂ paratype, on slide AB 5359, near Nugent Mt., Brewster Co., Texas. Fig. 14, ♀ genitalia of paratype, on slide ECK 849, Rio Grande Village, Big Bend Nat'l. Park, Texas. Segments = 1 mm.

the genus by features of the maculation, particularly the well defined black terminal dashes and obscure subterminal band and discal spot, which are well defined in the other species. In superficial appearance, it is more apt to be confused with *Olycella subumbrella* (Dyar), but differs in the labial palpi, which are of the *Melitara* type. The male genitalia differ from the other species of *Melitara*, chiefly in the shape of the gnathos and the longer, more slender aedeagus. It also differs in the sclerotization of the 8th abdominal segment. The female genitalia are not significantly different from *Melitara dentata* (Grote). The forewing venation differs slightly in that Rs and Sc are stalked beyond cell rather than approximate.

Pseudocabotia Blanchard & Knudson, New Genus

Type-species.—*Pseudocabotia balconiensis* Blanchard & Knudson.

Description.—*Head:* Front conical. Maxillary palpi squamous, ascending to ½ eye diameter. Labial palpi alike in both sexes, porrect, slightly downcurved, exceeding front by 1½ eye diameters. Tongue well developed. Antennae simple, minutely setose ventrally, base of flagellum unmodified. Chaetosema present. *Forewing* (Fig. 17): Smooth, 11 veins; R_2 from cell, shortly before upper outer angle; R_3 and R_4 united and anastamosed with R_5 at half its distance beyond cell; otherwise as in *Cabotia* Ragonot. *Hindwing* (Fig. 17): As in *Cabotia. Male genitalia* (Figs. 18–20): Uncus subtriangular, lightly setose. Gnathos undivided, elongate, apex pointed. Transtilla incomplete. Valves simple, narrow, costa lightly sclerotized, clasper absent. Anellus V shaped, well sclerotized. Aedeagus sinuate, vesica lightly scobinate. Eighth abdominal sternite represented in Fig. 20. Scale tufts, if originally present, not preserved in dissection. *Female genitalia* (Fig. 21): Apophyses anteriores equal in length to apophyses posteriores. Ostium bursae narrowly funnel shaped, membranous. Ductus bursae membranous, half the length of corpus bursae. Corpus bursae with diverticulum posteriorly, bearing ductus seminalis. Signa well developed, consisting of vertical rows of thornlike spines and a patch of similar spines at junction of diverticulum and corpus bursa.

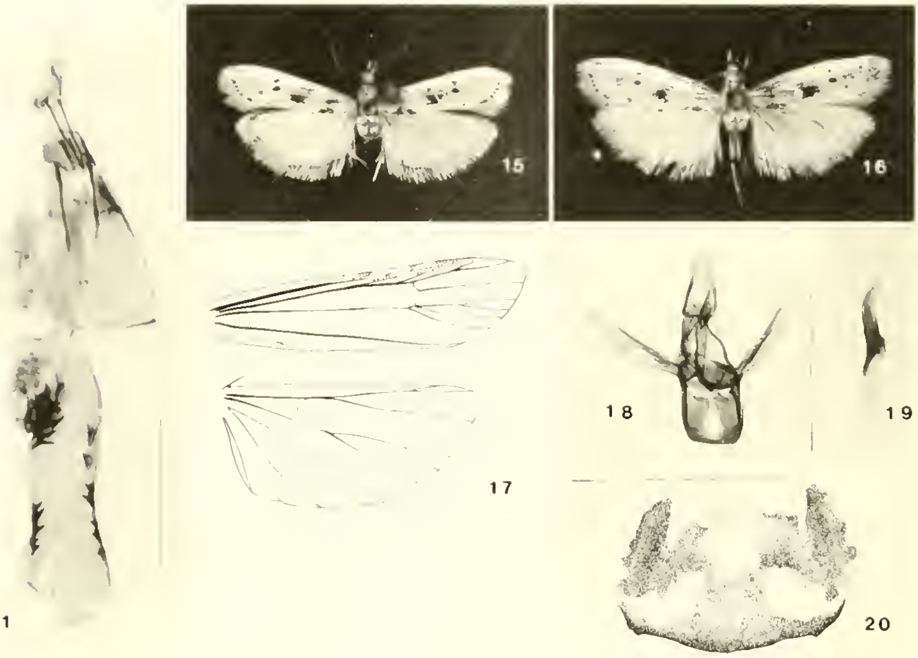
Remarks.—Based on venational characteristics, this new genus falls into Heinrich's group 2, division A of New World Phycitinae, but cannot be further assigned (Heinrich, 1956). The female genitalia are distinctive but similar to *Cabotia* Ragonot. The male genitalia differ from those of *Cabotia* in the shape of the gnathos and the absence of a clasper, in this being quite close to *Harnocha* Dyar, which differs in forewing venation. *Cabotia* has different maxillary palpi, which are aigrettes, resting in grooves in the labial palpi. The female of *Harnocha velassa* Dyar is still unknown.

Pseudocabotia balconiensis Blanchard & Knudson, New Species

Figs. 15–21

Description.—*Head:* Front and vertex pale ochreous. Maxillary palpi whitish, labial palpi brown laterally, whitish medially. Antennae brown scaled dorsally. *Thorax:* Patagia and mesonotum ochreous. Whitish beneath. *Forewing:* pale ochreous, costa broadly margined with white. Antemedial line indicated by a black dorsal spot ⅙ the distance from base and obscure black scaling above, extending to, but not beyond cell. Near middle of wing is a prominent black spot below cell. Discal spot double, the lower spot more prominent. Subterminal line obscure, whitish, margined by inner row of faint black spots, oblique from near apex to dorsal margin at outer ¼. Terminal spots black, well defined, not reaching apex. Fringe pale ochreous. *Hindwing:* Shining pale ochreous, with narrow fuscous terminal line. Fringe pale ochreous. *Length of forewing:* Males: N = 2, 7.1 and 8.3 mm., Females: N = 1, 6.4 mm. *Male and female genitalia:* As described for genus.

Holotype.—♀, Kerr Co., Texas, 10 miles west of Hunt, 4-IX-81, with genitalia slide ECK 215, collected by E. Knudson and deposited in the National Museum of Natural History. Paratypes.—Same locality as holotype, 25-VIII-81, 1 ♂, collected by E. Knudson. Comal Co., Texas, Guadalupe River near New Braunfels,



Figs. 15–21. *Pseudocabotia balconiensis*. Fig. 15, Holotype ♀. Fig. 16, Paratype ♂, same locality as holotype, genitalia on slide ECK 160, E. C. Knudson coll. Fig 17, Wing venation of ♂ paratype, on slide AB 5363, Comal Co., Texas. Fig. 18, ♂ genitalia of paratype, on slide AB 3098, same specimen as Fig 17. Fig. 19, Aedeagus of ♂ paratype, on slide AB 3098, same specimen as Fig. 17. Fig. 20, Sclerotized 8th abdominal sternite, same slide and specimen as Fig. 17. Fig. 21, ♀ genitalia of holotype. Segments = 1.0 mm except Fig. 20 = 0.5 mm.

12-III-72, 1 ♂, genitalia slide AB 3098, wing venation AB 5369, collected by A. & M. E. Blanchard.

Remarks.—This new species is known only from areas adjacent to the upper Guadalupe River on the Edwards plateau in central Texas. The name of the species refers to the Balconian biotic province where it occurs. The female was selected as holotype because of its distinctive genitalia.

Homoeosoma parvalbum **Blanchard & Knudson, NEW SPECIES**

Figs. 22–28

Description.—*Head:* Front pale fuscous; vertex white. Labial palpi upcurved, ascending to slightly above vertex, whitish ventrally and medially, light fuscous laterally. Maxillary palpi filiform, whitish. Antennae pale fuscous, lightly pubescent in male. *Thorax:* Whitish with a few scattered black scales. *Abdomen:* Whitish, shining. *Forewing:* Ground color white with evenly distributed peppering of black scales. Antemedial line prominent, black, angled outwardly from costa at basal ⅙ to dorsal margin at basal ⅓. Discal spots separate, black. Postmedial line well defined, black, parallel to termen. Terminal line indicated by 4 or 5 black dots from just above tornus, to beyond mid-termen, but not reaching apex. Fringe pale fuscous. *Hindwing:* Whitish, with fuscous terminal band. Fringe whitish, with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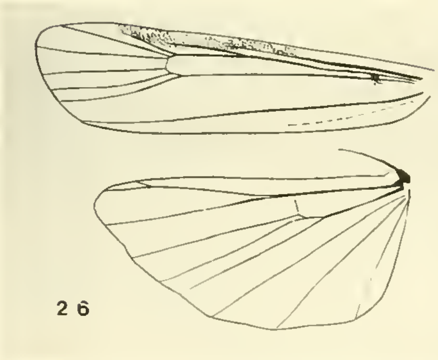
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Figs. 22–28. *Homoeosoma parvalbum.* Fig 22, Holotype ♂. Fig. 23, Paratype ♀, Dugout Wells, Brewster Co., Texas. Fig. 24, ♂ genitalia, aedeagus removed, of holotype, from slide ECK 851. Fig. 25, Aedeagus of holotype, from slide ECK 851. Fig. 26, Wing venation of paratype ♂, on slide AB 2776, same data as Fig. 23. Fig. 27, ♀ genitalia of paratype, Rio Grande Village, Brewster Co., Texas, on slide ECK 861. Fig. 28, Much enlarged signum from same slide as Fig. 27. Segments = 1.0 mm except Fig. 28 = 0.1 mm.

darker median band. *Wing venation* (Fig. 26): Forewing with 9 veins, M_2 and M_3 united, venation otherwise like other species of *Homoeosoma* Curtis. *Length of forewing:* Male: (N = 1), 7.4 mm. Females: (N = 8) 6.6–7.4 mm, average 6.9 mm. *Male genitalia* (Figs. 24–25): Uncus broadly rounded. Gnathos triangulate, produced to sharp points at apical and lateral processes. Vinculum with small lateral arms. Aedeagus (Fig. 25), with vesica scobinate, without cornuti. Eighth abdominal segment without scale tufts, sternite with small median thornlike process.

Female genitalia (Figs. 27–28): Papillae anales unsclerotized; ostium bursae simple, unsclerotized; ductus bursae membranous; corpus bursae membranous, with signum (Fig. 28), a patch of thornlike spines.

Holotype (Fig. 22).—♂, Brewster Co., Texas, Big Bend Nat'l. Park, Hot Springs, 4-IV-84, genitalia on slide ECK 851, collected by E. C. Knudson and deposited in the National Museum of Natural History. Paratypes.—All from Big Bend Nat'l. Park, Texas. Dugout Wells, 13-IX-71, 1 ♂, 3 ♀; K-Bar Research Station, 16-IX-71, 1 ♀; Chihuahuan Desert near Nugent Mt., 17-IX-71, 1 ♀; all collected by A. & M. E. Blanchard. Rio Grande Village, 6-IV-84, 3 ♀, collected by E. C. Knudson.

Remarks.—This new species differs from all other species of *Homoeosoma* in the forewing venation, in which M_2 and M_3 are united, rather than stalked. This proved constant in two wing preparations. Since all the other characters of the insect including both male and female genitalia are like those of *Homoeosoma*, it did not seem necessary to create a new genus, based only on a minor venational difference. The small size and conspicuous maculation should also serve to distinguish this species from all other North American species of *Homoeosoma*. The male genitalia are most similar to *Homoeosoma imitator* Heinrich, but differ in the shorter, more broadly rounded uncus, and the more elongate, tapered vinculum. The female genitalia are hardly distinguishable from other species with unsclerotized papillae anales.

ACKNOWLEDGMENTS

The authors are deeply grateful to Douglas C. Ferguson for examination and comparison of type material, and review of the manuscript. We also thank Frederick H. Rindge for examination and comparison with AMNH material, of the photographic plate of *Homoeosoma parvalbum*. We are also grateful to the National Park Service, Big Bend National Park, Texas, for providing access to collecting areas under terms of investigatory permits.

LITERATURE CITED

Heinrich, C. 1956. American Moths of the subfamily Phycitinae. U.S. Natl. Mus. Bull. 207. viii + 581 pp.

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 239–251

MORIBAETIS: A NEW GENUS OF NEOTROPICAL BAETIDAE (EPHEMEROPTERA)[1]

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Abstract—A new genus, ***Moribaetis***, erected for four species of Neotropical Baetidae, including *M.* ***ellenae*** (Mayo), new combination; *M.* ***maculipennis*** (Flowers), new combination; *M.* ***salvini*** (Eaton), new combination, and *M.* ***macaferti*** Waltz, new species. The subgenus ***Mayobaetis*** is proposed to include *M. ellenae*, whereas the remainder of the known species are placed in the subgenus *Moribaetis* s.s. Presumed but unassociated larvae of *M. salvini* (Eaton) are described and redescriptions of the larvae of *M. ellenae* and *M. maculipennis* are given. Keys to the four species in the larval stage and three species known as adults are provided, and new distribution records are cited. Phylogenetic relationships of the cited species are proposed.

The study of Central and South American collections of mayflies for the analysis of the generic relationships within the family Baetidae has led to the discovery of several new taxa. One of these taxa is described below as a new genus. Not only is this new genus morphologically striking, primarily because of its relatively large size and unique larval claw and gill structure, but its species demonstrate a biological trait apparently unique among baetids. Larvae are splash-zone dwellers that are frequently found exposed on wet surfaces above the water line of tropical streams. Further notes on biology and species relationships follow the generic and species descriptions.

Moribaetis Waltz and McCafferty, NEW GENUS

Type species: Baetis maculipennis Flowers, 1979: 187.

Adult diagnosis.—Adults will key to couplet 36 in Edmunds et al. (1976) as *Baetis*. Species of *Moribaetis* may, however, be distinguished from other known Baetidae by the following combination of characters: 1) a body length of 10–12 mm; 2) short-stalked turbinate eyes; 3) brown infuscations in male forewing (as in Fig. 43); 4) cubitoanal cells often with three or four marginal intercalaries; 5) paired marginal intercalaries shorter than cell width (Fig. 13) to often exceeding cell width (Fig. 43) by at least one member of the pair; 6) hindwings present with two or three veins and costal process; and 7) male genitalia of modified *intercalaris*-type (sensu Needham et al., 1935).

Larval diagnosis.—Larvae of *Moribaetis* will key to couplets 41 and 42 in Edmunds et al. (1976) as *Baetis*, from which they may be distinguished by the

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following combination of characters: 1) a peculiar claw structure (Fig. 40) with one to three stout unpaired subapical setae that are distinctly different than paired subapical setae discussed by Morihara and McCafferty (1979) and Corkum and Clifford (1981); 2) a relatively large body size of 9–12 mm; 3) deflected antennae; 4) a labrum that is basally narrowed (Figs. 6, 15, 25, 34) and with long plumose marginal setae; 5) a hypopharynx with a broadened and tongue-like lingua and without a dorso-median tuft of setae; 6) the presence of a pigmented anteromedial membrane of the abdominal terga that appears as a dark posteromedial border of the preceding tergum; 7) abdominal terga with rectangulate-based, broadly pointed scales; 8) asymmetric gills with gill 1 smallest (subequal to other gills in final instar); and 9) the presence of a well-developed median terminal filament.

Etymology.—Masculine gender. *Moribaetis* is named in recognition of Dennis Morihara for his revisionary contributions to the systematics of Baetidae.

Subgenus *Mayobaetis* Waltz and McCafferty, New Subgenus

Type species: Baetis ellenae Mayo, 1973: 285.

Adult male.—Body 10–11 mm long. Forewing (Fig. 13) with paired marginal intercalaries shorter than the marginal cell width. Hindwing (Fig. 14) with 2 longitudinal veins; 2nd vein not forked; costal margin with process; intercalaries and crossveins few or absent. Forceps with terminal segment elongate and ovoid.

Adult female.—Similar to male except body sometimes more darkly pigmented and wings may not always be pigmented.

Mature larva.—Head capsule round in frontal view (Fig. 1). Antenna subequal to head in length; pedicel and scape (Fig. 11) with longitudinal row of fine setae on outer margin, strongly dorso-ventrally flattened (pedicel broadened), with dorsal side having large blunted scale-like tuberculations. Labrum (Fig. 6) without basal-medial raised area. Mandibular denticles (Fig. 8) of outermost incisor group distinct. Maxillary palp (Fig. 9) often with indication of 3rd segment. Prothorax without coxal osmobranchia. Median terminal filament less than or subequal to ½ length of cerci.

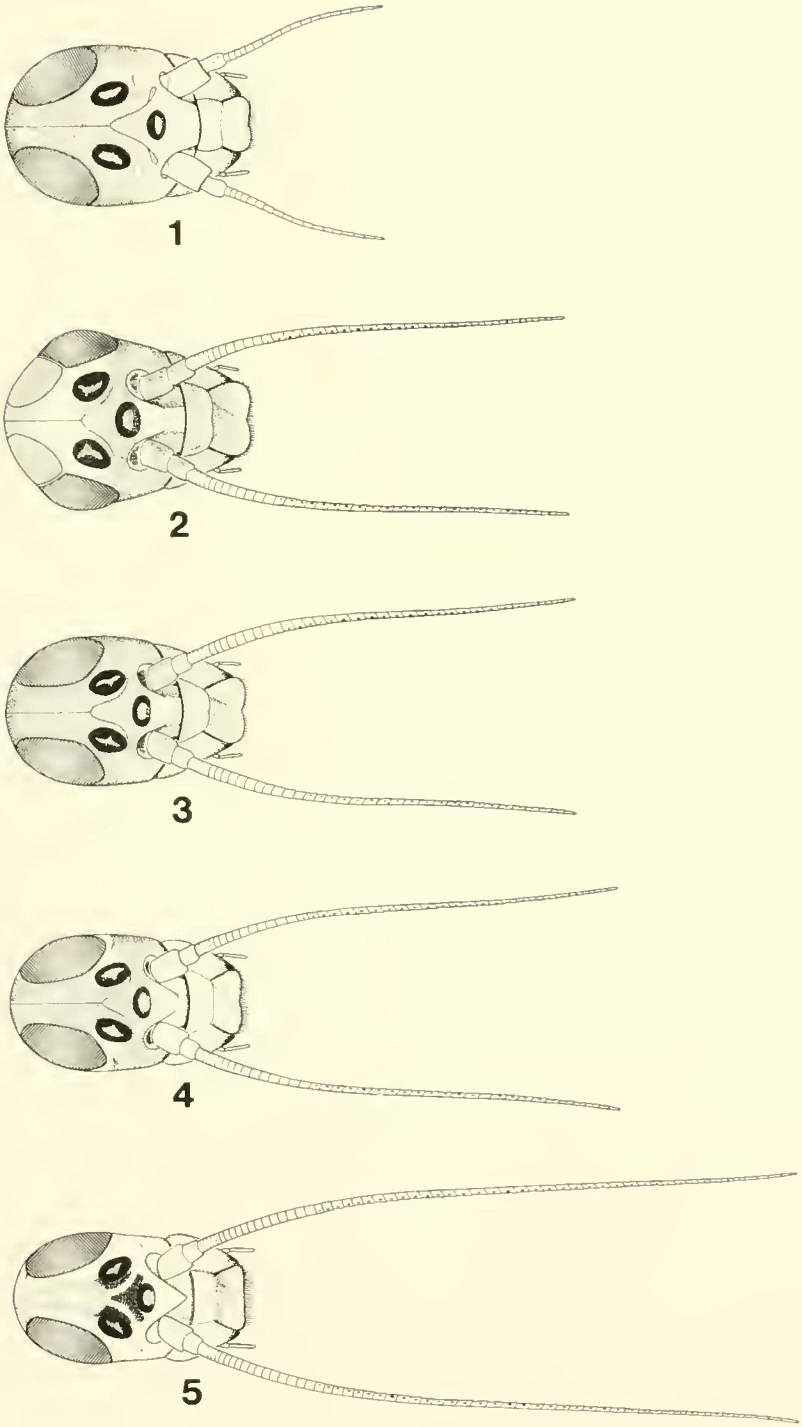
Etymology.—Masculine gender. This subgenus is named in honor of the ephemeropterist Mrs. Velma Knox Mayo.

Moribaetis (*Mayobaetis*) *ellenae* (Mayo), New Combination

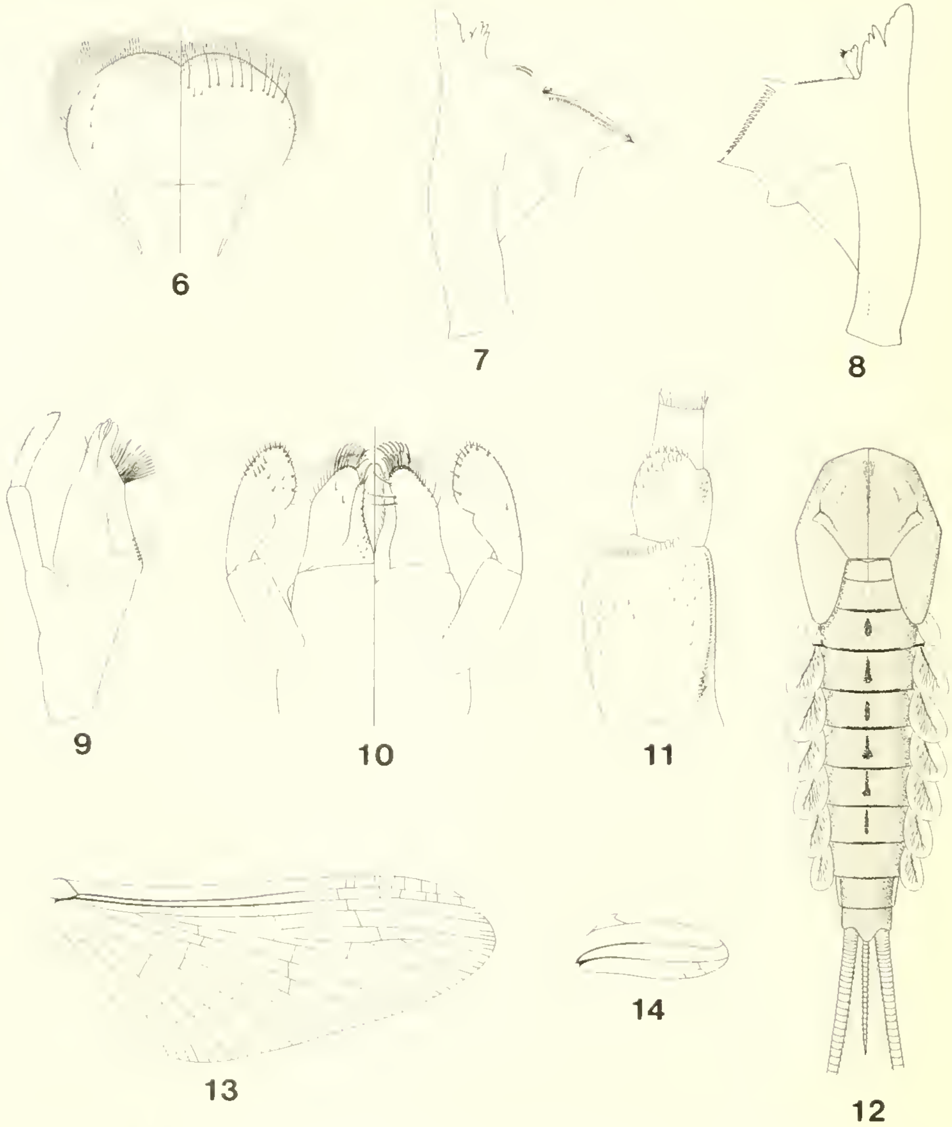
Baetis sp. 1 Roback, 1966: 137.
Baetis ellenae Mayo, 1973: 285; Berner, 1980: 190.

Adult male.—Adequately characterized by Mayo (1973).

Mature larva.—Head capsule (Fig. 1) rounded, uniformly colored. Antennae subequal to length of head capsule; pedicel ca. ½ length of scape; both scape and pedicel (Fig. 11) dorsoventrally flattened with scales, fine setae, and scale-like tuberculations and with longitudinal row of fine setae on outer margin; flagellum with subapical scales dorsally and clumped setae ventrally. Labrum (Fig. 6) with rounded anterior margins, strongly narrowed basally, without basomedian raised area, and with submarginal setae 1+9–10. Mandible (Figs. 7, 8) with divided incisors joined basally; prostheca of right mandible slender, bifurcate; thumb of left mandible elongate, narrow. Maxilla (Fig. 9) with palp exceeding galea-lacinea, and often with indication of 3rd segment. Segment 2 of labial palp (Fig. 10)



Figs. 1–5. *Moribaetis* larval head capsules (females). 1, *M. ellenae.* 2, *M. macaferti* (Guatemalan male). 3, *M. macaferti.* 4, *M. salvini.* 5, *M. maculipennis.*



Figs. 6–14. *Moribaetis ellenae*. 6, Labrum (left-ventral; right-dorsal). 7, Right mandible, ventral. 8, Left mandible, ventral. 9, Maxilla. 10, Labium (left-ventral; right-dorsal). 11, Antennal scape and pedicel (right side, dorsal view). 12, Dorsal color pattern. 13, Forewing, male imago. 14, Hindwing, male imago (not to scale).

subequal to segment 3; paraglossa with 3 apparent rows of apical setae; glossa with broadened (scraper type) setae and spine-like stout setae medially.

Diagnosis.—Larvae of *M. ellenae* may be separated from other species of this genus by the apically divided mandibular incisors (Figs. 7, 8); distinctive color pattern of the abdomen (Fig. 12); short stout antennae (Fig. 1); labial palp (Fig. 10) with segments 2 and 3 subequal; and a relatively round anterior margin of the labrum (Fig. 6). Adults of this species may be distinguished by a hindwing venation that consists of two veins with the second undivided (Fig. 14) and by the elongate terminal segment of the male forceps.

Known distribution.—Ecuador (type), Peru, Costa Rica, from 1400 m to 2000 m.

Material examined.—♀ larva (Paratype): Ecuador, Macuchi, Catopaxi Prov., Rio Amayo, VI-30-1943, 6000 ft. elev., V. K. Mayo. One larva: Costa Rica, San Jose, 12 mi N San Isidro del Genekal (Pan Amer. Hwy.), 5200 ft. VII-20-1962. G. G. Musser.

Subgenus *Moribaetis* sensu stricto

Adult male. Body 10–11 mm long. Forewing (Fig. 43) with ano-cubital cells frequently with 3 or 4 marginal intercalaries; all intercalaries long, equal to ½ cell width or more. Hindwing (Fig. 44) with 3 longitudinal veins, 2nd vein forked in known species and with few crossveins and intercalaries. Forceps of genitalia with terminal segment small, ovoid to nearly spherical.

Adult female.—Similar to male except sometimes more darkly pigmented and wings may not always be pigmented.

Mature larva.—Head capsule round to elongate in frontal view (Figs. 2–5). Antennae (Figs. 2–5) variable in length; pedicel and scape moderately dorsoventrally flattened, without (Figs. 22, 30) scale-like tuberculations, and without longitudinal row of fine setae on outer margin. Labrum (Figs. 15, 25, 34) with basomedial raised area. Mandibular denticles (Figs. 16, 17) of outermost incisor group fused. Maxillary palp (Fig. 28) 2-segmented. Prothorax with short, stout coxal osmobranchia (Fig. 31). Median terminal filament ½ to subequal length of cerci.

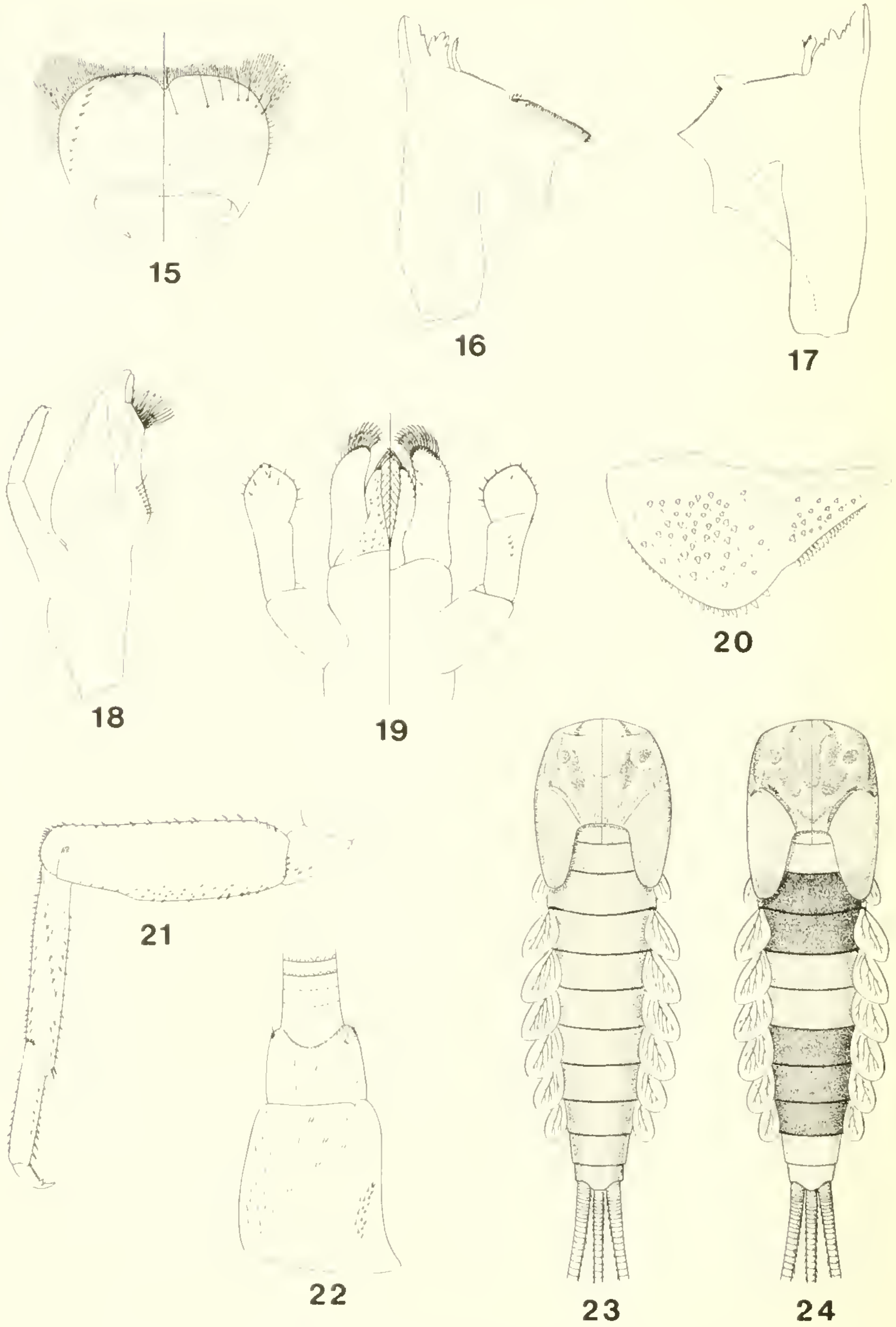
Subgeneric Diagnosis.—The two subgenera may be most easily distinguished as larvae by the following: the presence of procoxal osmobranchia (Fig. 31) [terminology after Shepard and Stewart (1983)] in *Moribaetis* versus none such in *Mayobaetis*; longer antennae relative to the head capsule (Figs. 2–5) in *Moribaetis* s.s. and a median terminal filament that is longer relative to the cerci in *Moribaetis* s.s.

The presence of three veins in the hind wing, the second of which is forked, in *Moribaetis* s.s. (Fig. 44) versus only two veins in *Mayobaetis* (Fig. 14), neither of which is forked; and a small spherical terminal genital forceps segment in *Moribaetis* s.s. versus an elongate, ovoid segment in *Mayobaetis*, will easily distinguish the known adults of the two subgenera.

Moribaetis (*Moribaetis*) *macaferti* Waltz, New Species

Adult.—Unknown.

Mature larva.—Body 8–9 mm long. Cerci 4.5–5.0 mm long. Terminal filament 3.5–4.0 mm long. Head (Fig. 2) rounded, yellow-brown to tan, without darkening between ocelli. Antennae deflected downward, paler ventrally, moderately long, reaching gill 3 to 5; scape and pedicel (Fig. 22) with random fine setae and clumped setae; pedicel with subapical scaling. Labrum (Fig. 15) with raised basal median area, and with rounded anterior margin; 1 + 5–6 stout submarginal setae; marginal setae long and plumose; sublateral row of ventral spines increasing in size from base to margin. Mandible (Figs. 16, 17) with row of fine spine-like setae between prostheca and molar area, outermost incisor denticles fused (few denticles may



Figs. 15–24. *Moribaetis macaferti.* 15, Labrum (left-ventral; right-dorsal). 16, Right mandible, ventral. 17, Left mandible, ventral. 18, Maxilla. 19, Labium (left-ventral; right-dorsal). 20, Paraproct. 21, Fore leg. 22, Antennal scape and pedicel (right side; dorsal view). 23, Dorsal color pattern. 24, Dorsal color pattern, Guatemalan male.

be discernible on margin), and innermost incisor tridentate or quadridentate, fused apically with outermost incisor on left mandible, free apically from outermost incisor on right mandible; thumb of left mandible broadly triangulate and blunt. Maxillary palp (Fig. 18) 2-segmented, subequal to galea-lacinea in length. Segment 3 of labial palp (Fig. 19) bulbous; segment 2 ca. 2–3× length of segment 3, with weak inner apical lobe and 4 dorsal setae; paraglossa with 3 apical rows of setae. Thorax tan and lacking medial stripe dorsally; procoxal osmobranchia present. Legs cream to tan, setation as in Fig. 21, tibia and tarsus uniformly colored, with spine-like setae and fine setae on dorsal and ventral margins; claws with 8 to 10 denticles and a strong subapical seta. Abdominal terga (Fig. 23) uniformly colored, without distinct patterning; posterior tergal margins with sharp spines. Gills asymmetric, with sclerotized anterior and posterior margins, and distinct tracheae; anterior margin serrate, with fine setae between serrations. Paraproct as in Fig. 20. Cerci and median terminal filament uniformly colored.

Variant.—A single larva from Guatemala possesses a unique color pattern (Figs. 2, 24) but is structurally identical with other specimens of *M. macaferti.*

Diagnosis.—*Moribaetis macaferti* may be distinguished from other species of this genus by the combination of characters as follow: shape of the mandibles (Figs. 16, 17) with distinctly denticled innermost incisors, right innermost incisor free apically from outermost incisor, left innermost incisor fused apically to outermost incisor; segment 2 of labial palp (Fig. 19) ca. 2–3× length of segment 3, and with four dorsal setae; paraglossa with three apical rows of setae (Fig. 19); submarginal row setal pattern of 1+5–6 stout setae on labrum (Fig. 15); antennae reaching gill 3 to 5 (Figs. 2, 3); and frons without medial pigment spot between ocelli. Adults are unknown.

Type material.—Holotype larva: Costa Rica, Guanacaste Pro., Rio Tenorio at Finca La Pacifica, E of Pan Amer. Hwy. II-2-1969. W. P. McCafferty, deposited in the Purdue University Entomological Research Collection. Three larval paratypes: same data and deposition as holotype, with one whole-mount slide preparation (3 slides), Hoyer's medium (water). One larval paratype: Guatemala, Escuiutla, VI-15-1962, G. G. Musser, with leg and mouthparts slide mounted in euparal (abs. alc.), deposited in the University of Utah Collections.

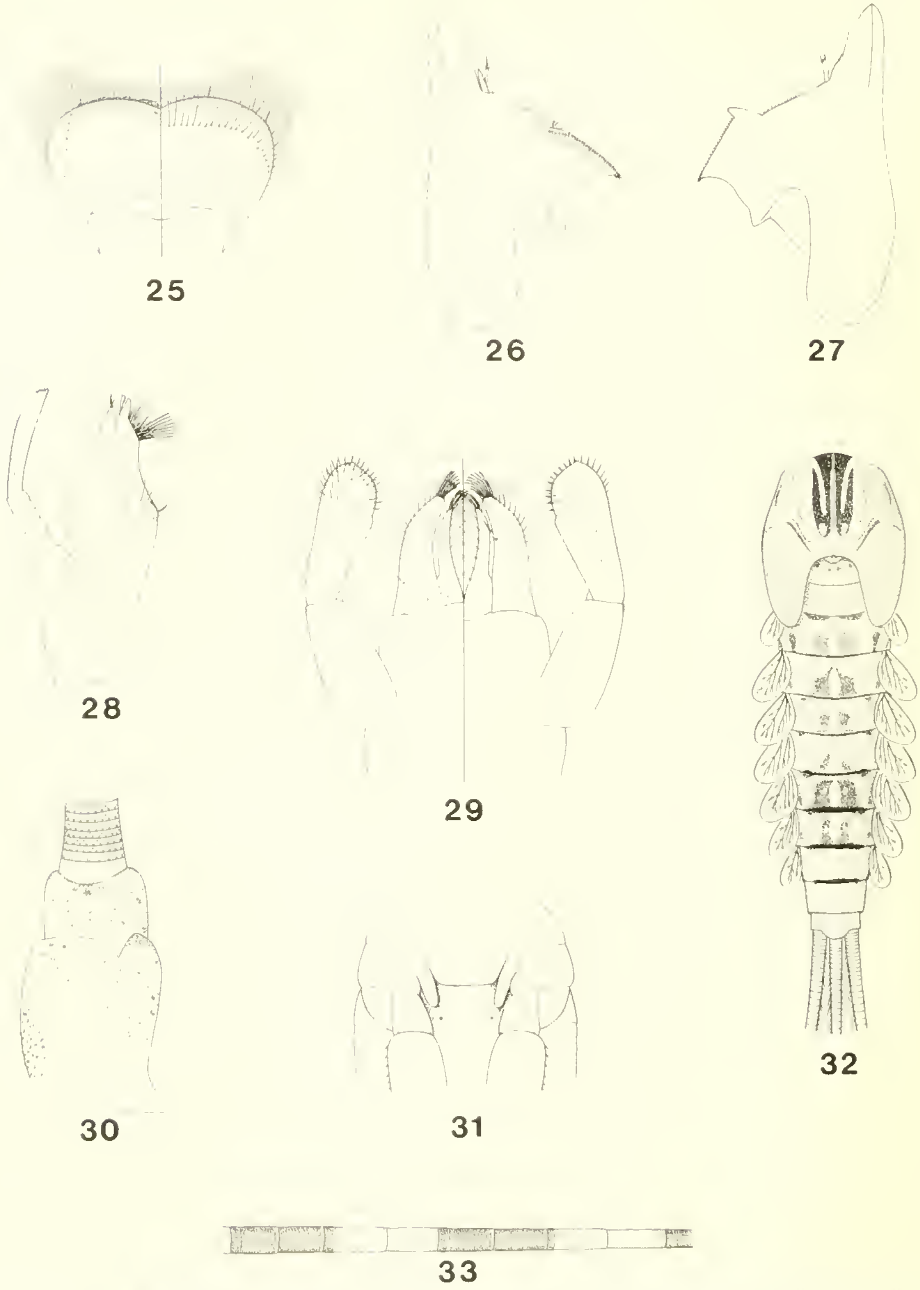
Etymology.—The specific epithet is a phonetic spelling of the collector's last name, McCafferty.

Moribaetis (*Moribaetis*) *maculipennis* (Flowers), NEW COMBINATION

Baetis maculipennis Flowers, 1979: 187.

Adult male.—Adequately characterized by Flowers (1979).

Mature larva.—Antennal scape (Fig. 30) subequal to pedicel in length, with scales, clumped setae, and random fine setae; flagellum with dorsal scales and ventral clumped setae. Labrum (Fig. 25) truncate apically, narrowed basally with prominent basal median raised area, and with submarginal setae 1+12–20. Mandible (Figs. 26, 27) with fine spine-like setae between prostheca and molar area; incisors of left mandible completely fused into single blade-like structure, innermost incisor of right mandible discernible as a smaller secondary blade near prostheca; prostheca slender, ribbonlike with apical furcations. Maxillary palp (Fig. 28) subequal to galea-lacinea in length, 2-segmented; galea-lacinea relatively



Figs. 25–33. *Moribaetis maculipennis*. 25, Labrum (left-ventral; right-dorsal). 26, Right mandible, ventral. 27, Left mandible, ventral. 28, Maxilla. 29, Labium (left-ventral; right-dorsal). 30, Antennal scape and pedicel (right side; dorsal view). 31, Prothorax ventral, procoxal osmobranchia. 32, Dorsal color pattern. 33, Male imago cercus (basal).

slender. Segment 2 of labial palp (Fig. 29) 2.5–3.0× length of segment 3 and with 6 or 7 dorsal setae; paraglossa with 2 apparent rows of apical setae; glossa narrowed, with serrate setae apically and long fine setae medially. Procoxal osmobranchia present (Fig. 31).

Diagnosis.—Larvae of *M. maculipennis* may be easily separated from other species of this genus by the distinctive abdominal color pattern (Fig. 32); the highly fused mandibular incisors forming a single blade (Figs. 26, 27), the relative second segment lengths and relation of the labial palp (Fig. 29); the relatively long antennae that may reach gill 7; and the distinct medial spot located on the frons (Fig. 5). Adults of this species may be recognized by the hindwing venation that includes a forked second vein with relatively few intercalaries within the fork; the abdominal color pattern; and cerci with an alternating pattern of one white segment then three darkened segments (Fig. 33).

Known distribution.—Costa Rica, Panama (Type).

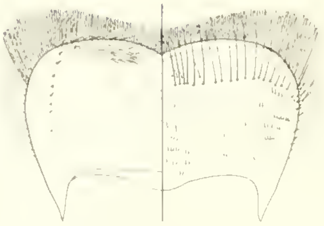
Material examined.—♂ adult paratype: Panama, Chiriqui, Fortuna, 8°44′N: 82°15′W. VI-8/14-1977 (light trap). Henk Wolda. Numerous larvae: Costa Rica, San Jose, 12 mi N San Isidro del Genekal (Pan Am. Hwy.) 5200 ft. elev. VIII-20-1962; G. G. Musser. Puntarenus Pro., 10 km N of San Vita at quarry waterfall, III-16-1969, W. P. McCafferty. Coniago, Moravia, 1116 m elev. VI-24-1962, G. G. Musser.

Moribaetis (*Moribaetis*) *salvini* (Eaton), NEW COMBINATION

Baetis salvini Eaton, 1885: 170; 1892: 13; Kimmins, 1934: 347; 1960: 289; Edmunds et al., 1976: 164.

Adult male.—Adequately characterized by Eaton (1885).

Mature larva.—Larvae that appear to match the adult color pattern of *M. salvini* and that fit the classification scheme concordant with the relationship of *M. salvini* to that of *M. maculipennis* are described as *M. salvini* as follows: Body 8–9.5 mm long. Head capsule (Fig. 4) elongated; yellow-brown to tan, vertex darker, without darkening between ocelli. Antenna deflexed, paler ventrally, 3× length of head capsule, reaching gill 3 to 5; scape and pedicel (as in Fig. 30) with clumped fine setae and random fine setae; pedicel with subapical scaling. Labrum (Fig. 34) with raised basal median area, with anterior margin slightly more projecting than in *M. maculipennis* and with submarginal setal pattern 1+7–9 (not including lateral field setae); marginal setae long, plumose; sublateral row of ventral spines 8–10. Mandible (Figs. 35, 36) with row of fine spine-like setae between prostheca and molar area, with outermost incisor denticles fused (few denticles may be discernible on margin), and with innermost incisor tridentate, fused apically with outermost incisor on left mandible, and free apically from outermost incisor on right mandible, thumb of left mandible elongate and blunt. Maxillary palp (Fig. 37) 2-segmented, subequal to galea-lacinea in length. Segment 3 of labial palp (Fig. 38) bulbous; segment 2 with weak inner apical lobe and 6 to 8 dorsal setae; paraglossa with 2 apical rows of closely set setae. Thorax tan, with medial stripe on pro- and mesonotum (as in Fig. 32); procoxal osmobranchia present. Legs cream colored and with setation as in Fig. 39; tibia and tarsus jointly graded from cream to tan distally, with spine-like setae dorsally and ventrally; claws (Fig. 40) with 8 or 9 denticles and 1 to 3 stout subapical seta(e) reaching apex. Abdominal tergal pattern with distinct lateral oblique bars; medial areas of terga with broken pigmented pattern similar to *M. maculipennis*; posterior margins of terga with sharp scales. Gills asymmetric, with sclerotized anterior and posterior margins, and distinct tracheae; apical margin serrate with several fine setae between teeth;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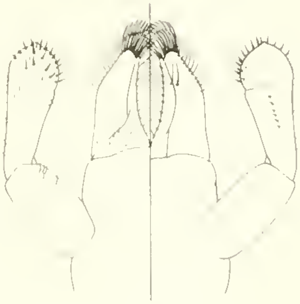
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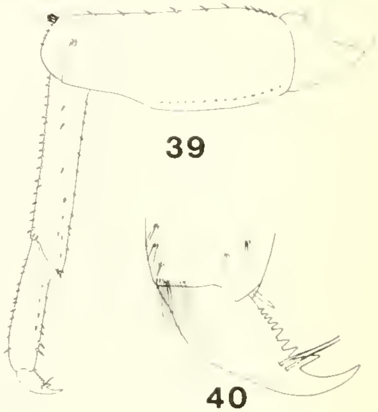
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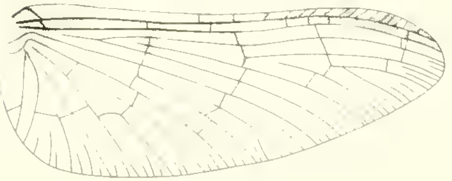
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Figs. 34–44. *Moribaetis salvini.* 34, Labrum (left-ventral; right-dorsal). 35, Right mandible, ventral. 36, Left mandible, ventral. 37, Maxilla. 38, Labium (left-ventral; right-dorsal). 39, Foreleg. 40, Foreclaw. 41, Paraproct. 42, Male imago cercus (basal). 43, Forewing, male. 44, Hindwing, male (not to scale).

gill on segment one smaller than those on remaining segments. Paraproct (Fig. 41) with sharp marginal denticles, not clustered apically, and with surface having fine setae and clumped setae. Cerci and median terminal filament unicolored.

Diagnosis.—Larvae of *M. salvini* may be separated from other species of the genus by the antennal length that reaches to gill 3–5 (Fig. 4); form of the mandibles (Figs. 35, 36), with distinctly denticled innermost incisors; frons without pigment spot between ocelli (Fig. 4); paraglossae with two apical rows of setae (Fig. 38); and paraproct (Fig. 41) denticles not clustered apically. Adults of *M. salvini* may be distinguished by the forked second vein of the hindwing (Fig. 44) with several relatively prominent marginal intercalaries; color pattern of the abdomen; and cerci (Fig. 42) of adult male, that have one darkened segment alternating with three light-colored segments.

Known distribution.—Costa Rica (type), Guatemala(?).

Material examined.—Lectotype male adult: Costa Rica: Volcan de Irazu, 6000 to 7000 ft. H. Rogers. Female adult: Guatemala: Panima, Vera Paz, no date, det. A. E. Eaton [Identification of this specimen is questionable]. Larvae: Costa Rica, San Jose. 12 mi N San Isidro del General, (Pan Amer. Hwy.) 5200 ft. VIII-20-1962, G. G. Musser. One male adult specimen in relatively poor condition that we have examined from Huatusco, Vera Cruz Pro., Mexico, agrees with the type in abdominal maculation pattern and hindwing venation but lacks other characters (especially of cerci and legs) that are found in other known adults of this species.

KEY TO MALE ADULTS OF *MORIBAETIS* SPECIES

1. Hindwing with two longitudinal veins (Fig. 14); forewing with little mottling; abdominal terga patterned on posterior margin with black-brown on either side of midline and laterally near pleural fold; terminal segment of forceps elongate-ovoid .... *M. ellenae*

– Hindwing with three longitudinal veins (Fig. 44); forewing patterned; abdominal terga with varied color patterns; terminal segment of forceps spherical, small 2

2. Hindwing with marginal intercalaries reduced, usually with one distinct intercalary and two minor intercalaries; cerci (Fig. 33) banded in alternating pattern of one white segment with three darkened segments .... *M. maculipennis*

– Hindwing with marginal intercalaries more apparent, usually with two distinct intercalaries and two or three minor intercalaries (Fig. 44); cerci (Fig. 42) banded in alternating pattern of one lightly darkened segment with three white segments .... *M. salvini*

KEY TO MATURE LARVAE OF *MORIBAETIS* SPECIES

1. Antennae short, subequal to head capsule in length (Fig. 1); segment 2 of labial palp subequal in length to segment 3 (Fig. 10); procoxal osmobranchia absent; median terminal filament less than or subequal to one-half length of the cerci; abdominal color pattern as in Fig. 12 .... *M. ellenae*

– Antennae distinctly longer than head capsule; segment 2 of labial palp longer than segment 3; procoxal osmobranchia present (Fig. 31); median terminal filament greater than or subequal to one-half length of cerci; abdominal color pattern varied 2

2. Incisors of mandible fused into one blade-like structure lacking denticles (Figs. 26, 27); antennae often reaching or surpassing gill 6 or 7; color pattern as in Fig. 32; frons with distinct medial pigmented area between ocelli (Fig. 5) .... *M. maculipennis*
– Incisors of mandible with easily discernible denticles (Figs. 16, 17 and 35, 36); antennae reaching gill 3 to 5; frons without medial pigmented area 3
3. Paraglossa (Fig. 19) with three apical rows of setae; segment 2 of labial palp with four dorsal setae (Fig. 19); abdominal terga without distinct color patterning (Figs. 23, 24) .... *M. macaferti*
– Paraglossa (Fig. 38) with two apical rows of setae; segment two of labial palp with six dorsal setae (Fig. 38); abdominal terga with distinctive color pattern similar to Fig. 32 .... *M. salvini*

Species Relationships

It is difficult at this time to determine the derivation of *Moribaetis* and therefore have use of the appropriate outgroup comparison for deciphering character state polarity. Nonetheless, certain evidence appears to support convincingly the relationships described below.

The common possession of procoxal osmobranchia and a labrum with a uniquely elevated basal medial area in *M. macaferti, M. maculipennis,* and *M. salvini* strongly suggests a synapomorphy tying these species (subgenus *Moribaetis*) to a common branch separate from a *M. ellenae* lineage (subgenus *Mayobaetis*). The short antennae of *M. ellenae,* among other character states, would appear to be an autapomorphy. Within the subgenus *Moribaetis,* the extremely reduced apices of the paraglossae and two apical rows of paraglossal setae of *M. maculipennis* and *M. salvini* would indicate that these species form a sister group on a branch separate from the *M. macaferti* lineage.

The above relationship predicts the polarity of other character states within the genus and indicates a number of possible evolutionary trends. These include the fusion of the mandibular incisors and independently a fusion of the denticles of the incisors, both lengthening and shortening of the antennae, increase in the distribution and intensity of abdominal pigmentation, elongation of the clypeus, narrowing of the intraantennal frontal process, and an increase in the size of the medial basal region of the labrum (possibly in conjunction with increased musculature). Furthermore these deductions may allow the origin of the genus to be hypothesized once more information on related baetid genera is available.

Biology

On the basis of collections taken in Ecuador and reported by Mayo (1973), observations discussed by Peters (1973), and field notes by W. P. McCafferty, the species of this genus frequent the upper surfaces of rocks in fast water, the bases of waterfalls in the splash zone, or rocks along the shoreline of fast-water areas. Peters (1973) states that the Peruvian baetid (*M. ellenae*?) he observed "could be found on the top of rocks instead of in the water." Peters also reported that when disturbed, the larvae would flip into the air up to 3 feet and escape into the water. Riek [see ref. Peters (1973)] and Edmunds et al. (1976) have also noted a similar phenomenon in species of Siphlonuridae.

The species of *Moribaetis* have sympatric distributions in Central America. Three of the species (*M. maculipennis, M. salvini,* and *M. ellenae*) have been collected together. Differences in habitat partitioning that may be attributed to specific mouthpart structure differences and possible related feeding behavior are at present unknown.

ACKNOWLEDGMENTS

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LITERATURE CITED

Berner, L. 1980. Results of the Catherwood Bolivian-Peruvian altiplano expedition Part I: aquatic insects except diptera. Proc. Acad. Nat. Sci. Phila. 132: 187–217.

Corkum, L. D. and H. F. Clifford. 1981. Function of the caudal filaments and correlated structures in mayfly nymphs, with special reference to *Baetis* (Ephemeroptera). Quaest. Entomol. 17: 129–146.

Eaton, A. E. 1883–1888. A revisional monograph of recent Ephemeridae or mayflies. Trans. Linn. Soc., London, 2nd Ser. Zool., No. 3. 352 pp.

———. 1892. Biologia Centrali-Americana: Insecta, Neuroptera, Ephemeridae. Vol. 38. Bernard Quaritch, Ltd., London, pp. 1–16.

Edmunds, G. F., Jr., S. L. Jensen, and L. Berner. 1976. Mayflies of North and Central America. Univ. Minn. Press. Minneapolis, x + 330 pp.

Flowers, W. 1979. A new species of *Baetis* from Panama (Ephemeroptera: Baetidae). Pan-Pac. Entomol. 55: 187–191.

Kimmins, D. E. 1934. Notes on the Ephemeroptera of the Godman and Salvin collection, with descriptions of two new species. Ann. Mag. Nat. Hist. (10)14: 338–353.

———. 1960. The Ephemeroptera types of species described by A. E. Eaton, R. McLachlan, and F. Walker. Bull. Brit. Mus. Nat. Hist. (Entomol.) 9: 269–318.

Mayo, V. K. 1973. A new species of *Baetis* from Ecuador (Ephemeroptera: Baetidae). Pan-Pac. Entomol. 49: 285–288.

Morihara, D. K. and W. P. McCafferty. 1979. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). Trans. Am. Entomol. Soc. 105: 139–221.

Needham, J. G., J. R. Traver, and Y. C. Hsu. 1935. The biology of mayflies with a systematic account of North American species. Comstock, Ithaca. 759 pp.

Peters, W. L. 1973. Discussion, p. 177. *In* Reik, E. F., The classification of the Ephemeroptera, pp. 160–178. *In* Peters, W. L. and J. G. Peters, eds., Proc. of the First International Conf. Ephemeroptera. E. J. Brill, Leiden. 312 pp.

Roback, S. S. 1966. The Catherwood Foundation Peruvian-Amazon expedition. Part VI. Ephemeroptera nymphs. Monogr. Acad. Nat. Sci. Phila. 14: 129–199.

Shepard, W. D. and K. W. Stewart. 1983. Comparative study of nymphal gills in North American stonefly genera and a new, proposed paradigm of plecoptera gill evolution. Misc. Publ. Entomol. Soc. Am., No. 55. 57 pp.

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87(1), 1985, p. 252

BOOK REVIEW

Eriophyid Mites of Alfred Nalepa. By Richard Albert Newkirk. Thomas Say Foundation Publications, Entomological Society of America, College Park, Maryland. Volume 9, 137 pp., 1984. $20.00, ESA Members $12.00.

Alfred Nalepa's eriophyoid publications covered a span of 43 years, beginning in 1886 and ending with his death in 1929. His last paper was published posthumously in 1930. Nalepa described 331 species, 42 varieties, and 28 subspecies. His works appeared under 113 separate titles. Nalepa was the dominating eriophyoid worker during his period, and today he is considered the "Founder of Eriophyidology."

Those who are involved in the systematics of eriophyoids know that studying Alfred Nalepa's works has been an avocation for Richard Albert Newkirk for many years. Thanks to E. W. Baker's encouragements, Newkirk has completed and published his studies in a highly academic paper.

Newkirk's book is divided into an introduction, format, acknowledgment, synopsis of Nalepa's works, host list, bibliography, index of plant names, and index of eriophyoid names.

The section on synopsis of Nalepa's work is possibly the most important to eriophyidologists. It is here that one finds Nalepa's eriophyoid works presented under 113 titles given in full. The titles are in chronological order, with a few noted exceptions. Under each title, the genera are arranged alphabetically with type species fixation for genera proposed by Nalepa. Under the genera, the species names are arranged alphabetically, followed by literature citation, host plant, changes in rank, emendations, errors, misidentifications, nomina nuda, preoccupied names, and synonyms.

In the section on host list, the plant taxa are arranged in a phylogenetic system similar to that employed by Nalepa in his 1929 "Katalog." Newkirk could have made this section more useful by having information on the relationship of the mite to the host plant as did Nalepa in his "Katalog."

Other than a few errors in spelling, the book is well-done. It should be available to eriophyidologists and to systematists involved in the identification of eriophyoids. It should be in all libraries with collections of acarological works.

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NOTE

Observations on the Reproductive Behavior of Two Neotropical Robber Fly Species (Diptera: Asilidae)

Most ethological research on adult robber flies has centered on the predatory behavior of north temperate species. Here I present some observations on the reproductive behavior of two neotropical asilid species. All observations were made in 1981 within the forest of Barro Colorado Island, Panama. Complete geologic, climatic, and floristic descriptions of Barro Colorado are given in Croat (1978. Flora of Barro Colorado Island, 943 pp.).

OBSERVATIONS OF *SENOBASIS CORSAIR* BROMLEY

The genus *Senobasis* (subfamily Dasypoginae) includes 17 described species all of which are neotropical in distribution (Papavero, 1975. Arq. Zool. 26: 191–318). *Senobasis corsair* has previously been reported from Panama, Colombia, and Costa Rica (Papavero, loc. cit.), but published behavioral observations are completely lacking. Females are slightly larger than males; for 5 males and 5 females, the mean body lengths were 18.3 mm and 19.1 mm, respectively. Both sexes possess black legs, a black face, a predominately bluish-black mesonotum, and brown wings which produce violaceous reflections. However, the sexes differ with respect to abdominal color. With the exception of narrow whitish bands on tergites 2 and 3, the female's abdominal tergites are completely black. In males, on the other hand, only tergites 1 and 5–7 are black, while tergites 2–4 are completely white.

Matings were observed on four different occasions between May 3–May 14 and were similar in each instance. Courtship appears to be absent; in each case a flying male simply pounced upon a perching female, and copulation followed immediately. When foraging, both sexes typically perch on horizontal branches with their wings resting directly over the abdomen. When in the end-to-end position, however, only the female maintains this typical perching posture. After coupling with the female, the male hangs vertically (head downward) behind the female. The male grips the branch with all its legs and is further supported by the female's weight, which is shifted slightly forward during copulation. While in this vertical position, the male also holds each wing at approximately a 45° angle to the body thus exposing the white segments of the abdomen. Copulations lasted 50–135 min and were apparently terminated by the male who, in each case, suddenly disengaged and flew off.

For a male in copulo, the vertical position, the violaceous reflections of the wings, and the contrasting black and white tergites collectively create an unusual visual effect. As an initial hypothesis, I suggest that this visual effect may serve to confuse predators (e.g. birds) and thus reduce the risk of predation during the rather lengthy copulation. This lowered risk might result from either a predator's failure to recognize the mating pair as potential prey or a reduction in the speed and/or accuracy of an attempted capture. The validity of this "predator confusion" hypothesis, of course, still requires experimental verification.

Following one copulation, the female was captured, returned to the laboratory, and placed in a plastic container. Approximately 48 h later, eight eggs were found on a side of the container. The eggs were laid more or less end-to-end in a straight line, and adjacent eggs were firmly stuck together. The eggs were grayish-black, elongate ovals with an average length of 1.4 mm (range: 1.2–1.5) and an average width of 0.55 mm (range: 0.5–0.7). No surface ridges or sculpturing were apparent under a light microscope (430×). No hatching occurred after 7 days at which time the eggs were preserved. Although oviposition was not observed in the field, a female was seen walking slowly on bare ground for approximately 45 minutes. Her abdomen was held above ground during most of this time, but during 5 short intervals (5–15 s) she lowered the tip of her abdomen to the ground and moved it back and forth slowly over the surface. These 5 sites were examined and then excavated, but no eggs were found.

An Observed Oviposition and the Eggs of *Promachus anceps* Osten Sacken

Although *Promachus* is a large (approximately 250 species; Hull 1962) cosmopolitan genus, oviposition and eggs have been described for only a few species (Felt, 1915, N.Y. State Mus. Bull. 175: 24–26; Davis, 1919, Bull. Nat. Hist. Sur. Ill. 13: 53–138; Lavigne and Holland, 1969, Univ. Wyo. Agric. Exp. Stn. Sci. Monogr. 18: 1–61). *Promachus anceps* has previously been reported from Panama and Mexico (Osten Sacken, 1887, Biologia-Centrali Americana, pp. 167–213), but there are no published accounts of its biology. On June 23 at approximately 1045 h, a female was observed walking along a fallen, dead branch that was suspended about 2 m above ground by some other branches. Apparently searching for a suitable site, the female stopped frequently and "tested" the branch surface with her ovipositor. To do so, she curled the tip of her abdomen forward and made distinct probes while simultaneously moving it from side to side. After making 15–20 such "tests" (each lasting 2–3 s), she reached one end of the branch and, finding it hollow, turned around and inserted her curled abdomen into the opening. She remained in this position for approximately 30 s after which she flew off and was lost from view.

Examination of the stick revealed that, while no eggs were laid on the surface, 20 eggs had been deposited in the open end. The eggs were pale white, elongate ovals with an average length of 1.55 mm (range: 1.4–1.65) and an average width of 0.5 mm (range: 0.4–0.55). The eggs were arranged in two adjacent rows, and neighboring eggs were cemented together. The whole egg mass was 7.9 mm long and 0.9–1.1 mm wide (these latter values corresponding to the diameter of the hollow groove) and was 5.1 mm from the end of the stick. No surface ridges or sculpturing were apparent under a light microscope (430×). No hatching occurred after 13 days at which time the eggs were preserved.

I am grateful to E. Fisher for identifying the species.

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NOTE

Range Extensions and Ecological Data for Southern United States Ephemeroptera

While conducting ecological studies of southern rivers, I found six mayfly species beyond their previously known ranges. Since little or no ecological information exists for these species and the new state records better define range extremes, the following data are presented.

Anepeorus simplex (Walsh) (Heptageniidae): Arkansas, Jefferson County, Arkansas River near Pine Bluff. T.6S., R.7W., S.7. 15 May 1980. Previously known from Illinois, Iowa, and Georgia. *Baetis ephippiatus* Traver (Baetidae): Louisiana, Natchitoches Parish and Red River Parish line, Bayou Pierre near Evelyn. T.12N., R.10W., S.36. 21 Aug. 1979. Formerly reported from the extreme southeast, west to Alabama, and north to Indiana and Virginia. *Baetis longipalpus* Morihara and McCafferty: Louisiana, Red River Parish, Red River near Grand Bayou. T.13N, R.11W., S.2. 22 Aug. 1979. Indiana and Wisconsin were the only known localities. *Baetis quilleri* Dobbs: Louisiana, De Soto Parish and Red River Parish line, Bayou Pierre near Lake End. T.11N., R.9W., S.36. 22 Aug. 1979. Common to the extreme southwest. *Leptohyphes dolani* Allen (Tricorythidae): Florida, Hamilton County and Madison County line, Withlacoochee River near Pinetta. T.3N., R.10E., S.204,205. 13 Sept. 1979. Previously collected from Savannah River, Georgia. *Spinadis* sp. Edmunds and Jensen (Heptageniidae): Arkansas, Jefferson County, Arkansas River near Pine Bluff. T.6S., R.7W., S.7. 15 May 1980. This rarely collected genus was known from Georgia, Indiana, and Wisconsin.

Baetis ephippiatus and *Baetis quilleri* larvae were collected from submerged aquatic vegetation and wood in current varying from 0.2 m/s in silty areas to 0.4 m/s in sandy reaches. Riparian vegetation formed a partially closed canopy over the stream which varied from 3 m to 15 m in width. Common co-habitors were *Hydropsyche rossi* Flint, Voshell, and Parker, *Caenis* sp., *Stenacron floridensis* (Lewis), *Polypedilum* sp. and *Rheotanytarsus* sp. In Florida, *B. ephippiatus* occurs on vegetation in sand bottom streams (Berner, L., 1950. Univ. Fla. Biol. Sci. Ser. 4:1–267). Since *B. quillieri* larvae were only recently described no comparative ecological data exist.

Baetis longipalpus colonized bole wood, tree limbs, and whole trees in the Red River, a highly erosional environment where shifting sand is the dominate bottom type. The collection area was 250 m to 400 m wide and 4 m deep; current varied from 0.3 m/s to 0.8 m/s. Large rivers are the only known habitat of *B. longipalpus* (Morihara, D. K. and W. P. McCafferty, 1979. Proc. Entomol. Soc. Wash. 81: 34–37). Other species sharing this habitat were *Hydropsyche orris* Ross, *Pychopsyche flava* (Hagen), *Pentagenia vittigera* (Walsh), *Torotopus incertus* (Traver), *Polypedilum* sp., and *Rheotanytarsus* sp. The ephemeroids were captured from the drift; presumably they burrowed into stable clay banks.

Since *Spinadis* sp. and *Anepeorus simplex* were collected in drift nets in mid-river, their specific habitat was not observed. At the collection site, the Arkansas River is 500 m wide and 6 m deep with a boulder and gravel bottom. Current varied from 0.7 m/s to 0.9 m/s; however, wingdams greatly reduced the current near shore permitting a silty substrata to form. These species are apparently restricted to large rivers (Edmunds, G. F. Jr., S. L. Jensen, and L. Berner, 1976. Univ. Minn. Press, Minneapolis, pp. 1–330). *Cyrnellus fraternus* (Banks), *H. orris, Hexagenia* sp., *P. vittigera, Dicrotendipes* sp., and *Gyptotendipes* sp. were dominant members in this community.

Leptohyphes dolani occurred on calcareous rock and wood in slow current (0.2 m/s) in the Withlacoochee River; most of the surface was shaded by a dense tree canopy. *Baetis ephippiatus, Stenonema exiguum* Traver, *Hydropsyche venularis* Banks, *Chimara socia* Hagen, *Pentaneura* sp., and *Rheotanytarsus* sp. were abundant at this site. Allen (1967. Can. Entomol. 99: 350–375) reported *L. dolani* from the Savannah River in Georgia but did not describe the habitat.

I thank W. P. McCafferty and J. D. Unzicker for verification of Ephemeroptera and Trichoptera identifications, respectively.

Thomas M. Lager, *3184 W. Fairview Rd., Neenah, Wisconsin 54956.*

BOOK NOTICE

Butterflies East of the Great Plains. By Paul A. Opler and George O. Krizek. 1984. Johns Hopkins University Press, Baltimore and London. xvii, 294 p., 54 pls. Price: $49.50.

I am proud to have my name acknowledged in this excellent book, although I merely furnished the authors with a little information concerning the derivation of some of the scientific names. It is a fine compendium of knowledge of the nearly 300 species of butterflies found east of the Great Plains, including the first row of States west of the Mississippi River, and with the distribution of most of them on outline maps. Jerry A. Powell, who wrote the foreword, concisely states "What sets this book apart from its predecessors is its emphasis on biological relationships." The plates show 324 color figures of photographs of live specimens, some of which are therefore naturally not very artistic, but they do show how the insect actually appears.

The book is an excellent example of the bookmaking art; it will stand a lot of handling, is easy to read, and contains ample indexes as well as a bibliography of 285 citations. One of my lepidopterist colleagues remarked in pure Colloquial American, "I see where I'm gonna hafta lay out fifty bucks for another butterfly book."

George C. Steyskal, *Cooperating Scientist, Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, USDA, % U.S. National Museum of Natural History, NHB 168, Washington, D.C. 20560.*

ANNOUNCEMENT

The International Commission on Zoological Nomenclature publishes notices of possible use of its plenary powers in the *Bulletin of Zoological Nomenclature*. In order that the Commission have the best possible advice from zoologists, the Secretary of the Commission, R. V. Melville, asked that the Proceedings carry these notices for additional publicity. Beginning with this issue, the Proceedings will list, as they are received, the notices dealing with names of insects.

The following notices were published in *Bull. Zool. Nomencl.* 41(3) on August 23, 1984. The Commission welcomes comments and advice on these within six months or as soon as possible after the date of publication in the *Bulletin*. Send comments to: Secretary, International Commission on Zoological Nomenclature, ℅ British Museum (Nat. Hist.), London SW7 5BD, United Kingdom.

Case No. 239.—*Tibicina* Amyot, 1847 and *Lyristes* Horváth, 1926 (Insecta, Hemiptera, Homoptera): proposed conservation by the suppression of *Tibicen* Berthold, 1827. Also, Arguments pour la suppression du nom de genre *Tibicen* et de ses dérivés dans la nomenclature de la superfamille CICADOIDEA.

Case No. 2142.—*Hypocryphalus mangiferae* (Stebbing, 1914) (Insecta, Coleoptera): proposed conservation under the plenary powers.

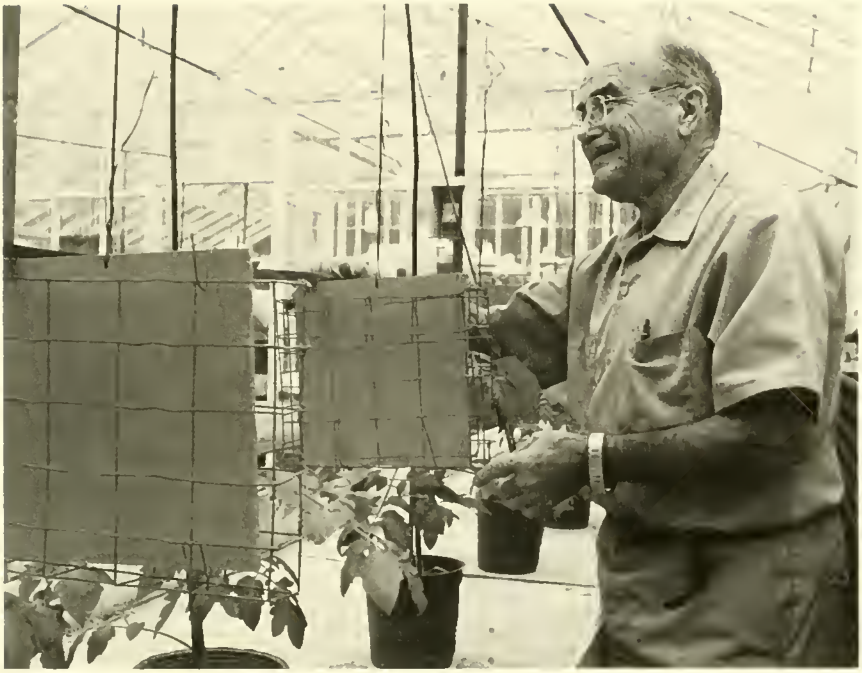
ANNOUNCEMENT

The International Commission on Zoological Nomenclature announces that the Third Edition of the International Code of Zoological Nomenclature will soon be available. The book consists of parallel English and French texts, totaling about 320 pages (216 mm × 318 mm). It will be for sale for £15, plus £1.50 for postage and handling, through the Publications Sales, British Museum (Natural History), Cromwell Road, London SW7 5BD, United Kingdom. Individuals and organizations may also purchase the book for $21.50, postage and handling included, through the American Association for Zoological Nomenclature, Room W-115, National Museum of Natural History, Washington, D.C. 20560.

A prepublication price of $18.75, postage and handling included, for individuals is in effect until March 31, 1985. Delivery of the Code will be in spring, 1985. Checks drawn on a United States bank or International Money Orders should accompany all U.S. orders. Please make checks payable to American Association for Zoological Nomenclature.

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 259–261

OBITUARY



FLOYD FRANKLIN SMITH
1900–1984

On April 26, 1984, Floyd F. Smith died of complications following an operation. Thus ended an extraordinarily productive career in economic entomology, acarology, and virus–vector relationships that spanned 60 years. Floyd was born on July 27, 1900, on a farm in Hinckley, Ohio. He was educated in the public school system, and went on to graduate from Ohio State University in Agriculture in 1923. While still a student, Floyd worked for the USDA scouting corn borers and studying the insect vectors of the virus diseases of raspberries. This latter work was published in *Phytopathology* in 1924, the first of over 100 papers relating primarily to plant diseases and virus–vector relationships.

After receiving his MS degree from Ohio State University in 1924, Floyd was employed by the Pennsylvania Bureau of Plant Industry, Willow Grove, Pennsylvania, where he studied insects of greenhouse and nursery crops and conducted nursery inspection. This provided him with a first hand working knowledge of the pest problems faced by nurserymen and greenhouse operators that proved valuable through his entire career. He continued his studies at Ohio State during this period, completing his Ph.D. requirements in Entomology in 1929. This same year he joined the Agricultural Research Service, where he worked with F. W. Poos until 1931, studying the biology and control of leafhoppers affecting forage crops at Arlington Farm, Virginia. The most important work of Floyd's early career includes his studies on the biology and control of the black vine weevil (the subject of his Ph.D. dissertation), the work on leafhopper feeding damage that elucidated the true nature of hopperburn, and his work demonstrating the nature of the sheath material in the feeding punctures of leafhoppers. These studies are still regularly cited in the literature more than 50 years after publication.

From 1931 to 1957, Floyd worked on the biology and control of insects and mites of ornamental and greenhouse crops, first in Washington, D.C., and later at Beltsville, Maryland. He became Station Head for this group in 1953. His most important contribution during this period was the introduction in 1943 of the insecticidal aerosol for use by greenhouse ornamental and vegetable growers. This resulted in the elimination of many common greenhouse pests and greatly increased the level of control of other pests, resulting in improved crop yields and quality. Also during this period, Floyd saved the gladiolus industry from possible destruction by the gladiolus thrips, which had spread throughout the U.S. and Canada following its introduction in 1929. He discovered that the insect cannot survive out-of-doors in temperate regions but passes the winter in the corms in storage. With his development of effective treatment for the corms, the thrips were effectively controlled.

In 1957 Floyd became an administrator, as Acting Head, Truck Crop and Garden Insects Section, Fruit and Vegetable Insects Research Branch of the Entomology Research Division. Floyd detested administration and gratefully returned to active research in 1958 as Investigations Leader, Ornamental and Greenhouse Crop Insects Investigations (later renamed Vegetable and Ornamental Plant Insects Investigations), where he remained until his 'retirement' in 1970. In 1962, he was the first to report a new leafminer pest on chrysanthemum, and he worked on aspects of the biology and control of this increasingly important pest now known to be *Liriomyza trifolii* for the next 22 years. During this time he also developed the concept of insect repellency using reflective foil mulches.

After his formal retirement, Floyd remained active in research as a Collaborator with the Florist and Nursery Crops Laboratory. He collaborated in biology and control studies on the greenhouse whitefly, rose midge, willow beaked-gall midge, and the periodical cicada. Beginning in 1964, Floyd made a number of trips to El Salvador giving technical assistance to the Government of El Salvador. Working with plant pathologists such as J. P. Meiners, R. H. Lawson, H. E. Waterworth and others, Floyd spent a large part of his retirement identifying the viral problems of Central American crops. The use of sticky yellow panels to monitor or control various greenhouse pests was one of the principal projects of his last years. Floyd remained active to the very end, and was writing manuscripts and planning new studies up to the time of his death.

Besides being an entomologist and a plant pathologist, Floyd was an internationally known acarologist. Floyd's contributions to acarology are documented in some 47 papers. His early work in this area consisted primarily of studies on the biology and control of tarsonemid mites such as the cyclamen mite and the broad mite. However, his most economically significant work was with the two-spotted spider mite. Floyd was the first, in 1949, to find two-spotted spider mites resistant to organophosphate pesticides. He also pioneered the development of integrated biological/chemical methods of controlling spider mites using insecticide-tolerant strains of *Phytoseiulus* and *Typhlodromus* predator mites. In summary, he succeeded, over a 30 year span, in reducing the two-spotted spider mite from a serious threat to the greenhouse industry to a pest that is ever present but readily controlled.

Floyd was an honorary member of the Entomological Society of America, which he served as past president of the Eastern Branch, past chairman, Section C, as Representative to the National Academy of Sciences Division of Biology and Agriculture (1951–1956), and as official ESA delegate to the Eleventh International Congress of Entomology, Vienna, Austria, 1960 (where he was also the official delegate of the American Phytopathological Society). Among his many awards were the USDA Superior Service Award, the Outstanding Achievement Award (now the L. O. Howard Award) from the Eastern Branch, ESA, the William Herbert Medal from the American Plant Life Society, and the Outstanding Research Award from the Foundation for Floriculture of the Society of American Florists.

Floyd was unfailingly polite but firm of opinion. He enjoyed the company of others and attended grower or professional meetings with zest, being constantly engaged in conversation from early morning to late night. He was always busy, but never too busy to help younger scientists or to meet visitors. He was generous with praise and in giving credit to others. His vast store of knowledge, his gentle sense of humor, and his willingness to listen made him a joy to know and an ideal collaborator.

The publication list for Floyd F. Smith has been compiled and totals 337 entries, with Floyd as senior author of 140.

His wife, Dorothy K. Smith, died in 1983. He is survived by his son Dwight and his daughter Margaret, and by seven grandchildren.

Ralph E. Webb, *Florist & Nursery Crops Laboratory, Agricultural Research Service, USDA, Beltsville, Maryland 20705.*

(Remarks read at memorial service, May 12, 1984,
Beltsville Agricultural Research Center.)

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 261–263

I believe—in one way or another—we all had a love affair with Floyd Franklin Smith. I first met Floyd in the late sixties when I was working as a graduate student on forage crop insects at the University of Maryland. I later joined the Agricultural Research Service in 1970 and became increasingly aware of Floyd, mostly through passing conversations, and developed an easy association in 1977 after transferring to the Florist and Nursery Crops Laboratory. It seems terribly ironic to meet a man professionally at an age when most are retired or are deceased. Floyd and I spent a lot of time together discussing the joy we found in entomology, and interestingly enough, we were never destined to publish jointly. I would like to think our association was more that of friends with common interests than of research colleagues.

Floyd was a forty-niner of sorts, a pioneer in the fields of entomology and plant pathology. Floyd's favorite expression to convey the meaning of a significant new finding was to refer to it as a nugget. Floyd's sharp mind and eyes were always on the alert for new nuggets or those overlooked by others. New findings were as important to him as the discovery of a new species by a taxonomist. These nuggets were the treasures of his life.

Floyd's attitude towards insects was simple: "Bet on the bug" he would say. Pressed on the meaning, Floyd would smile, in the way only he could, and tell of the way entomologists 40 years ago were sweating out their futures during the advent of DDT. DDT, it was said, would put many entomologists out of work. The realities of insect resistance certainly changed the concern for entomologists but it also instilled in Floyd a greater respect for insects.

Floyd loved to laugh and tell stories as well as share anecdotes. In recent years he found room in his life to laugh at events in the past which were annoyances or impediments to progress during an earlier time. We all have guidelines or internal mechanisms that we rely on to get us through the tribulations of life. Floyd had humor and laughter and he would gladly espouse the practice to others. His basic recommendation was that vigorous daily exercise of the diaphragm was essential to good mental health. Floyd had a deep hearty infectious laugh, one that would carry the distance and cause others to smile or laugh with him.

Floyd knew well the value of the dollar. He was extremely grateful to have a job with the USDA at Arlington Farms and Beltsville during the terrible depression. Salaries for scientists until recent times were only enough to get by on. There is a record of Floyd as a GS-15 during the sixties receiving $13,700 per annum. How, then, does one send a very bright young son to medical school? This is a story very few know and I think it should be told since it says so much about Floyd's unselfishness. Floyd would drive to turf farms in the evenings and on weekends to collect grubs from cut sod. At home he would inject them with milky spore disease and harvest the grubs 21 days later to be sold to a commercial producer of milky spore disease in Virginia. Floyd and Dorothy both worked on this project and it provided financial resources to help send Dwight to medical school.

One would be inclined to wonder how a very busy man in his fifties would have time to establish a wholesale nursery. The nursery served Floyd well. Floyd would have disagreements on occasion with line management. Bear Garden Nursery was a wonderful outlet to deal with frustration. Floyd once mentioned that he never let personal differences interfere with research goals. Bear Garden also provided an opportunity to perfect grafting skills which were also applied in research. Sales from Bear Garden provided an opportunity to establish a scholarship fund in entomology at Ohio State University. The only vacation Floyd ever admitted to taking from his research program was a week of annual leave in the early fifties to work with Tony Boswell to erect a shed at the nursery. Floyd's favorite conifer was the hemlock and I cannot tell you why.

Floyd always had a long list of research projects that he considered important. These were serious goals and were part of the motivating force and drive that resulted in 14 years of postretirement service to science and the government. Floyd's most recent joy was the arrival of Hiram Larew as a post-doc and now a career scientist with this agency. Floyd has always been troubled with the wealth of unknown information on the dogwood club gall which is a chronic problem in the nursery trade as well as Bear Garden. The arrival of Hiram with a devoted interest in gall insects provided Floyd with an additional incentive to finally chip away at this giant nugget.

To my knowledge there is only one student of Floyd Smith. Ralph Webb will probably share with us some day what it was like to have Floyd as one's supervisor and mentor and how he stood the heat. Floyd obviously selected Ralph as carefully as he selected his research projects and pursued both with equal vigor. We see in Ralph an accomplished scientist in his own right.

Floyd is best known for his devotion to science. His career is characterized by hundreds of publications in diverse areas of entomology and plant pathology. An anecdotal story about Floyd's graduation from Ohio State perhaps hints at his leadership and his strong independent nature. Floyd and George Langford were classmates and scheduled to graduate at the same ceremony. They decided for independent and various reasons not to attend the Saturday graduation rehearsal. It was coincidental that Floyd and George were seated in the front row next to the aisle. At the close of the ceremony, when everyone stood up, Floyd and George took this as the signal to lead the procession of students out of the auditorium and they thus departed up the aisle. It was not until they were outside and saw that they were immediately followed by the Regents, the President and faculty, did they realize what independent steps they had taken. Years later George and Floyd were both to work closely with Maryland nurserymen for several decades and George Langford is with us today.

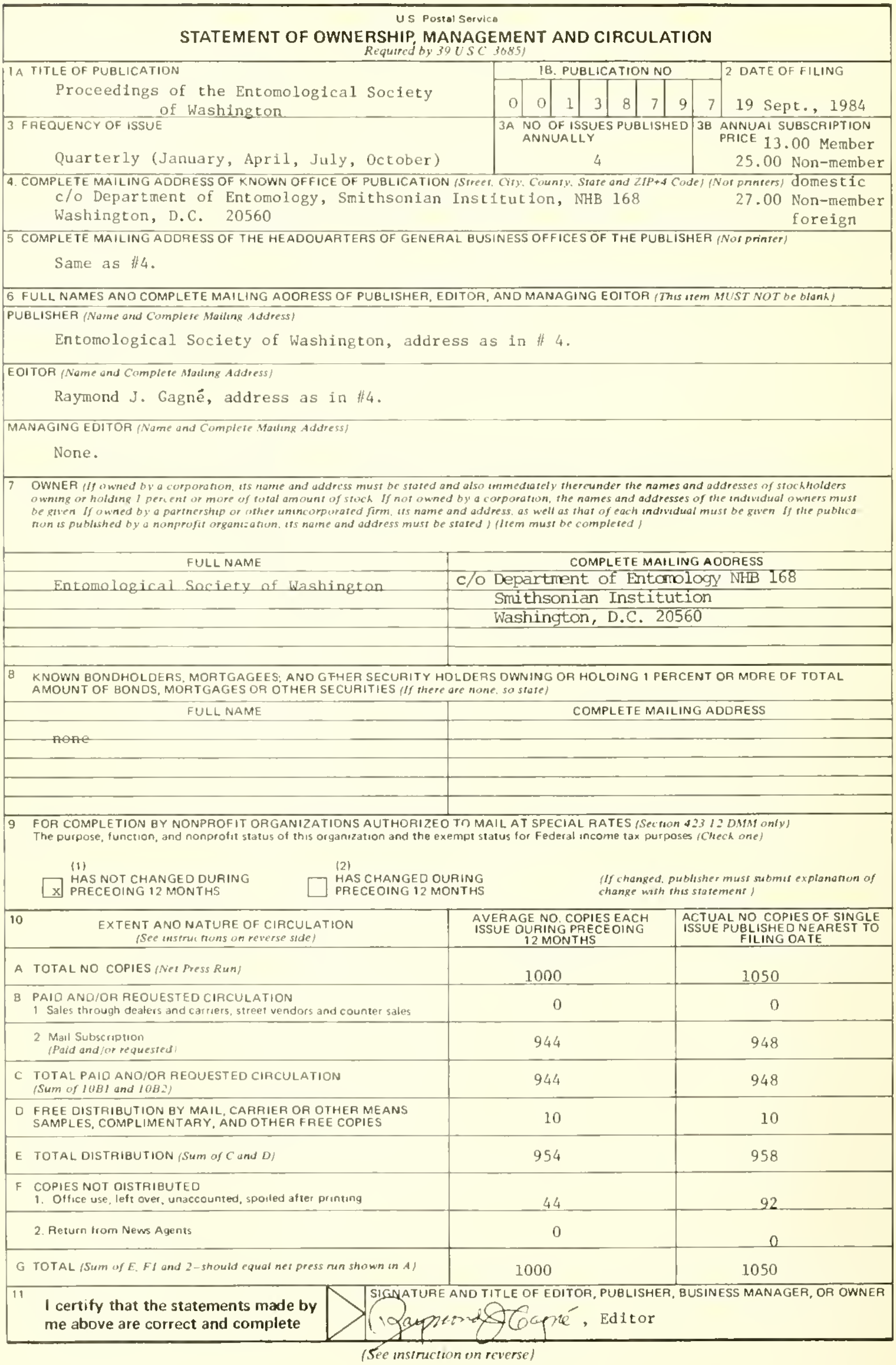
I once asked Floyd which research accomplishments throughout his career he felt the best about, that is, which were his most significant contributions. Floyd's pause was significant. He mentioned his Ph.D. work on the black vine weevil; the discovery of the true cause of hopperburn in potatoes and beans—that it was not a virus as suspected but that the condition was due to mechanical damage and plugging of vascular tissue; he also mentioned finding the first phosphate resistance in two-spotted spider mites. I asked him what, if any, they had in common. He again paused to reflect. He said that they would stand the test of time. I believe this statement would be a fitting epitaph. Floyd—as a loving father, a faithful husband to Dorothy, the quintessential scientist devoted to solving problems and as a friend—has stood the test of time.

Floyd was the first to announce spring to those who worked in Building 470—his address for almost 50 years. Everyone knew spring was at hand when Floyd would put on his battered straw hat, pick up his garden basket and pruning shears, and head off to the willow grove in late February to continue his annual love affair with the willow gall midges. Floyd would always bring pussy willow cuttings back for the secretaries.

Floyd's wealth was in the fundamental freedom to pursue research goals, to make important discoveries and to have these findings become available to the nurseryman and homeowner. Floyd was a unique civil servant; he had a social conscience. Floyd felt strongly that since his career was supported by the taxpayer, it was his obligation to solve problems of practical value.

After Dorothy died, which was a little more than a year ago, Floyd expressed his greatest concern. He said it was always a shock to him to enter a room at home where he would normally expect to see Dorothy and find only emptiness and silence. This bothered him greatly. He said he found great comfort with his friends here at the research center. I am certain Floyd would find some discomfort by what is said of him here today and in the way we hold him in such high esteem. I do hope that what passes here today is of some comfort to the family and friends of Floyd Franklin Smith.

John W. Neal, Jr., *Florist and Nursery Crops Laboratory, Agricultural Research Service, USDA, Beltsville, Maryland 20705.*



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of the
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QUARTERLY

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THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

ORGANIZED MARCH 12, 1884

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All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, c/o Department of Entomology, NHB 168, Smithsonian Institution, Washington, D.C. 20560.

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Please see p. 730 of the July 1984 issue for information regarding preparation of manuscripts.

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HOST ALTERNATION: A NEWLY DISCOVERED ATTRIBUTE OF THE PHYLLOXERIDAE (HOMOPTERA: APHIDOIDEA)

MANYA B. STOETZEL

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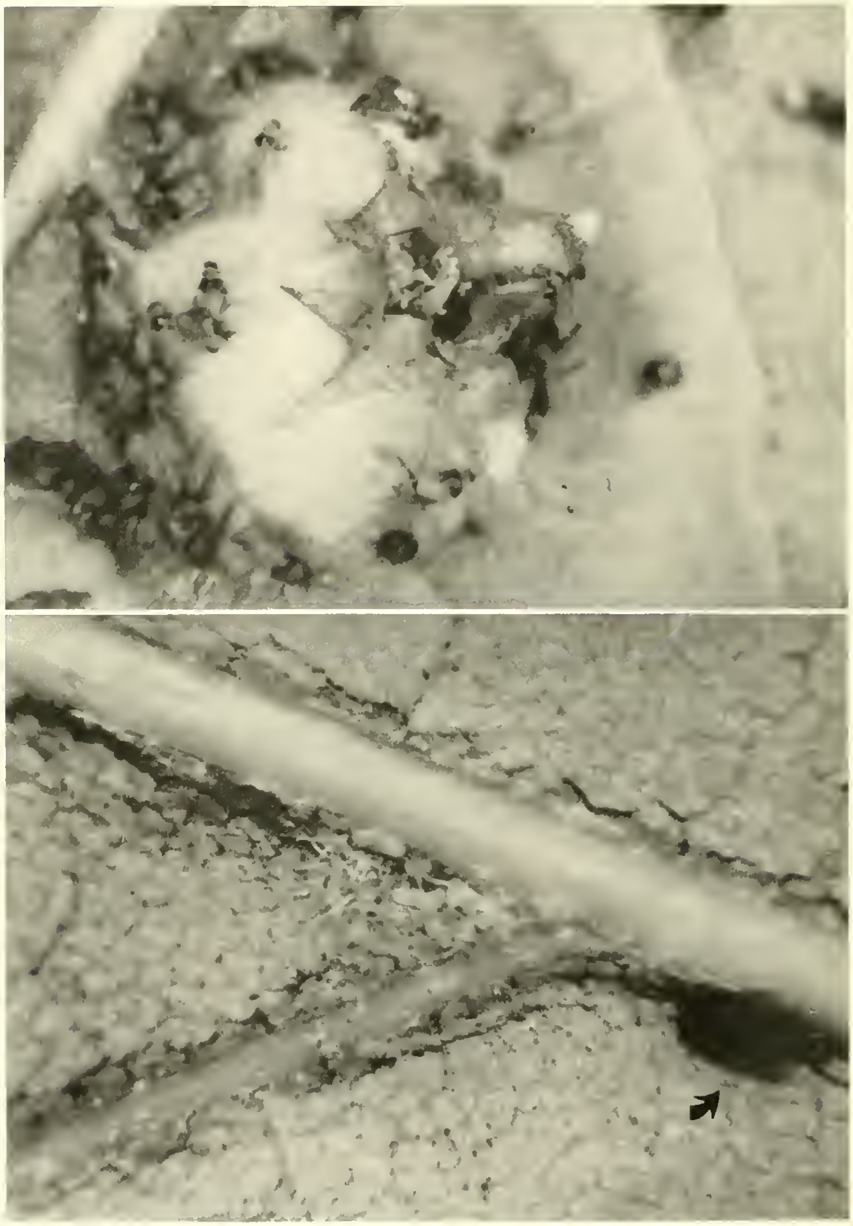
Abstract.—This is the first report of host alternation in the Phylloxeridae from one plant family (Juglandaceae) to another (Fagaceae). A six-year study of *Phylloxera* indicates that *P. texana* Stoetzel and *P. castanea* Pergande exhibit host alternation in their life cycles. In these species of *Phylloxera, Carya* (hickory) is the primary host with the secondary host being a species of *Quercus* (oak) or *Castanea* (chestnut). The Phylloxeridae, Aphididae (aphids), and Adelgidae (adelgids) constitute the superfamily Aphidoidea (Homoptera); and host alternation from one plant genus or family to another is well established in the Aphididae and Adelgidae. However, host alternation from one plant genus or family to another has not been reported or even suspected previously in the Phylloxeridae.

This paper reports for the first time the existence of host alternation in the Phylloxeridae from one plant family (Juglandaceae) to another (Fagaceae). The Phylloxeridae, Aphididae (aphids), and Adelgidae (adelgids) constitute the superfamily Aphidoidea (Homoptera); and host alternation from one plant genus or family to another is well established in the Aphididae and Adelgidae. Eastop (1966) reported that in Europe *Phylloxera florentina* Targioni-Tozzetti alternates between *Quercus ilex* and *Q. robur*, but host alternation from one plant genus or family to another has not been reported or even suspected previously in the Phylloxeridae.

From 1978 to 1984, I conducted a detailed study of the biology and morphology of species of *Phylloxera* on *Carya illinoiensis* (Wang.) K. Koch. (pecan) in Georgia, Louisiana, Oklahoma, and Texas (Stoetzel, 1981). During the study, I followed the development of the life stages from overwintering egg to overwintering egg for three gall-producing species that spend their entire life cycles on pecan in the United States; namely, *Phylloxera devastatrix* Pergande, *Phylloxera notabilis* Pergande, and *Phylloxera russellae* Stoetzel. I also observed a fourth species, *Phylloxera texana* Stoetzel, which exhibited a different developmental cycle.

In the spring, *P. texana* produced galls on pecan leaves; alate females escaped from the galls (Fig. 1), but further development on pecan was not observed, and overwintering eggs were never found. In an attempt to collect eggs, several hundred alate females of *P. texana* were collected from leaf galls and were isolated in small dishes. Only rarely did a female lay an egg, and no eggs hatched. Currently, *P. texana* is known only from the Texas counties of Brazos, Brown, and Menard.

In mid-May 1982 I studied populations of *P. texana* on pecan in Texas. When I isolated alate females from leaf galls in dishes with moistened filter paper or



Figs. 1–2. 1 (top), Alate females of *Phylloxera texana* escaping from gall on pecan leaf. 2 (bottom), Alate female of *Phyloloxera texana*, at arrow, with eggs and first instar nymphs in the tufts of hairs at the intersection of a secondary vein with the midvein on the lower surface of an oak leaf.

with newly formed pecan leaves or with pecan stems, the females died without laying eggs. When I put alate females from leaf galls in containers with leaves from *Quercus falcata* Michx. or *Q. virginiana* Mill., they readily laid many eggs that hatched into feeding first instar nymphs. An intensive check of the leaves of oak trees in the vicinity of the pecan trees resulted in the collection of alate females of *P. texana* laying eggs in the tufts of hairs at the intersections of the secondary veins with the midvein on the lower surface of the oak leaves (Fig. 2). By late May immature stages and a few adult apterous females were found on oak leaves. Development continued on oak with the production of both alate and apterous females were found on oak leaves. Development continued on oak with the production of both alate and apterous females in June. Based on my experience with and knowledge of the developmental cycles of other species of *Phylloxera*, I predict that alate females of *P. texana* return to pecan in the fall and lay eggs that develop into sexual males and females (oviparae), and that, after mating, a sexual female will produce one overwintering egg. My attempts to establish greenhouse colonies of *P. texana* have been unsuccessful; and, since I have not been in Texas during the months of September and October, I have been unable to observe field populations in the fall.

From 1979 to 1984, I studied species of *Phylloxera* on chestnut (*Castanea dentata* (Marsh.) Borkh., *C. mollissima* Blume) and oak (*Quercus alba* L., *Q. palustris* Muenchh.) samples sent to me from West Virginia. From January to June of 1980, I was not able to find overwintering eggs on samples of twigs or branches of either chestnut or oak. The first phylloxerans I observed in samples from these trees were found in early June on the leaves, and they were alate females laying eggs that hatched into feeding first instar nymphs. Several overlapping generations of alate and apterous females were produced throughout the summer months and into September and October when the leaves began to senesce and fall from the trees. No males or overwintering eggs were collected from chestnut or oak; and only one oviparous female was collected, in October 1980, from chestnut. In June 1981 I spent a week in Frametown, West Virginia, looking for overwintering eggs and early developmental forms of phylloxerans on chestnut trees. The first life stage encountered on chestnut leaves were alate females which laid many eggs that hatched into feeding first instar nymphs. During this same period, I collected galls of an undescribed *Phylloxera* from three hickory trees, *Carya tomentosa* (Poir.) Nutt., bordering one of the nurseries containing the chestnut seedlings; and I discovered that the alate females escaping from galls on the hickory trees appeared to be identical, morphologically, with the alate females I was collecting from chestnut leaves. In late September 1981 I again spent a week in West Virginia working in the same chestnut nurseries. I found no sexual forms on the chestnut trees, but I did find solitary alate females laying eggs that were producing sexual males and females on the hickory trees. Overwintering eggs were also found on these hickory trees.

In March 1982, 1–2 year old bare-rooted seedlings of *Carya glabra*, *C. tomentosa*, *Castanea dentata*, *C. mollissima*, *Quercus alba*, and *Q. palustris* were fumigated, planted, and held in a greenhouse for transfer work. In June 1982, pots containing these six plants plus *Rosa* 'Forever Yours' were isolated in 6 cages with 32 × 32 mesh screen. I received samples of leaf galls from one of the *Carya tomentosa* bordering the chestnut nursery near Frametown, West Virginia; and I put these samples into 4 of the 6 cages with the test trees. Additionally, leaf galls were put into a small, isolated greenhouse far removed from the other plants and in which I had put two *Quercus alba*, two *Q. palustris*, four *Castanea dentata*, and four *C. mollissima*. By July it was clearly evident that no phylloxerans were on the *Carya*, *Quercus*, or *Rosa* plants in any of the six cages or in the isolated greenhouse. However, large populations of phylloxerans had developed and were causing discoloration along the veins of the leaves on the chestnuts in the four cages and on all of the leaves of the chestnuts in the isolated greenhouse into which leaf galls from the hickory tree had been placed. None of the chestnut plants outside the cages in the large greenhouse had any phylloxerans on them. In September 1982, I tried to transfer alate females from *Castanea* back to *Carya,* but the transfers were unsuccessful. I conclude that the hickories, for one reason or another, were not acceptable to the phylloxerans. Hickory trees are slow bearing, and I have been unable to obtain nuts from the trees in West Virginia. During 1983 I did not find even one phylloxeran on the 8 chestnut plants in the isolated greenhouse or on the 8 caged chestnut plants in the large greenhouse. The plants survived over winter, leafed out in the spring, and continued to do well throughout 1983 and again in 1984. The phylloxeran population had been very heavy on all of these chestnuts during 1982; and, if sexual males and females and overwintering eggs had been produced, there should have been enough produced to have carried the population into 1983.

This six-year study of *Phylloxera* populations indicates that *P. texana* and *P. castanea* exhibit host alternation. I maintain that in these species of *Phylloxera, Carya* (hickory) is the primary host with the secondary host being a species of *Quercus* (oak) or *Castanea* (chestnut).

In North America, only *Phylloxera castanea* has been reported from *Castanea,* eight species of *Phylloxera* have been reported from *Quercus,* and approximately 50 species of *Phylloxera* have been reported from *Carya* (Haldeman, 1850; Riley, 1874; Pergande, 1904; Ferris, 1919; Duncan, 1922). Only by doing host transfers from *Carya* to *Quercus* and/or *Castanea* and back to *Carya* will it be possible to show relationships of species and to determine which specific names are valid.

LITERATURE CITED

Duncan, C. D. 1922. The North American species of *Phylloxera* infesting oak and chestnut (Hemiptera: Phylloxeridae). Can. Entomol. 54: 275–276.

Eastop, V. F. 1966. A taxonomic study of Australian Aphidoidea (Homoptera). Aust. J. Zool. 14: 550.

Ferris, G. F. 1919. Two species of *Phylloxera* from California (Hemiptera: Aphidae). Entomol. News. 30: 103–105.

Haldeman, S. S. 1850. On four new species of Hemiptera. Am. J. Sci. Arts, 9 (2nd series). 9: 108.

Pergande, T. 1904. North American Phylloxerinae affecting Hicoria (Carya) and other trees. Proc. Davenport Acad. Sci. 9: 187–274.

Riley, C. V. 1874. The American oak *Phylloxera.* Sixth Rpt. Noxious and Beneficial Insects of Missouri. 6: 64–65.

Stoetzel, M. B. 1981. Two new species of *Phylloxera* (Phylloxeridae: Homoptera). J. Georgia Entomol. Soc. 16: 127–144.

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A NEW NEARCTIC SPECIES OF *PHROSINELLA* (DIPTERA: SARCOPHAGIDAE)

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Abstract.—*Phrosinella* ***aurifacies***, n. sp., is described from the Nearctic Region. It is the most common species of the genus in eastern North America but was overlooked because it has been confused with *Phrosinella fulvicornis* Allen. The male genitalia are very uniform and not useful for distinguishing species in this group. Apparently ***aurifacies*** is isolated from sympatric relatives primarily by means of the females' recognition of the male facial pattern rather than by anatomical incompatibilities in the male genitalia.

A previously unrecognized *Phrosinella* is described below to make the name available for the paper by Margery Spofford and Frank Kurczewski, which follows. It is a typical miltogrammine fly (Miltogramminae, Miltogrammini). The morphological terminology is that of the "Manual of Nearctic Diptera, Vol. 1" (McAlpine et al., 1981). The means with standard deviations are each derived from measurements of 13 specimens.

This species exhibits all the principal characters of *Phrosinella* as redefined in a forthcoming revision of the Nearctic Miltogramminae: some whitish hairs present on posterior surface of head below neck; frontal vitta broad, about 4 times as wide as frontoorbital plate halfway from median ocellus to lunule; 2 proclinate and 1 reclinate frontoorbitals; lunule setulate and pollinose; parafacial with scattered minute setulae only; facial ridge without large bristles above vibrissae; vibrissae differentiated and at level of ventral edge of facial plate; third antennal segment 3 or more times length of second; hinge plate rudimentary; palpus orange; prementum short, bulbous and pollinose. Distal section of CuA_1 (beyond crossvein dm-cu) less than half length of basal section; distal half of fore tibia with a loose ventral comb or brush of amber bristles in a longitudinal row (both sexes).

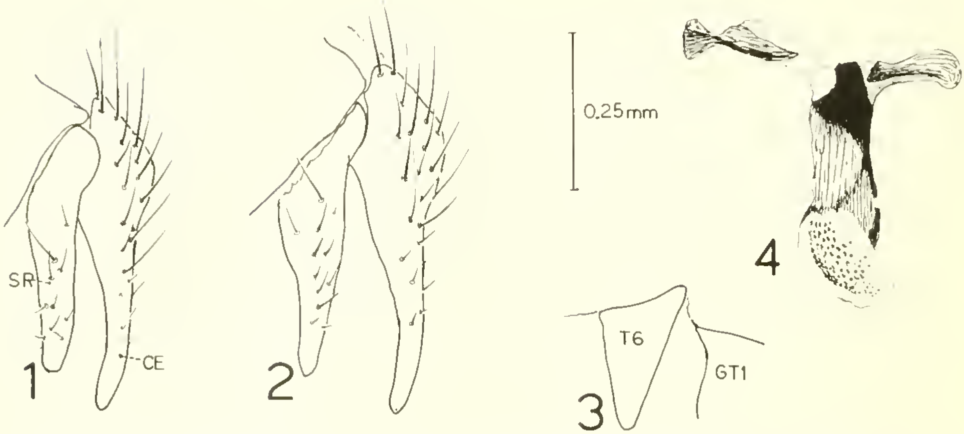
Phrosinella aurifacies, NEW SPECIES

Figs. 1–4

Size.—3.5 to 7.0 mm.

Male.—Frontal vitta, frontoorbital, facial and parafacial plates golden pollinose (vitta sometimes paler to light tan on middle); front at level of anterior ocellus 0.425 ± .012 of head width (holotype, 0.41), at narrowest near antennal base, 0.367 ± .014 (holotype, 0.37); antenna bright orange; arista thickened 0.518 ± .027 of length (holotype, 0.54).

Dorsum of thorax with acrostichal area to most of upper surface tan to brown or somewhat bronze pollinose; lateral edges of scutellum dark tan to brown pol-



Figs. 1–4. 1, *Phrosinella aurifacies,* cercus (CE) and surstylus (SR), lat. view. 2, *Phrosinella fulvicornis,* cercus and surstylus, lat. view. 3, Lateral profile of sixth tergum (T6) and anterior portion of syntergosternum 7 + 8 (GT1) of *Phrosinella fulvicornis.* 4, *Phrosinella aurifacies,* aedeagus (lat. view) with attached duct and pump sclerite. All figures are at same scale; the parts are drawn as if genitalia were spread with the tips of cerci, surstyli, and aedeagus pointing ventrally, and with the fly facing left.

linose (rarely pale); acrostichals, 0:1; dorsocentrals, 2:3; intraalars, 1:1; supraalars, 1:2 (the posteriormost of the usual set of 3 absent or weak); dorsal katepisternals, 2.

Foretibia without or with a very weakly differentiated posterior bristle; foretarsus modified, 2nd segment short, with a loose ventral and somewhat posterior tuft of fine long hairs extending beyond tip of fourth tarsomere; tarsomeres 3 to 5 atrophied (fig. 16, of Allen, 1926); legs black in ground color.

Wing with a faint but distinct clear brownish tinge on middle anterior part of wing (mainly along veins bordering cells sc, r1, r2, r4, br, and dm), rarely absent (?teneral specimens).

Abdominal terga 2 to 4 with 3 rows of blackish spots, lateral spots sometimes faint and those of tergum 4 sometimes confluent at posterior margin.

All sclerotized postabdominal parts blackish, surstyli somewhat paler; sixth tergum usually without setae, occasionally a bristle or two present; sixth tergum at middorsal, posterior edge produced dorsally into a small, distinctive quarter-spherical bump (Fig. 3), separated from syntergosternite 7 + 8 by a considerable length of membrane; surstylus, in lateral view, only slightly tapering from base to tip (Fig. 4); aedeagus of the basic miltogrammine type, without any conspicuously distinctive features (Fig. 4); epiphallus well-developed; pump sclerite unusually small (Fig. 4).

Female.—As male, except frontal vitta and adjacent frontoorbital tan to brown or bronze pollinose; facial plate usually golden pollinose, sometimes very faintly so; parafacial and anterior frontoorbital plates silver-white pollinose; front at level of median ocellus 0.452 ± .012 of head width, at base of antennae 0.450 ± .011; antennae usually orange, 3rd segment sometimes infuscated but not completely black beyond junction area with second segment; arista thickened 0.489 ± .031 of length.

Foretarsomeres dorsoventrally flattened, ventral surfaces of tarsomeres 2–5 covered with very fine, yellowish hairs. Wings not or but very faintly brown-tinged (in same areas as male).

Holotype:—♂, Shiawasee Co., Mich., Rose Lake Conserv. Area, June 11, 1982, Wm. L. Downes Jr., in the U.S. National Museum of Natural History, Washington, D.C.

Paratypes.—187 ♂ & 252 ♀ from the following states and Canadian provinces: Connecticut, Illinois, Iowa, Kansas, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Jersey, New York, Ohio, Pennsylvania, South Carolina, South Dakota, Alberta, Manitoba, New Brunswick, Ontario, and Quebec. A list of paratypes with collection label data is available from the author upon request. Paratypes will be distributed with copies of the collection data list to lenders and to various other institutions after this paper has been published.

The surstylus of males of the closely related *P. fulvicornis* (Fig. 2) taper more obviously in lateral view than the surstylus of *aurifacies* (Fig. 1), but the male genitalia are somewhat variable, and this difference may not hold for all specimens.

The general brown tint of the body of *aurifacies* seems to represent cryptic coloration that enables them to blend in better with the bare, brown sand on which they are usually encountered.

P. aurifacies is the most common and widespread eastern North American species of *Phrosinella*. Apparently, two more or less peripheral populations have differentiated as distinct species from it. One of these is the 'true' *P. fulvicornis* (Coquillett), with which *aurifacies* has previously been confused. *Phrosionella fulvicornis* (in agreement with the holotype in the U.S. National Museum) is conspicuously silver-white in contrast to the tan-brown of *aurifacies*, and the males lack the bright golden head pollen of *aurifacies*. *Phrosinella fumosa* Allen is the second splinter species; it differs from *aurifacies* in having a blackish third antennal segment and prominent wing spots in the male.

Both *fumosa* and *fulvicornis* have much more restricted distributions than *aurifacies*. *Phrosinella fulvicornis* has been collected along the eastern North American seaboard, the eastern shore of Lake Michigan, and in the Medora Sand Dunes in Kansas. *Phrosinella fumosa* is not commonly collected. It has been found in Delaware, Maryland, Virginia, and Michigan.

Both species are also sympatric with *aurifacies*. I have taken *fumosa* in the same sand pit and at the same time with *aurifacies* near Lansing, Michigan. I have also collected *fulvicornis* simultaneously with *aurifacies* a short distance from the seacoast near New Haven, Connecticut and near the shore of Lake Michigan in Berrien Co., Michigan.

Where they occur together (and in eastern United States in general), the males of the three species are readily distinguished, even by naked eye in the field. *Phrosinella fumosa* males have black antennae and wing spots; *aurifacies* males have a golden, and *fulvicornis*, a silver-white face and parafacialium. The wing of male *fulvicornis* lacks the faint brown tinge of *aurifacies*, but occasional *aurifacies* males (which may be teneral) also lack the brown tinge.

The females are less distinct. The usually white frontal vitta of *fulvicornis* females sometimes has a diffuse tan to brown spot on its central region, and the corresponding region in *aurifacies* is sometimes quite pale. However, the color, even when pale, usually spreads well beyond the vitta onto the frontoorbital plate in *aurifacies*, but not in *fulvicornis*. The arista is thickened to a greater extent in *fulvicornis* (0.6 of its length or a little more in both sexes), but there is a little overlap in this measurement. Some eastern females of *aurifacies* have infuscated antennae, but none from that area have antennae as black as those of *fumosa*.

Certain peripheral populations are not as easily classified. Two females from Sioux City, Iowa have very black third antennal segments, and are not included in the paratype series. The males of an excellent series from Prince Edward Island in the Canadian National Collection have quite pale pollen on their heads; it is conceivable that the series is actually *fulvicornis*. These too have been omitted from the paratype series, since their status is not clear.

In a short series of specimens from Nebraska the aristae are thickened to a greater extent than in typical *aurifacies*, and the male 'face' is only pale golden pollinose. While they are thus somewhat intermediate between *fulvicornis* and *aurifacies*, they fit *aurifacies* best, and have been assigned there. In making this judgment, I have assumed that *aurifacies* followed the Missouri River westward; it didn't differentiate there because sibling species weren't present to effect the character displacements found in the sympatric populations elsewhere.

While the male genitalia have been given special prominence in species discriminations in the Sarcophagidae, they are of little practical use in *Phrosinella*. In this respect *aurifacies* and its relatives are remarkably like the picture-winged drosophiloids of Hawaii (Kaneshiro, 1952): the males have conspicuous external differences, the male genitalia are very uniform, and the species have a courtship (see the following paper by Spofford & Kurczewski). *Phrosinella* fumosa even has pictured wings! This contrasts strikingly with many Sarcophaginae or *Eumacronychia* (Miltogrammini) in which the flies are externally very uniform but have very distinctive genitalia—just as in the scaptomyzoid drosophilids!

LITERATURE CITED

Allen, H. W. 1926. North American species of two-winged flies belonging to the tribe Miltogrammini. Proc. U.S. Natl. Mus. 68(9): 1–106, 5 pls.

McAlpine, J. F., B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood (eds.). 1981. Manual of Nearctic Diptera, Vol. 1. Ottawa, Ontario; Biosystematic Research Institute. Agriculture Canada. vi + 674 pp.

Kaneshiro, K. Y. 1952. Phylogenetic relationships of Hawaiian Drosophilidae based on morphology. Pp. 102–110. *In* Patterson, J. T. and W. S. Stone, eds. Evolution in the genus *Drosophila*. New York; the Macmillan Company. [vii] + 610 pp.

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COURTSHIP AND MATING BEHAVIOR OF *PHROSINELLA AURIFACIES* DOWNES (DIPTERA: SARCOPHAGIDAE: MILTOGRAMMINAE)

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Abstract.—The behavior of males and females of *Phrosinella aurifacies* Downes leading to courtship and mating is described and sequenced chronologically. Both sexes leave the surrounding vegetation in the morning and congregate near aphid colonies to obtain honeydew. Male-male confrontations include facing-off, sidling clockwise or counterclockwise, back-mounting and crawling-over, and trailing and chasing (often involving many males in tandem) flights. Male-male interactions intensify as the females become more abundant. Male-female interactions include facing-off, male wing scissoring; ovipositor rubbing/licking, back-mounting, and trailing, "yo-yo" and "roller coaster" flights. The behavior resulting from the male-male contacts may serve to decrease aggression and space the males, whereas that between male and female is invariably oriented toward copulation and insemination.

The genus *Phrosinella* contains six described Nearctic species: *aldrichi* Allen, *fulvicornis* (Coquillett), *fumosa* Allen, *pilosifrons* Allen, *talpina* Reinhard and *aurifacies* Downes in America north of Mexico (Downes, in Stone et al., 1965; Downes, 1985). *P. aurifacies* is a common eastern species which has been confused with *P. fulvicornis* until recently. The bright golden pollen of the facial and frontal areas and the bright orange antennae distinguish the males of *P. aurifacies* from all other congeners. The females usually differ from those of other species in having a tan to bronze pollinose frontal vitta with the color usually spreading well out onto the frontoorbital plate. The females of *P. aurifacies* are not always separable from those of *P. fulvicornis* (Downes, 1985).

Little is known of the ethology of *Phrosinella* spp. The adults occur on sandy or gravelly soils with sparse vegetation. Females are usually seen flying near the ground in an irregular, gyrating pattern that appears to be a search flight. They are able to find closed wasp nest entrances, at which they dig and larviposit. They may also enter "wasp-sized" holes (Allen, 1926; Evans, 1970; Peckham, 1977). Nothing has been reported of the male activity and mating behavior of members of this genus (Downes, 1983, pers. comm.).

ECOLOGY

Adults of *P. aurifacies* have several generations per year in upstate New York, based upon our rearings. They occur from mid-May through mid-October. We observed this species at three sites near Auburn, Cayuga County, and one near Chittenango, Madison County, during 1982 and 1983. The four sites, each comprised of sand or fine gravel with sparse herbaceous vegetation, were surrounded by either cottonwoods, locusts, or willows (Auburn), or, a hardwood swamp and a red pine plantation (Chittenango).

Males left the surrounding fields in early morning to congregate in open areas beneath white sweet clover (*Melilotus alba* Desr.) and cottonwood (*Populus deltoides* Marsh.). During late May and early June 1982, rainy periods dampened male activity and delayed female emergence. On sunny days the males were active from 0830 to 1840 h, and the females from 1000 to 1630 h (EDT). Both sexes reduced their activities during midday (1200–1400 h) when sand surface temperatures exceeded 45°C. Although sand surface temperatures varied from 26° to 62°C, most fly activity occurred between 35° and 40°C. In 1983 when sand temperatures in the sun reached 61°C, flies moved to the shade of the cottonwoods where surface temperatures were only 41°C. As the temperature increased, fly activity on vegetation intensified. With decreased sunlight and temperature, the flies moved back to the sand surface.

BEHAVIOR

Male interactions (Fig. 1).—*Male emergence:* The first males emerged on 17 May 1982 and 25 May 1983. They alternated resting motionless with searching for honeydew on the sand and low vegetation. While searching on the ground, the flies walked circuitously and sinuously. On vegetation, the males searched the leaf circumference and walked up and down the stems, repeatedly licking the substrate with their mouthparts. Recently emerged males spent much time on vegetation near aphid colonies.

Sand grain manipulation: Shortly after emerging and inspecting plants nearby, the males walked down from the vegetation to the ground beneath the aphid colonies and began to manipulate sand grains, interspersed with circuitous searching on the sand surface. A searching male extended his mouthparts to the sand grain, lifted it between his foretarsi and labella, and rolled it between the brushes on his foretarsi by alternately rubbing each leg forward over the grain. He then dropped the grain and stroked his mouthparts with his foretarsal brushes 2–3 times. This process was repeated 3–8 times within a 4 cm^2 area. A male then flew 5–10 cm away and repeated this manipulation. One male was seen manipulating a dead aphid that lay on the sand under the colony. Older males alternated sand grain manipulation with flights onto low vegetation.

Male-male encounters: During the sand grain manipulations and searching behavior, encounters between conspecific males were commonplace, resulting in bilateral tolerance, sidling or circling, face-offs, back-mounting and crawling over, trailing and/or chasing flights. Recently emerged males allowed one another to remain nearby for many minutes. Further intermale meetings led to rotating together on the ground by both males within a 4–10 cm^2 area. The males aligned themselves laterally, head to tail, and sidestepped clockwise or counterclockwise for 3–10 sec. Sometimes one male circled a motionless second male. Such maneuvers might then give way to any of the other above-mentioned behaviors.

As the males became more aggregatory, they approached one another and then

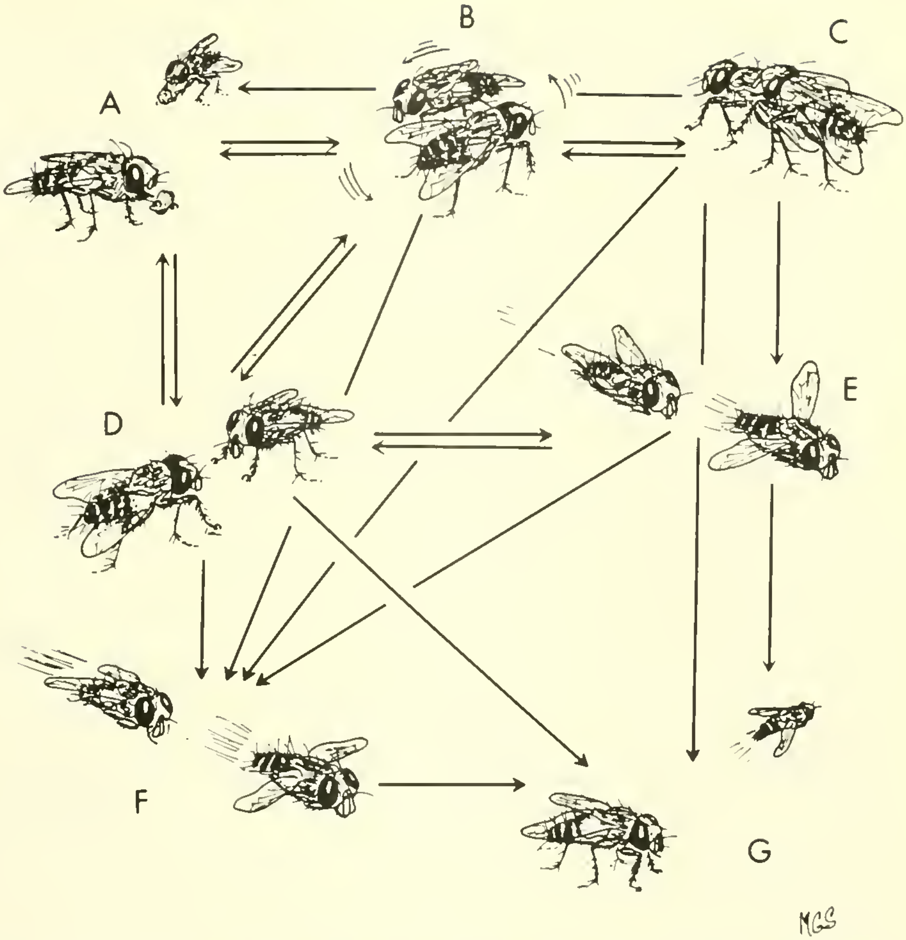

Fig. 1. Male-male encounters. A, Sand grain/vegetation manipulation (honeydew feeding). B, Sidle: two individuals walk clockwise or counterclockwise about a fixed spot. C, Back-mount/crawl-over. D, Face-off. E, Trailing flight: two or more males fly in tandem. F, Chasing flight: one male rapidly chases another. G, Separation of two males.

stood motionless face-to-face for 2–5 sec. Such face-offs may serve in sexual recognition because males had brilliant golden pollinose fronses, in contrast with tan to bronze fronses of females. Male face-offs culminated in either tolerance, feeding, back-mounting and crawling over or trailing/chasing flights. Back-mounts/crawl-overs invariably involved larger males approaching motionless smaller males from the rear, mounting them and either remaining there for 1–2 sec, or crawling over and dismounting at the opposite end.

Older males became increasingly less tolerant and chased one another in flight. This decrease in tolerance coincided with the emergence and increase in the number of females. Individual flights of males lasted 1–5 sec, attained heights of 10–30 cm for distances of 15–200 cm, and were repeated 3–16 times for a total flight time of 10–90 sec. As the fly population increased, these flights involved

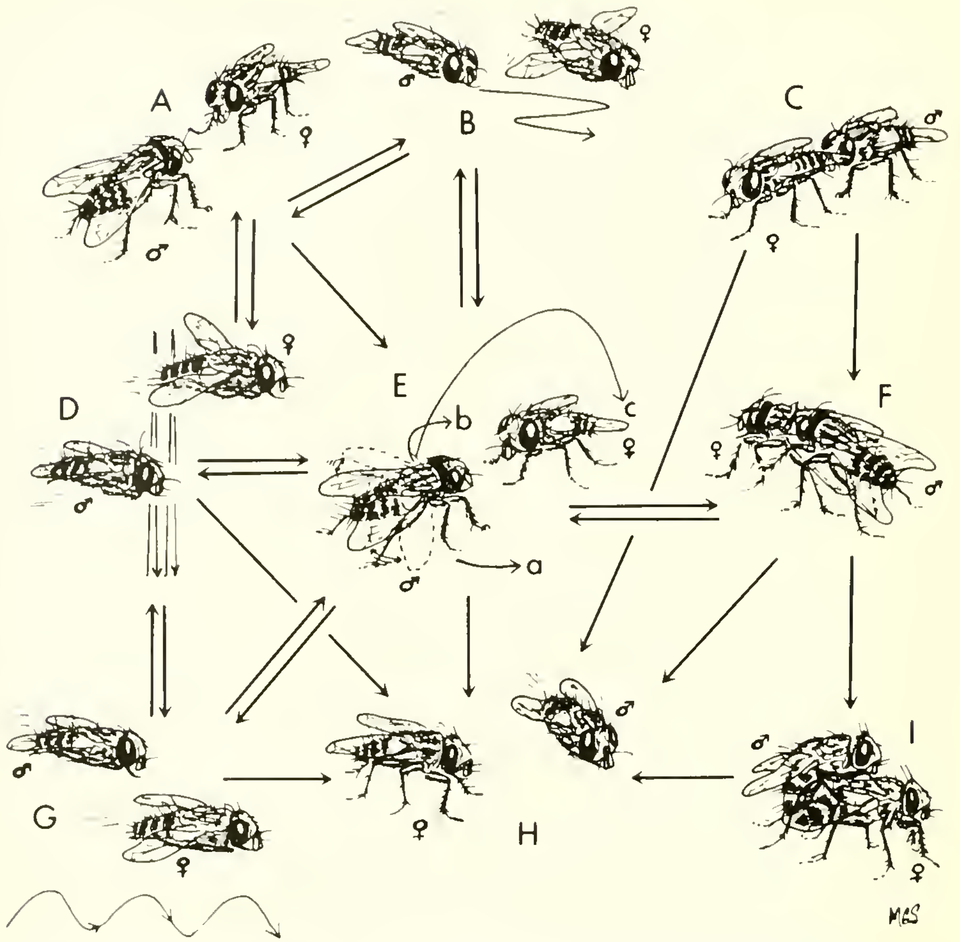

Fig. 2. Male-female encounters. A, Face-off. B, Trailing flight: male often makes zigzag flight beneath female. C, Ovipositor licking. D, Yo-yo flight: male always remains slightly below female as they both fly vertically up- and downward. E, Wing-scissoring: male scissors wings horizontally at any or all orientations (a, b, c). F, Back-mount. G, Roller coaster flight: male trails female, below her on upward portion and above her on downward portion of flight. H, Separation. I, Copulation.

as many as five males in tandem. Such flights often terminated when one or more males flew through vegetation. Some intermale encounters resulted immediately in chasing flights.

Male-female interactions (Fig. 2).—*Female emergence:* The first females of *P. aurifacies* emerged on 21 May 1982 and 6 June 1983. They walked circuitously, flew short distances, lowered their heads and paused motionless on the sand. Females focused their activities near low vegetation (*Melilotus alba, Taraxacum* sp., *Fragaria* sp.).

Male-female interactions involved elaborate courtship displays observed 95 times when sand surface temperatures were 26° to 49.5° ($\bar{x}$ = 37°) C. The bisexual displays progressed from wing-scissoring (Spieth, 1974) through trailing flights, finally, to so-called "yo-yo" and/or "roller coaster" flights.

Wing-scissoring: As a male approached a female from the front the pair paused motionless on the sand in a face-off. The male then oriented his body 45°–60° from a face-to-face alignment with hers while rapidly scissoring both wings simultaneously and horizontally for 2–5 s. During wing-scissoring a male's body sometimes waggled vigorously. A male then flew to the opposite side of a female and wing-scissored. Such bouts were repeated 3–8 ($\bar{x} = 5$) times in rapid succession, after which a male flew over and landed facing the posterior end of a female's abdomen. He either recommenced wing-scissoring, or, walked toward her and rubbed his antennae and licked with his mouthparts on her terminal abdominal segment (ovipositor?) for 1–3 ($\bar{x} = 2$) s, flew over her, landed face-to-face and repeated this sequence 1–3 times within 5–120 ($\bar{x} = 10$) s.

Some males, rather than flying over the female, sidled posteriorly across the sand, always facing her, in order to approach her from the rear. Such a male then walked toward the female and rubbed his antennae on her terminal abdominal segment. He then backed away, flew over her, landed and faced her, and recommenced his wing-scissoring.

Trailing flights: The sequence of wing-scissoring displays exhibited by a male induced a female to fly 50–250 ($\bar{x} = 75$) cm to another bare sand area, trailed 3–10 ($\bar{x} = 5$) cm by a male. Flights (N = 42) varied from 5–60 ($\bar{x} = 20$) cm in height and took 1–5 ($\bar{x} = 3.5$) s. Wing-scissoring by a male recommenced and the entire sequence was repeated.

"Yo-yo" flights: "Yo-yo" flights were elaborations of the trailing flights with a male trailing a female. Pairs (N = 36) rose repeatedly 10–40 ($\bar{x} = 25$) cm above the surface and returned to the ground from 2–9 ($\bar{x} = 4$) times in 1–6 ($\bar{x} = 2$) s, interspersed with motionless pauses of 4–20 ($\bar{x} = 6$) s or wing-scissoring. A high-pitched buzz was emitted during these and the following type of flight, but it was not ascertained which of the pair, if not both, produced the sound. Longer pauses between "yo-yo" flights occurred early in the morning (0835–0920 h) during cooler temperatures. Often, as a pair flew downward to within 5 cm of the ground, a male flew zigzag beneath a female, as though attempting to make contact with her.

"Roller coaster" flights: "Roller coaster" flights, too, were elaborations of the trailing flights, occurring usually as the sand temperatures increased. A male and female undulated in flights that ranged from 10–50 ($\bar{x} = 30$) cm above the substrate for 2–4 ($\bar{x} = 3.5$) min without landing. Sometimes during the flight the female assumed a stationary hover, 25–35 cm above the sand, for 4–7 ($\bar{x} = 6$) s, whereupon the trailing male flitted from side-to-side at 0.5–1 s intervals at a position 2–3 cm behind her. Such flights were terminated by a female landing first on the sand or leaves/twigs of nearby vegetation. A male followed and immediately commenced wing-scissoring. If he lost sight of the female when she resumed her flight, he returned to the last wing-scissoring station. The female then sallied past the male, which flew upward and followed in another "roller coaster" flight.

Many of these courtship displays terminated with either a female flying through vegetation and thereby eluding a male, the pair landing well separated, or, with the interference activities of other males. Rarely, a male lost interest in a female and flew away without any obvious external interference.

Copulation: Four copulations (1982: May 26, 1530 h, 41°C; June 9, 1650 h, 44°C; and 1983: June 16, 1420 and 1425 h, 41°C) began with antennal/mouthparts-ovipositor(?) rubbing/licking, wing-scissoring, and "yo-yo"/"roller coaster" flights. Three others (1982: June 8, 1000 h, 28°C; June 10, 1020 h, 32°C; June 18, 1004 h, 29°–30°C) were observed in progress. After the "yo-yo" or "roller coaster" flights over bare sand some females flew to moderately vegetated sand, followed by a male. The male proceeded to wing-scissor vigorously, sidle to the rear of the motionless female, climb atop her and bend his abdomen under hers. Two such copulations lasted 3 and 5 min, with individual couplings of 5–90 ($\bar{x} = 47.5$) s. Once coupled a pair made slow, ca. 30-cm-long, flights interspersed with 5–10 s pauses, over bare sand 1–4 m away.

One pair of *P. aurifacies* on damp, shaded sand was disturbed during copulation. The male struggled for 10 s to escape the genital hold of the female, which remained motionless on the substrate during all of the male's thrashings and twistings. The male eventually flew away, after which the female continued her motionless stance. She was collected in a plastic film canister, but when the canister was opened inside of an insect net, the female made no attempt to fly upward. She was dumped into the net whereupon she remained motionless. Placed in a vial, 10 min after copulation, she still had not resumed activity, appearing to be in a state of catalepsy.

On June 18, 1982 on damp bare sand, one male mounted a female and held his body at nearly a 45° angle to her dorsum with his abdomen distinctly curved under hers. The pair remained in this position for several min during which the male held the female's wings inward and almost parallel to each other with his mid- and, sometimes, forelegs. The male's wings were held backward in a "V" position. Sometimes his forelegs rested on the dorsum of her pro- or mesothorax or atop her wings. His hindlegs grasped the substrate. All of the female's legs were on the substrate, except when she used her fore- and hindlegs for cleaning.

Eight times, at intervals of 2–8 min, the male stroked the sides of the female's wings and body with his fore- and/or midlegs, usually rubbing one side at a time. The female responded by moving her hindlegs over the edges of her wings and then rubbing the underside of her abdomen with them. Then she cleaned her face, including eyes, by moving her head in clockwise and counterclockwise directions while brushing with her forelegs. She then cleaned her mouthparts with the forelegs. The male readjusted his mount on the female four times and rhythmically moved his abdominal segments.

The pair made three flights *in copulo* that were 10, 100 and 300 cm long. Each time the pair landed on an elevated ridge and, prior to take-off and after landing, the pair assumed a horizontal rather than angular posture with the male atop the female.

After 26 min of coupling, the female kicked her hindlegs alternately for 30 s, seemingly pushing upward on the underside of the male's abdomen. The male responded by cleaning his face and mouthparts with his forelegs, then lowered himself to the horizontal position. The male disengaged, dismounted and cleaned his head and mouthparts with his forelegs. The female cleaned her head and wings, then flew a few centimeters away. She made three several centimeter-long flights, pursued by the male. The male and female then made one trailing flight; he approached her twice and attempted to mount her from the rear, but both times she sidestepped him. She then flew away, and he flew off in a different direction.

DISCUSSION

Nothing has been reported on male activity or mating behavior in the Miltogramminae. No sarcophagid, and possibly no calyptrate, is known to exhibit ritualized courtship (Downes, 1984, pers. comm.). Oldroyd (1964) notes that general behavioral patterns are repetitive throughout the Diptera. Therefore, an attempt has been made to associate references based upon the described behaviors of other fly species with those observed in this study for *Phrosinella aurifacies.*

Shortly after emergence, adults of *P. aurifacies* congregate to feed upon honeydew. They spend the night in the surrounding fields and leave in the early morning where they localize beside or beneath the aphid colonies. Downes (1983, pers. comm.) has also observed this species and *Gymnoprosopa milanoensis* Reinhard (Miltogramminae) feeding on honeydew. Sugar consumption by *P. aurifacies* males and females is obligatory because Miltogramminae need high concentrations of sugars to carry out their life activities (Downes, 1983, pers. comm.). *P. aurifacies* males manipulate honeydew-covered sand grains between their labella and foretarsal brushes, drop the grains, and then lap the brushes with their labella. A pheromone may be distributed by the male's foretarsal brushes. Honeydew so augmented could conceivably be used to attract conspecifics to feeding sites and thus assemble potential mates.

Because the males of *P. aurifacies* emerge first, they must wait in the area for the females. In many calyptrates and, perhaps all Sarcophaginae, the males congregate at station markers (Downes, 1983, pers. comm.). In *P. aurifacies* the males await female emergence in the area near honeydew. The females emerge, feed on honeydew, mate, and then oviposit/larviposit on the appropriate hosts. Thomas (1950) found that certain sarcophagids occur regularly at specific sites. He believes that particular environmental factors, perhaps food, limit a species to a locale and thus facilitate the meeting of the sexes.

Males of *P. aurifacies,* upon emergence, congregate at honeydew sites and, as their numbers increased, male-male encounters increase. Downes (1983, pers. comm.) has also noted that an abundance of males in a small area results in much chasing activity by virtue of "chain reactions" in which a single male leaving his perch induces others to follow. The station-taking territoriality (lekking) described for Hawaiian Drosophilidae (Spieth, 1952) was not evident in *P. aurifacies,* although males became more aggressive after female emergence.

Morphological sexual dimorphism exists in *P. aurifacies.* The males possess reduced foretarsi with foretarsal brushes and brightly pollinose fronses. Many families of more primitive dipterans, e.g., Culicidae, Dolichopodidae, Sepsidae, and Drosophilidae, contain species which also exhibit sexual dimorphism (Oldroyd, 1964). Spieth (1952) states that species of Hawaiian Drosophilidae not only possess a variety of morphological dimorphisms, e.g., on the foretarsus, -tibia and -femur, but also accompanying pigmentation dimorphisms involving the mouthparts, face, antennae, wings and legs. Each male dimorphism "is involved in the male's courtship behavior" (Spieth, 1952).

No sarcophagid is known to depend on visual patterns to discriminate a mate from an unsuitable one at close range (Downes, 1983, pers. comm.), but the bright golden pollinose frons of male *P. aurifacies* appears to function as a visual cue during stationary face-offs. After a male-male face-off, the males either return to feed, back-mount or crawl over, or one male chases the other away. After a male-female face-off, the male invariably commences courtship with wing-scissoring.

Elaborate male courtship displays are unknown for sarcophagids or calyptrates (Downes, 1983, pers. comm.), yet such precopulatory displays occur in other dipterans, e.g., mating flights in Sepsidae and Piophilidae (Oldroyd, 1964). Rau (1937) notes males and females of *Ptecticus trivittatus* Say (Stratiomyidae) hovering above garbage heaps during courtship. In addition, males of Piophilidae (Oldroyd, 1964), Drosophilidae (Brown, 1966; Spieth, 1952, 1974, 1978), and *Phrosinella fumosa* Allen (Downes, 1983, pers. comm.) circle 360° in hovering flights around a stationary female.

Wing waving is common among acalyptrates, and many males have conspicuously marked wings used to attract attention (Oldroyd, 1964). Such wing displays, which are a prerequisite to mating, may be visual and/or auditory and may involve one or both wings simultaneously, as in Drosophilidae (Brown, 1966; Bennet-Clark and Ewing, 1970; Spieth, 1952, 1974, 1978). In species where sound is the major element in mating, wing vibrations generate a species-specific sound during the wing upstroke, which the females sense with their antennal aristae (Bennet-Clark and Ewing, 1970).

In *P. aurifacies*, both wings scissor simultaneously and horizontally to the substrate. Often a male of *P. aurifacies* interrupts the scissoring to rub his antennae and lick with his mouthparts on the female's terminal abdominal segment (ovipositor?). Chemicals are known to function as precopulatory stimuli in the acalyptrates, e.g., females of *Sepsis* (Sepsidae) emit an odor that can be detected by humans (Oldroyd, 1964), and males of *Drosophila melanogaster* Meigen lick a female's ovipositor for species recognition (Spieth, 1952, 1974, 1978). *P. aurifacies* males may recognize a female in this manner.

An unreceptive (immature or already mated) female *P. aurifacies* eludes a male by flying through low vegetation. On the other hand, a receptive female may initiate trailing, yo-yo, or roller coaster flights. On occasion, when a male loses sight of a female, he returns to his last wing-scissoring station, and she sallies past him, perhaps indicating her receptivity. We found no mention of such behavior for any other fly species. *Drosophila* females exhibit acceptance by wing and/or genital spreading, ovipositor extrusion, or dancing (Brown, 1966; Spieth, 1974).

Aerial capture for mating is common but not universal in the Sarcophaginae (Downes, 1983, pers. comm.) and many other Diptera (Rau, 1937; Oldroyd, 1964). Moradeshaghi and Bohart (1968) state that *Euphyto* (= *Euphytomima*) *nomiivora* (James) males may either pounce directly from the air or land nearby and then jump on a female's back. Saccá (1964) states that, in *Musca*, "the union of the two sexes never takes place while flying." Similarly, in all sexual contacts by *P. aurifacies*, a male follows a female to the substrate and then climbs on her dorsum from the rear. The copulatory position assumed by *P. aurifacies* is similar to the median ventral position (Richards, 1927) of *Sarcophaga* sp. (Thomas, 1950), *Musca domestica* (Saccá, 1964), *Drosophila* spp. (Brown, 1966; Spieth, 1974, 1978), and *E. nomiivora* (Moradeshaghi and Bohart, 1968).

During copulation, a male of *P. aurifacies* periodically strokes a female's wings and body with his fore- and midlegs. His foretarsal brushes may play a part in this aspect of the courtship. The female responds by rubbing her own wings and abdomen with her hindlegs. Few accounts of other copulatory behavior have been recorded for dipterans. A *Ptecticus trivittatus* female, which assumes a position dorsal to the smaller male, caresses a male's frons and eyes with her forelegs; he responds by licking her legs with his proboscis (Rau, 1937). Moradeshaghi and Bohart (1968) make no mention of male behavior in *Euphyto nomiivora,* but state that a female intermittently stretches her legs and buzzes her wings during copulation. Males of *Musca domestica* caress a female's frons with their labella and, if she is receptive, she extrudes her ovipositor. If a *M. domestica* female is unreceptive, she kicks the male's wings with her midtibiae. *P. aurifacies* females exhibited similar behavior.

Copulation in *P. aurifacies* lasts from 3 to 26 min. Similar durations have been noted for *Euphyto nomiivora* (Moradeshaghi and Bohart, 1968). Downes (1983, pers. comm.) and Thomas (1950) state that, in Sarcophaginae, copulations last from as little as 4–5 min to over 4 h, but the shorter copulation times are atypical. According to Downes, copulations of short duration occur in species with enormous sperm pumps. He states that *Phrosinella* has one of the smallest sperm pumps in the family; therefore, the shorter copulations we observed in *P. aurifacies* may actually represent pseudocopulations (see Saccá, 1964). Moradeshaghi and Bohart (1968) report that a male of *E. nomiivora* will bend the end of his abdomen and attach it to a female's genital area to prevent successful approaches by other males. Such a pair, when disturbed, can separate immediately. Pairs *in copula* cannot be separated. Saccá (1964) states "the insemination reaction, consequent to the ejection of the spermatozoa into the vaginal sacs of *Musca domestica,* causes swelling of the latter, so at this moment the two sexes cannot part." This is probably true for *P. aurifacies* since one male was observed struggling to free himself from a female when interrupted *in copula.*

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LITERATURE CITED

Allen, H. W. 1926. North American species of two-winged flies belonging to the tribe Miltogrammini. Proc. U.S. Natl. Mus. 68: 1–106.

Bennet-Clark, H. C. and A. W. Ewing. 1970. The love song of the fruit fly. Pp. 180–187. *In* Eisner, T. and E. O. Wilson, eds., The Insects. Sci. Amer. W. H. Freeman and Co., San Francisco.

Brown, R. G. 1966. Courtship behaviour in the *Drosophila obscura* group. 2. Comparative studies. Behaviour 25: 281–323.

Downes, W. L. 1965. Sarcophagidae. Pp. 933–961. *In* Stone, A. et al. A Catalog of the Diptera of America North of Mexico. U.S.D.A. Agric. Handbk. No. 276. iv and 1696 pp. Washington, D.C.

———. 1985. A new nearctic species of *Phrosinella* (Diptera: Sarcophagidae). Proc. Entomol. Soc. Wash. 87: 269–272.

Evans, H. E. 1970. Ecological-behavioral studies of the wasps of Jackson Hole, Wyoming. Bull. Mus. Comp. Zool. 140: 451–511.

Moradeshaghi, M. J. and G. E. Bohart. 1968. The biology of *Euphytomima nomiivora* (Diptera: Sarcophagidae), a parasite of the alkali bee, *Nomia melanderi* (Hymenoptera: Halictidae). J. Kans. Entomol. Soc. 41: 456–473.

Oldroyd, H. 1964. The natural history of flies. W. W. Norton and Co., Inc., New York. xiv + 324 pp.

Peckham, D. J. 1977. Reduction of miltogrammine cleptoparasitism by male *Oxybelus subulatus* (Hymenoptera: Sphecidae). Ann. Entomol. Soc. Am. 70: 823–828.

Rau, P. 1937. Notes on the courtship and mating of the fly, *Ptecticus trivittatus* Say. Psyche 44: 141–142.

Richards, O. W. 1927. Sexual selection and allied problems in the insects. Biol. Rev. 2: 298–360.

Saccá, G. 1964. Comparative bionomics in the genus *Musca.* Ann. Rev. Entomol. 9: 341–358.

Spieth, H. T. 1952. Mating behavior and evolution of the Hawaiian *Drosophila.* Pp. 94–101. *In* Patterson, J. T. and W. S. Stone, eds., Evolution in the genus *Drosophila.* The Macmillan Co., New York.

———. 1974. Courtship behavior in *Drosophila.* Ann. Rev. Entomol. 19: 385–405.

———. 1978. Courtship patterns and evolution of *Drosophila adiastola* and *Drosophila planitibia* species subgroups. Evol. 32: 435–451.

Thomas, H. T. 1950. Field notes on the mating habits of *Sarcophaga* Meigen (Diptera). Proc. R. Entomol. Soc. Lond. (A) 25: 93–98.

PROC. ENTOMOL. SOC. WASH.
87(2), 1985, pp. 283–307

THE GENUS *CELAENEPHES* SCHMIDT-GÖBEL: CHARACTERISTICS, SPECIES, AND RELATIONSHIPS (COLEOPTERA: CARABIDAE: LEBIINI)

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Abstract.—Based on structural features of adults, the Indo-Australian *Celaenephes* Schmidt-Göbel (type-species: *C. parallelus* Schmidt-Göbel, 1846) is included in a monobasic subtribe, Celaenephina, postulated to be the most ancestral of the known extant subtribes of Lebiini. Apotypic features of the Celaenephina include: lateral areas of elytra and ventral surface of body with a sparse vestiture of short setae; front and middle trochanters and stylomere 2 of the ovipositor each with unusually long setae; ventral surfaces of antennomeres 4–11 each with an ovoid pit containing numerous sense organs; left mandible without a terebral tooth, but with an anterior retinacular tooth; maxillary galeomere 2 with setae apically; labium with paraglossae broad, broadly adnate to glossal sclerite, and anterior margins truncate; metathoracic wing with shortened oblongum cell; and abdominal tergum VIII and sternum X markedly sclerotized. Alternatively, interpretation as apotypic of the seemingly plesiotypic features of body color, tarsi, pronotal shape, ovipositor, and male genitalia, plus the apotypic feature of setation of the elytra and the front coxal cavities possibly secondarily uniperforate, form the basis for considering *Celaenephes* as a close relative of the subgenus *Cymindis* Latreille. In addition to the type species, *C. parallelus* (junior synonyms, *C. foersteri* Bouchard, 1903 and *Fukuchina sanadai* Habu, 1960; range, the Indian sub-continent eastward to northeastern Australia, and northward through the Philippine Islands and Taiwan to the Japanese Archipelago), the genus includes *C. linearis* (Walker) (junior synonyms, *Taromorpha alternata* Blackburn, 1894 and *C. rechingeri* Csiki, 1915; range, Sri Lanka and India eastward through Burma, Indo-China and the Indo-Australian Archipelago to Australia, New Caledonia, the Solomon Islands and Samoa, and northward through the Caroline and Philippine Islands to the Ryukyu Archipelago). Adults of the two species are distinguished from one another by differences in color of appendages, details of the elytral surface, and form of the apices of the elytra. Males are further distinguished by differences in form of the middle tibiae and in form of the median lobe.

During the last century, men of nous were familiar with the classic languages. Even so, it seems remarkable that H. M. Schmidt-Göbel (1846: 77) knew and published the ancient word from Homeric Greek, "*Celaenephes*," as a name for a seemingly non-descript lebiine adult. The word means "shrouded in dark clouds." Schmidt-Göbel did not explain why he chose this name, though the dark cuticle of specimens of this genus probably provided the required inspiration.

Such a name might also have implied uncertainty about relationships of this genus. However, the author specified that it was probably related to *Arsinoe* Laporte, suggesting that he was not troubled by concern about relationships. The name, nonetheless, was prophetic. Relationships of the genus were, in fact, uncertain. Lacordaire (1854: 138) included it in the Péricalides, a taxon now ranked as a subtribe (Pericalina) of Lebiini (Ball, 1975). Bates (1886: 211) considered *Celaenephes* as a cymindine, related to *Dromius*. Csiki (1932: 1412), Jedlička (1963: 299), and Habu (1967: 250) included this genus in the subtribe Dromiina. Basilewsky (1984: 528) stated that *Celaenephes* was certainly not a lebiine but rather a platynine. He did not indicate to what group of platynines *Celaenephes* was related.

Specimens were sufficiently obscure and thus difficult to characterize that the genus escaped the attention of some subsequent workers. Thus, Blackburn (1894: 85) proposed the generic name *Taromorpha* for a specimen of *Celaenephes* collected in eastern Australia, and Habu (1960) proposed the name *Fukuchina* for material of *Celaenephes* collected in Japan.

Problems with recognition of the genus were paralleled by problems with recognition of species. Six specific epithets were proposed in the following combinations: *C. parallelus* Schmidt-Göbel; *Leistus linearis* Walker, 1858; *Taromorpha alternata* Blackburn, 1894; *C. foersteri* Bouchard, 1903; *C. rechingeri* Csiki, 1915; and *Fukuchina sanadai* Habu, 1960. Bates (1886: 211) remarked, when synonymizing the names *Celaenephes parallelus* and *Leistus linearis* Walker that: "the reference of a Truncatipenne allied to *Dromius* to the genus *Leistus* must be considered one of Walker's greatest feats of random identification." Possibly so, but the seeming dark clouds that enshrouded *Celaenephes* may have obscured Walker's vision.

Andrewes (1930a: 81) listed *L. linearis, T. alternata, C. foersteri*, and *C. rechingeri* as junior synonyms of *C. parallelus*, and Habu (1967: 250) added *F. sanadai*.

Thus, in 1967, *Celaenephes* was recognized as a monobasic genus, within the subtribe Dromiina. Habu (*loc. cit.*, p. 210), however, noted that the features of the ovipositors of *Celaenephes* females were not consonant with ovipositors of other dromiines. Based on this consideration, Habu (1982: 113–114) removed *Celaenephes* from the Dromiina, erecting a new monobasic subtribe, Celaenephina, to include it. Ball and Hilchie (1983: 112, 204) independently reached this conclusion. Habu (*loc. cit.*, pp. 113–114) indicated that he regarded the celaenephine ovipositor as derived, having evolved toward more complete development of the stylomeres. Ball and Hilchie (*loc. cit.*, pp. 113–114) stated that the ovipositor was primitive, overall.

Two of the present authors (D.S. and G.E.B.) decided to review more extensively the position of *Celaenephes*, and in the process of examining some borrowed material, discovered that the genus included two different forms rather than only the one (*C. parallelus* Schmidt-Göbel), as recognized recently. At this stage, advice and assistance were sought from R. B. Madge; his contributions, communicated in letters and based on study of specimens in the collections at the British Museum (Natural History) and on examination of the literature, became sufficiently extensive to require including him as a third author. Together, we reviewed the evidence for recognition of the subtribe Celaenephina, and for the recognition of two species of *Celaenephes*, rather than one.

MATERIAL

This study was based on examination of 449 adult carabids representing the genus *Celaenephes*. As a basis for detailed comparison of character states of *Celaenephes*, 20 specimens of other taxa were dissected to verify published details, or to determine range of variation of particular features. These taxa were represented: *Calathus ingratus* Dejean, *Synuchus dubius* LeConte, and *Platynus decentis* Say (Tribe Platynini); *Peronoscelis latipennis* Chaudoir, and *Masoreus* species (Tribe Cyclosomini); and members of the tribe Lebiini—*Phloeoxena herculeano* Ball, and *Coptodera elongata* Chaudoir (subtribe Pericalina); *Apenes* species (subtribe Apenina); *Cymindis* (*Pinacodera*) *chevrolati* Dejean (subtribe Cymindina); *Euproctinus subdeletus* Bates (tentatively, subtribe Metallicina); *Agra* species (subtribe Agrina); *Gallerucidia erotyloides* Bates and *Calleida* species (subtribe Calleidina); *Dromius flohri* Bates (subtribe Dromiina); and *Lebia urania* Bates (subtribe Lebiina).

Specimens of *Celaenephes* were borrowed from the following institutions. Associated acronyms are used in the text to indicate source of particular specimens.

BMHH	Department of Entomology, Bernice P. Bishop Museum, 1355 Kalihi St., P.O. Box 19000-A, Honolulu, Hawaii 96819, U.S.A.
BMNH	Department of Entomology, British Museum (Natural History), Cromwell Road, London SW7 5BD, England
CAS	Department of Entomology, California Academy of Sciences, Golden Gate Park, San Francisco, California 94118, U.S.A.
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts 02138, U.S.A.
RTB	R. T. Bell Collection, Department of Zoology, The University of Vermont, Burlington, Vermont 05405, U.S.A.
SMNH	Section of Entomology, Swedish Museum of Natural History, S-104 05 Stockholm, Sweden
USNM	Department of Entomology, United States Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

Type material was loaned to us by the Department of Entomology, National Museum in Prague, Czechoslovakia.

METHODS

Material used for detailed comparison was restricted to the Tribe Platynini, and to those lebiine subtribes with which *Celaenephes* had been associated: Pericalina, Cymindina, and Dromiina. We noted in passing characteristics of other subtribes (Apenina, Metallicina, Calleidina, Agrina, and Lebiina), but did not record information about them because such was not essential for our study.

Because of the nature of this study, no attempt was made to obtain all available material of *Celaenephes,* nor to assess in detail intraspecific variation. Rather, we worked with material that was readily available which we judged in terms of experience with other taxa to be adequate for our purposes.

For comparison, we used few representatives of other taxa, choosing for study characters about whose range of variation something was known. We assessed variation of few characters, principally those used by previous authors in establishing higher taxa of Lebiini. We examined as well a few autapotypic traits of *Celaenephes.*

Taxonomic and phylogenetic principles, criteria used for ranking taxa, and general working methods were the same as those previously described (see Ball and Shpeley, 1983), and are not repeated here.

Genitalia and sclerites of ovipositors were preserved in glycerine, in microvials. Mouthparts and wings that were removed were glued on small cards. Microvials and cards were pinned beneath the specimens from which the sclerites had been removed.

For examination and illustration of some structures, a stereo-electron microscope, Cambridge Model S-150, was used. Specimens were cleaned using a sonicator, and were then gold-coated.

Terms for Structures

In addition to words established by years of general usage, we have used several that have so far appeared principally in publications about carabids. Attention is drawn to them here, in the interest of clarity.

For micro-units of surface sculpture bounded by lines of microsculpture ("micro-lines"), we use "sculpticell" (Allen and Ball, 1980: 486); for elytral stria, "interneur" (Erwin, 1974: 3–5). For abdominal terga and sterna, Roman numerals are used, the first visible sternum being II, and the last one that is normally not retracted, VII.

Sclerites and setae of the ovipositor are named according to a system fully explained by Ball and Shpeley (1983: 746–749). Surfaces are named according to their orientation with the ovipositor fully extended, rather than retracted. The retracted condition is seen in most dead specimens, and is the way that the ovipositor is carried except when in use. Thus, the surface that is ventral in the retracted position is lateral with the ovipositor extended, and is named accordingly, with other surfaces named correspondingly.

Two structures not previously noted in carabids were found; they are as follows. On the ventral surfaces of antennomeres 4–11, pits were noted, each containing a number of structures that seem to be sensory (Fig. 12). These cavities are named "sensory pits." On the ventral surface of each mandible is a groove that houses numerous pores, each with a filament (Fig. 17). Because these filaments seem to be secretions, the grooves containing them are named "secretory grooves."

Subtribe Celaenephina

Recognition.—Adults of this group have the following combination of putatively apotypic (derived) character states: elytron with apical fringe of microsetae; ventral surface with sparse vestiture of short setae; front and middle trochanters each with a long seta; antennomeres 4–11 ventrally each with pit containing sensory organs (Fig. 12); left mandible with an anterior retinacular tooth, without terebral tooth (Figs. 15A, B); each mandible ventrally with a secretory groove (Figs. 15B, 16B, 17A, B); galeomere 2 of maxilla with apical half setose (Fig. 13); labium with paraglossae adnate to glossal sclerite (Fig 14); elytra with apices subtruncate; tergum VIII completely sclerotized, without membranous area medially (Fig. 7); (cf. Figs. 24–26); sternum X sclerotized (Fig. 10). Females have the nematoid setae as long or longer than stylomere 2 (Figs. 21A, C).

Included taxa.—This subtribe includes only the genus *Celaenephes* Schmidt-Göbel.

Relationships.—This subtribe is here suggested to be the most ancestral group of extant lebiines, and the sister group of the remaining subtribes. Details supporting this hypothesis are presented, following taxonomic treatment of the genus and species.

Geographical distribution.—The range of this Old World subtribe extends from Sri Lanka and India eastward in the Oriental Region through the Indo-Australian Archipelago to eastern Australia, New Caledonia, and the Samoan Archipelago. Northward, the range extends through the Philippine Archipelago and Taiwan to the southern part of the Japanese Archipelago (cf. Figs. 22 and 23).

Celaenephes Schmidt-Göbel

Celaenephes Schmidt-Göbel, 1846: 78–79. TYPE SPECIES: *Celaenephes parallelus* Schmidt-Göbel, 1846: 78 (by monotypy).—Lacordaire, 1854: 138.—Bates, 1892: 420.—Andrewes, 1927a: 272.—1927b: 11.—1930a: 81.—1930b: 337.—Csiki, 1932: 1412.—Jedlička, 1963: 299.—Habu, 1967: 249–250.—Darlington, 1968: 135.—Habu, 1982: 113–114.—Ball and Hilchie, 1983: 112 and 204.

Taromorpha Blackburn, 1894: 85. TYPE SPECIES: *Taromorpha alternata* Blackburn, 1894: 85 (by monotypy).—Andrewes, 1927a: 272.

Fukuchina Habu, 1960: 4–5. TYPE SPECIES: *Fukuchina sanadai* Habu, 1960: 5–6 (by monotypy).—Jedlička, 1963: 430–431.—Habu, 1967: 249.

Notes about synonymy.—Andrewes (1927a: 272) synonymized the names *Taromorpha* and *Celaenephes* without presenting supporting statements. We have seen type material of both type species and believe that they are congeneric.

Habu (1967: 249) synonymized the names *Fukuchina* and *Celaenephes*. We have not seen the holotype of *F. sanadai* Habu, but illustrations of type material (*loc. cit.*, figs. 421–428) show that Habu (1960) had in hand specimens of *C. parallelus* on which he based the description of the type species of *Fukuchina*.

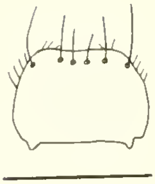
Description.—Standardized Body Length 5.32–7.36 mm (males) and 5.60–7.16 mm (females).

Color.—Head, thorax, and abdominal sterna castaneous to black, antennae and mouthparts testaceous to black.

Microsculpture.—Dorsal surface with mesh pattern isodiametric, microlines faint on clypeus, frons, vertex, and disc of pronotum; more easily seen laterally on pronotum and elytra. Ventral surface with mesh pattern slightly transverse on head near eyes, thoracic sterna, pterothoracic pleura, and abdominal sterna medially; isodiametric on proepisternum and abdominal sterna laterally; microlines not evident medially on head.

Luster.—Surface moderately shining.

Fixed setae.—Typical for Lebiini, those of fore and middle trochanters longer than normal.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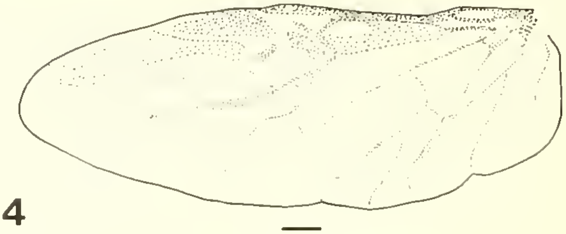
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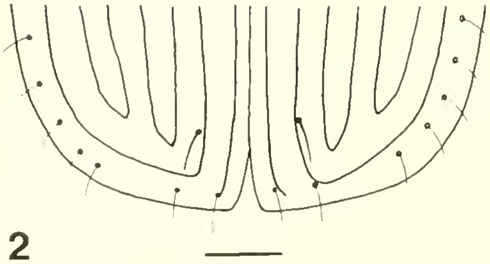
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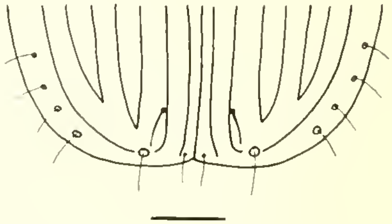
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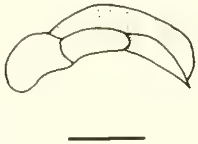
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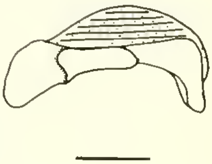
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5c

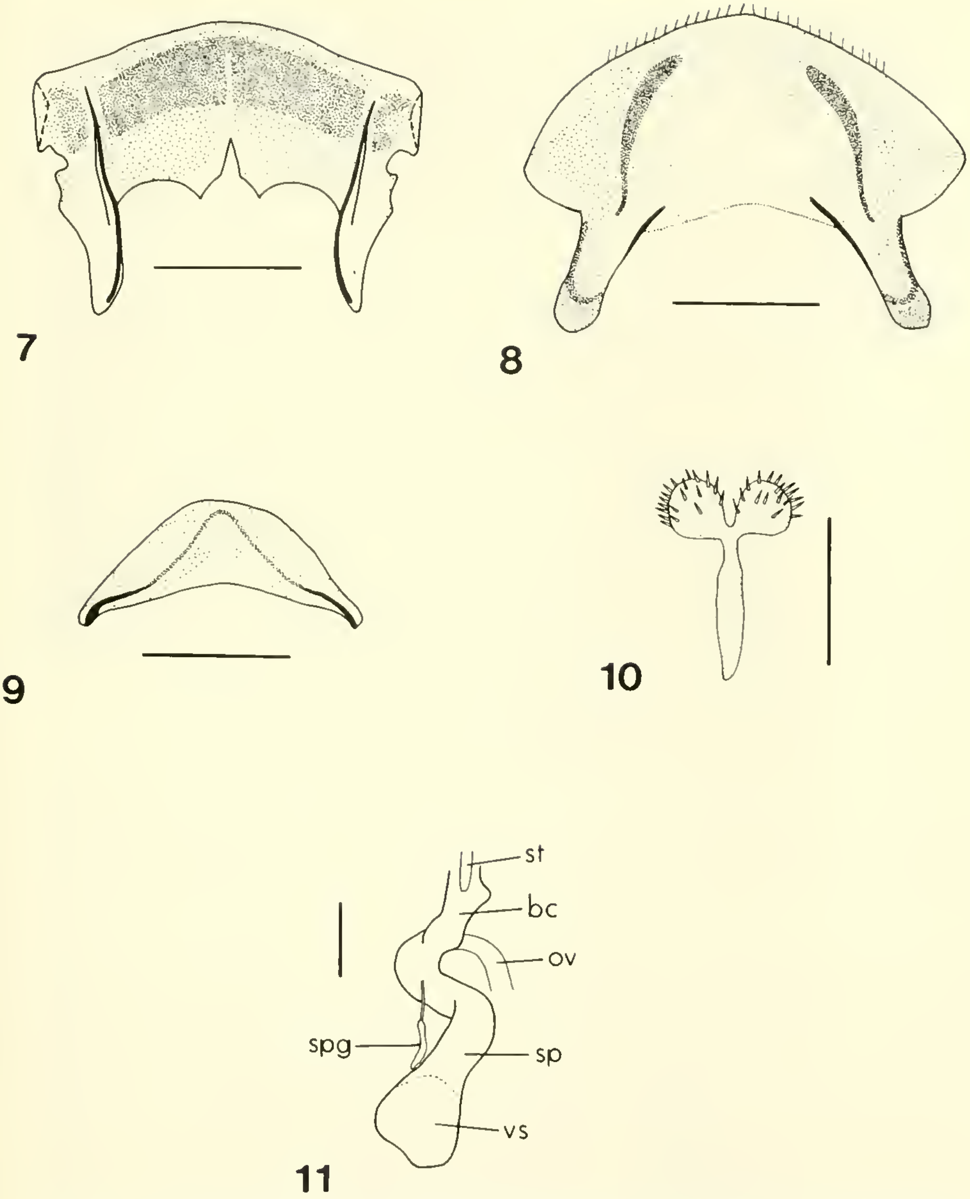

6b


6c

Figs. 1–6. Line drawings of sclerites of *Celaenephes* adults (scale bars = 0.50 mm). 1, labrum of *C. linearis*. 2–3, Apices of elytra: 2, *C. parallelus*; 3, *C. linearis*. 4, Left hind wing of *C. linearis*. 5–6, Male genitalia (A, median lobe and left paramere, left lateral aspect; B and C, median lobe, dorsal and ventral aspects, respectively). 5, *C. parallelus*. 6, *C. linearis*.

Vestiture.—Elytra with intervals 7, 8, and 9 with sparse covering of fine short setae. Ventral surface of head with few fine setae near eyes. Palpomeres, thoracic and abdominal sterna and metepisterna finely setose. Fore coxae with few short setae. Middle coxae with numerous moderately long and few markedly longer setae. Hind coxae with lateral-posterior margins fringed with numerous long setae. Tarsomeres with dorsal surfaces setose.

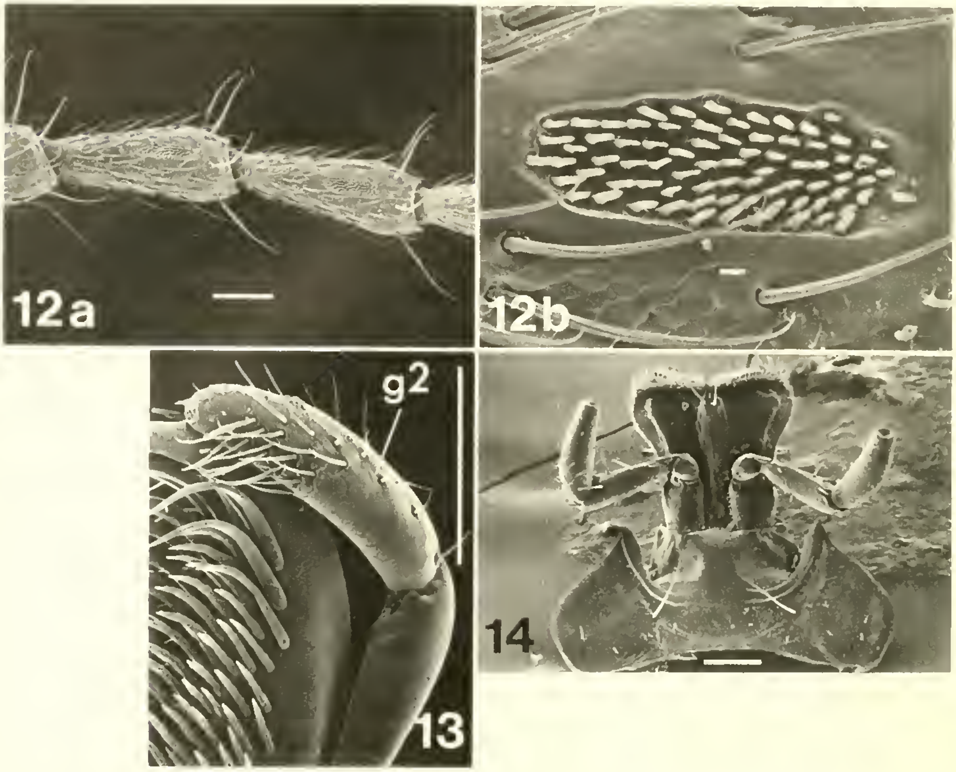
Head.—Labrum as in Fig. 1. Frons smooth with fine punctures. Clypeus rect-



Figs. 7–11. Line drawings of structures of *Celaenephes linearis* adults (scale bars = 0.50 mm). Figs. 7–10, terminal abdominal sclerites. 7, Tergum VIII. 8, Sternum VIII. 9, tergum X. 10, Sternum X. 11, Female reproductive tract and associated sternum X, dorsal aspect. (bc, bursa copulatrix; ov, oviduct; sp, spermatheca; spg, spermathecal gland; st, sternum X; vs, ventral sclerite).

angular, with anterior margin straight. Eyes large, subgenae very small. Antennae of average length, extended beyond base of pronotum. Antennomeres 2 and 3 each with ring of setae apically, few fine setae scattered over surface. Antennomere 4 setose in apical three fourths; antennomeres 5–11 generally setose. Antennomeres 4–11 each with ventral sensory pit (Figs. 12A, B).

Mouthparts.—Left mandible (Figs. 15A, B) with cutting edge formed by retinac-



Figs. 12–14. SEM photographs of sclerites of *Celaenephes* adults. 12, Antenna, ventral aspect, of *C. linearis.* (A, antennomeres 7–10 (scale bar = 100 μm); B, antennomere 9, enlargement to show detail of sensory pit (scale bar = 5 μm). 13–14, Mouthparts of *C. linearis.* 13, Left maxilla, ventral aspect (scale bar = 100 μm), g2, galeomere 2. 14, labium ventral aspect (scale bar = 100 μm).

ular ridge; posterior retinacular tooth prominent; anterior retinacular, premolar, and molar teeth present. Right mandible (Figs. 16A, B) with cutting edge formed by terebral ridge; terebral, retinacular, premolar and molar teeth present. Both mandibles ventrally with long secretory groove (Figs. 17A, B). Maxillae average for Lebiini; galeomere 2 setose near apex (Fig. 13); maxillary palpomere 4 fusiform, subequal in length to palpomere 3. Labium with ligula (Fig. 14) with large membranous paraglossae, densely setose along lateral margins, broadly adnate to glossal sclerite; latter narrow, with two long setae apically; labial palpomere 3 fusiform, subequal in length to bisetose palpomere 2; mentum edentate.

Thorax.—Pronotum slightly convex, wider than long; anterior margin slightly concave, posterior margin slightly convex; anterior angles rounded, posterior angles obtuse; lateral margins reflexed; side sinuate before posterior angles. Pro-

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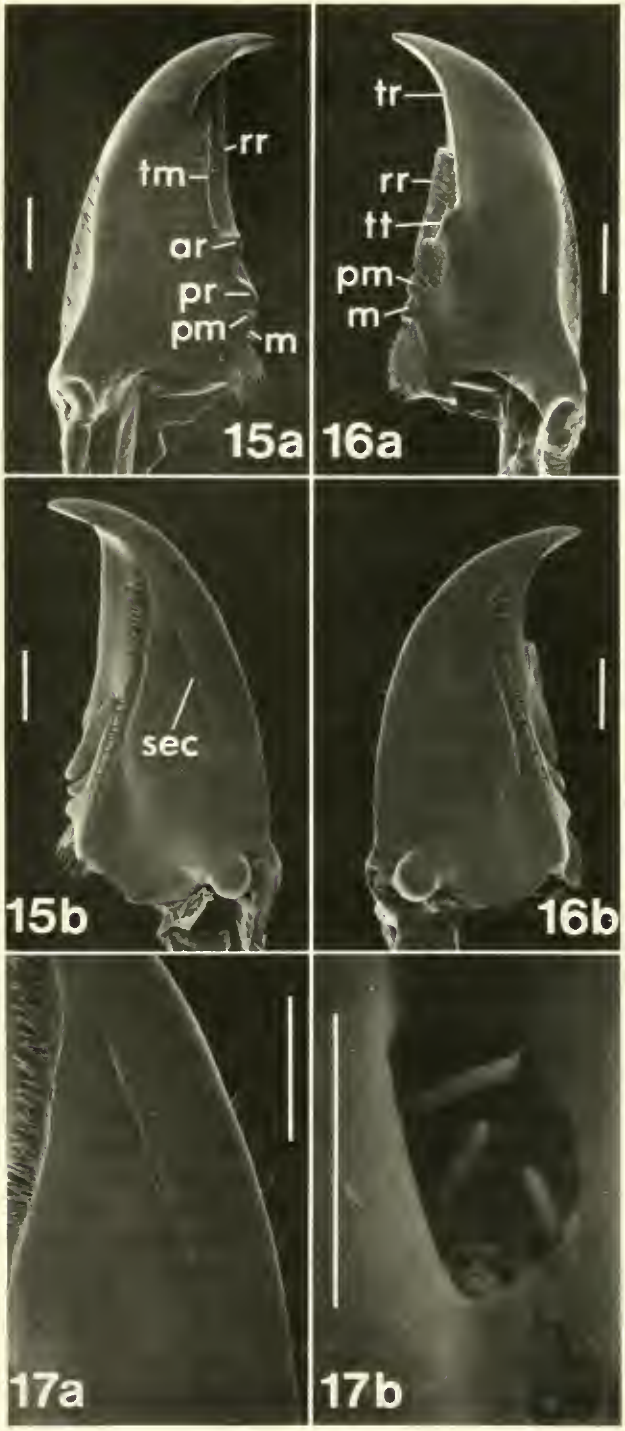
Figs. 15–17. SEM photographs of mandibles of *C. linearis* adults. 15A and B, left mandible, dorsal and ventral aspects, respectively. 16A and B, Right mandible, dorsal and ventral aspects, respectively (scale bars = 100 μm) (ar, anterior retinacular tooth; m, molar; pm, premolar tooth; pr, posterior



retinacular tooth; rr, retinacular ridge; sec, secretory groove; tm, terebral margin; tr, terebral ridge; tt, terebral tooth). 17A, Portion of left mandible, ventral aspect, showing secretory groove (scale bar = 100 μm); 17B, enlargement of 17A, showing detail of secretory groove (scale bar = 2 μm).

sternum with intercoxal process bisetose. Anterior coxal cavities uniperforate. Pterothorax with metepisternum elongate, lateral margin about twice as long as anterior margin.

Elytra.—Widened apically; apical angle either obtuse and preapical angle slightly rounded (Fig. 2), or apical angle nearly rectangular, and preapical angle markedly rounded (Fig. 3). Interneurs shallow; intervals broad, only slightly convex. Interval 3 with three setigerous punctures. Interval 4 uniformly convex, or depressed medially. Umbilical series with 22 or fewer (average 20) setigerous punctures. Basal ridge incomplete (Fig. 18A), extended only to near base of interneur 4; apex with fringe of fine setae (Fig. 18B).

Hind wings.—Fully developed, oblongum cell reduced, wedge cell present (Fig. 4).

Legs.—Long and slender, hind tarsus and tibia subequal (length hind tarsus/length hind tibia = 0.85) in length. Middle tibia of male either unmodified (Fig. 20), or with notch in ventral surface (Fig. 19). Males with tarsomeres 1–3 of front leg with adhesive vestiture biseriate. Tarsal claws smooth, not pectinate.

Abdomen.—Sterna IV, V, and VI each with one pair of long (ambulatory) setae. Sternum VII of male with one pair of anal setae, female with two pair. Tergum VIII (Fig. 7) sclerotized throughout; sternum VIII (Fig. 8) membranous medially. Tergum X as in Fig. 9; sternum X (Fig. 10) well developed.

Male genitalia.—Median lobe slender, dorsal surface to basal bulb membranous, membrane either smooth (Fig. 5A) or carinate; apex in ventral aspect slender and pointed (Figs. 5B, C), or thickened and broadly rounded (Figs. 6B, C); apical orifice dorsal. Internal sac without armature. Parameres subequal in length, apices of each broadly rounded.

Ovipositor.—Stylomere 1 setose medially near apex (Fig. 21A). Stylomere 2 (Figs. 21A, B) falcate, with broadly rounded apex; one dorsal ensiform seta medially, two to four laterally; nematoid setae as long or longer than stylomere 2.

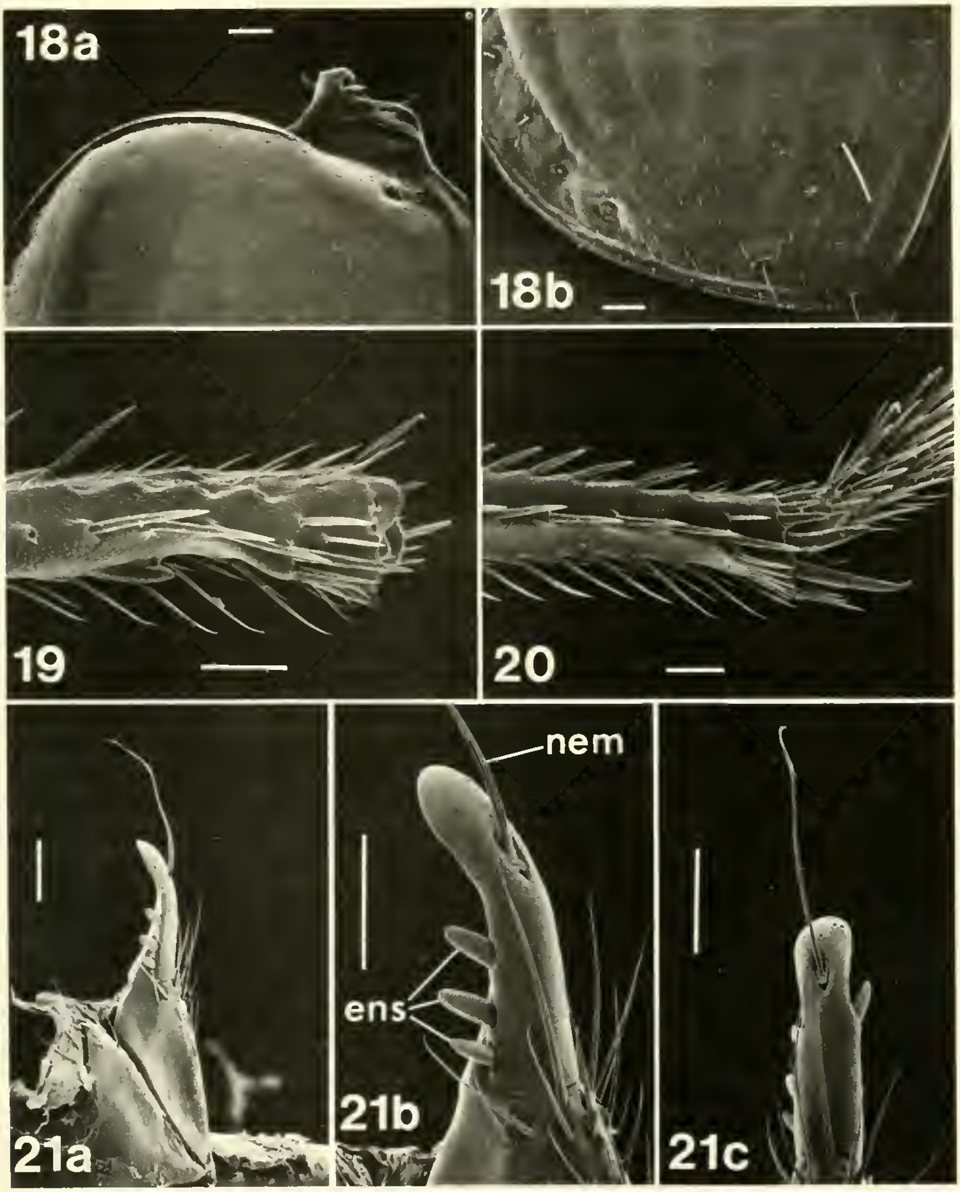
Female genitalia.—*Bursa copulatrix* reduced; spermatheca very large, with terminal sclerite ventrally; spermathecal gland present (Fig. 11).

KEY TO SPECIES OF *CELAENEPHES* SCHMIDT-GÖBEL, BASED ON FEATURES OF ADULTS

1. Terminal palpomeres with only apices pale, latter markedly contrasted with dark bases. Elytron with interval four even, surface not depressed at middle. Middle tibia of male with inner (i.e., ventral) margin with single deep notch, preapically (Fig. 19), and median lobe of genitalia with apex pointed (Figs. 5B, C) .... *C. parallelus* Schmidt-Göbel.
– Terminal palpomeres pale, almost without contrast between base and apex. Elytral interval 4 of most specimens with shallow depression at middle. Male with inner margin of middle tibia with series of shallow emarginations (Fig. 20), and median lobe of genitalia with apex broad (Figs. 6B, C) .... *C. linearis* (Walker).

Celaenephes parallelus Schmidt-Göbel

Celaenephes parallelus Schmidt-Göbel 1846: 78–79. TYPE MATERIAL: one male and three females. LECTOTYPE (here selected), male, labelled: MUS. PRAGENSE TENASSERIM COLL. HELFER; Typus! teste Dr. J. Obenberger



Figs. 18–21. SEM photographs of sclerites of *Celaenephes* adults (scale bars = 100 μm). 18, Left elytron, dorsal apsect, of *C. linearis.* (A, base; B, apex). 19–20, Middle tibiae, anterior aspect, apical portion. 19, *C. parallelus.* 20, *C. linearis.* 21, Left stylomeres 1 and 2 of ovipositor of *C. linearis.* (A, stylomeres 1 and 2, lateral aspect; B and C, stylomere 2, lateral and ventral aspects, respectively; ens, ensiform setae; nem, nematoid setae (scale bars = 100 μm)).

[red paper]; parallelus Sch. G. COL. HELFER [handwritten above type]; Mus. Nat. Pragae Inv. 26638 [orange paper]; PARALECTOTYPES: two females, Nos. 26636 and 26637 labelled as above. One female labelled: MUS. PRAGENSE COLL. HELFER; Burma Helfer [handwritten]; Typus! teste Dr. J.

Obenberger [red paper]; parallelus Sch. G. COL. HELFER [handwritten above type]; Mus. Nat. Pragae Inv. 26635 [orange paper] (National Museum in Prague, Czechoslovakia). TYPE LOCALITY: Burma, Tenasserim.—Bates, 1886: 211.—1892: 420.—Andrewes, 1919: 188.—1923: 46.—1927a: 272.—1927b: 11.—1929: 314.—1930a: 81.—1930b: 337.—1947: 12.—Csiki, 1932: 1412.—Landin, 1955: 405, 466.—Jedlička, 1963: 399–400.—Habu, 1967: 250–253.—Darlington, 1968: 135.

Celoenephes (sic) parallelus; Bouchard, 1903: 176.—Habu, 1967: 251.

Coloenephes (sic) foersteri Bouchard, 1903: 176. TYPE MATERIAL: Not seen. TYPE AREA: Sumatra.—Andrewes, 1927b: 11.—1930a: 81.

Fukuchina sanadai Habu, 1960: 5–6. TYPE MATERIAL: not seen. HOLOTYPE female, labelled: VIII.7, 1956 Mt. Fukuchi K. Sanada leg. TYPE LOCALITY: Fukuoka Prefecture, North Kyushu, Japan.—Jedlička, 1963: 430–431.—Habu, 1967: 251.

Celaenephes parallelus (in part); Darlington, 1968: 135.

Notes about synonymy.—Andrewes (1930a: 81) synonymized the names *C. parallelus* and *C. foersteri.* We have not seen type material of the latter named form, but accept the synonymy, reasoning as follows. Bouchard compared the character states of *C. foersteri* with those of *C. parallelus,* and from the statements made, we believe that Bouchard identified specimens of *C. linearis* (Walker) as *C. parallelus.* Thus, Bouchard's new species was the true *C. parallelus,* the specimens in question being smaller and darker. Habu (1967: 250) synonymized the names *F. sanadai* and *C. parallelus.* For further details, see synonymical notes under the genus *Celaenephes.*

Recognition.—In addition to features presented in the key, adults have piceous to black antennae and mouthparts, and the sutural angle of the elytron is rounded (Fig. 2). Standardized Body Length ranges as follows: 5.32–6.04 mm (males) and 5.60–6.60 mm (females).

Notes about habitat and life history.—Adults of this species are probably arboreal, as are those of *C. linearis.* However, only one specimen (from New Guinea) that we have seen is associated with habitat data: "on maize leaf." Because maize is an introduced species of plant, the association of it and *C. parallelus* may be evidence that the latter species can survive in habitats disturbed by man.

Collecting records extend from May to November, and specimens have been collected at light from May to September. Adults may be active fliers throughout the year, but this cannot be established from the few available records.

Remarks about *C. parallelus* by Darlington (1968: 135) refer principally to *C. linearis.*

Geographical distribution (Fig. 22).—The range of this species extends from India (Amalai Hills, Madras [B. P. Moore, personal communication]) to northeastern Australia, and through the Philippines and Taiwan to Kyushu Island in the Japanese Archipelago. (The Australian specimens [male and three females] were collected at Cardstone, North Queensland, November 15–28, 1966 [B. P. Moore, CSIRO, personal communication]). The seemingly isolated occurrences of *C. parallelus* in New Guinea and Australia are likely to be artifacts of collecting, rather than representing populations far removed from the other populations of the species.

Chorological affinities.—The ranges of *C. parallelus* and *C. linearis* overlap

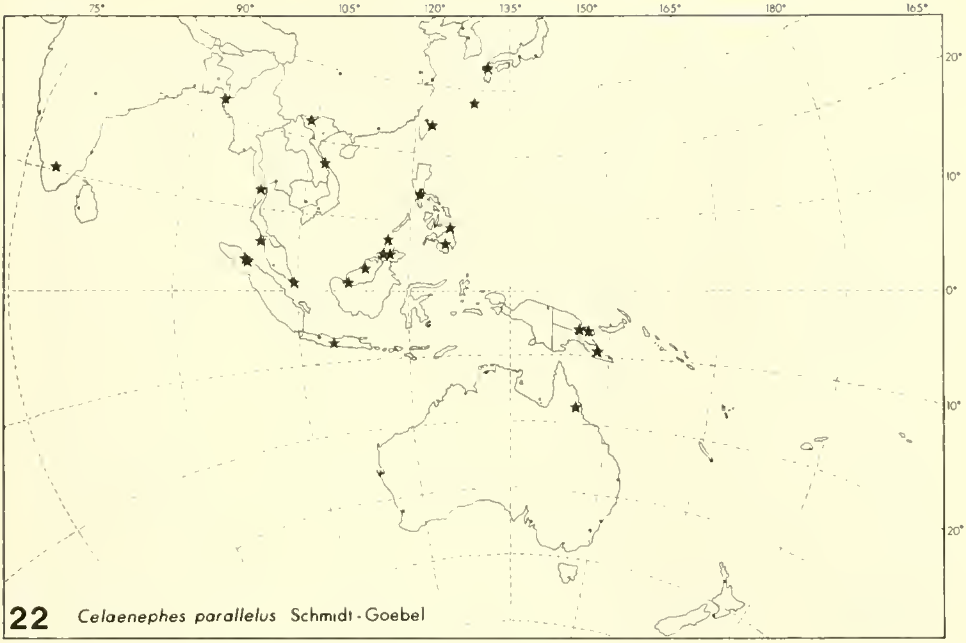


Fig. 22. Geographical distribution of *Celaenephes parallelus.*

broadly (*cf.* Figs. 22 and 23). Furthermore, both species have been taken at the same localities in Burma, Viet Nam, the Philippine Islands, Sabah, Sarawak, the Riouw Archipelago off Sumatra, New Guinea, and Australia. Such extensive sympatry, both general and specific, provides good presumptive evidence that the two forms, established on morphological differences, are indeed reproductively isolated from one another, and hence are specifically distinct. However, the extensive overlap prevents inferring the location or nature of the barrier that led to the differentiation of the ancestral stocks of the two species. It remains to be determined if they occupy different habitats, and the role of structural differences in maintaining their reproductive isolation.

Material examined.—We have seen 42 specimens including types of this species. Non-type material was seen from the following localities: BANGLADESH. Sitapahar R., Chittagong, H.T. (BMNH). BURMA. Myitkyina, 175 m (SMNH). Tenasserim (BMNH). INDONESIA Java. Djeroeklegi, Zuid-Banjoemas (BMNH). Sumatra. Riouw Arch. (BMNH). Sumatra's O.K., Soengei Merah (BMNH). Tijinta Radja (BMNH). MALAYSIA Sabah-Borneo. Borneo North (BMNH). 5 mi S Mt. Trus Madi, 1800 ft (BMNH). R. Karamuak, 7 mi SSE Telupid (BMNH). Tawai Plat., 8 mi S Telupid, 1300 ft. (BMNH). Sarawak-Borneo. foot of Mt. Dulit, jct. of rivers Tinjar & Lejok (BMNH). LUBOK ANTU (BMNH). Malaya. Penang. (BMNH). PAPUA. New Guinea. Goroka, 1550 m (MCZ). Madang Dist., Finisterre Mts., 3500 ft (BMNH). Oro Bay (MCZ). Popondetta (MCZ). Wabag (RTB). Wau (RTB). PHILIPPINE ISLANDS. Balabac (BMNH). Mindanao I.: (BMNH); Davao (BMNH) (USNM); Surigao (BMNH) (USNM). Luzon I., Laguna, Mt. Makiling (CAS). VIET NAM. Quang Tri Prov.: 1 mi N Quang Tri (USNM); Cam Lo, 7 mi W Dong Ha (USNM). Tonkin, Chapa (BMNH).

***Celaenephes linearis* (Walker)**

Leistus (?) *linearis* Walker, 1858: 203. HOLOTYPE male, labelled: Type, H. T. [white disc, ringed with red]; Ceylon [handwritten, on pale blue disc], 59 106 [on under surface]; Leistus? linearis Walker Ann. N. Hist. (Type) [handwritten, on blue paper] (BMNH). TYPE AREA: Ceylon.—Bates, 1886: 211.—Andrewes, 1919: 188.—1927b: 11.—1930a: 81.—Csiki, 1932: 1412.—Habu, 1967: 250.

Taromorpha alternata Blackburn, 1894: 85. HOLOTYPE male, labelled: 4997 Cairns [handwritten in red ink on card supporting specimen]; Type [white disc, ringed with red]; Australia, Blackburn Coll., B.M. 1910-236; Taromorpha alternata, Blackb. [handwritten]. (BMNH). TYPE LOCALITY: Cairns, Australia. NEW SYNONYMY.—Andrewes, 1927a: 272.—1927b: 11.—1930a: 81.—Csiki, 1932: 1412.—Jedlička, 1963: 399.—Habu, 1967: 250.

Celaenephes rechingeri Csiki, 1915: 164. LECTOTYPE (here selected) teneral male, labelled: Upolu Samoa Rechinger; Celaenephes Rechingeri m. Typus! [in red ink] det. Csiki [handwritten]; borrowed fr. Budapest Mus. (MCZ). PARALECTOTYPE female, labelled: Savaii Samoa Rechinger '05; Celaenephes Rechingeri m. Typus! [in red ink]; det. Csiki [handwritten]; borrowed fr. Budapest Mus. (MCZ). PARALECTOTYPES (sex not determined), labelled as above, one from Savaii, two from Upolu (Naturhistorisches Museum Wien).—TYPE LOCALITY: Samoa, Upolu Island. NEW SYNONYMY.—Andewes, 1927b: 11.—1930a: 81.—Csiki, 1932: 1412.—Jedlička, 1963: 399.—Habu, 1967: 251.

Celaenephes parallelus (in part); Habu, 1967: 251.—Darlington, 1968: 135.—1970: 43.

Notes about synonymy.—Bates (1886: 211) synonymized *Leistus linearis* Walker with *C. parallelus* Schmidt-Goebel. This action was incorrect, for the holotype of *L. linearis* is clearly specifically distinct from the type of *C. parallelus.*

We have examined the types of *T. alternata* Blackburn, and *C. rechingeri* Csiki, and both are conspecific with the holotype of *L. linearis.*

Jedlička (1963: 399) records the location of the type of *C. rechingeri* as the Berlin Museum. However, we have seen specimens labelled as "type" in the Naturhistorisches Museum Wien, and in the MCZ; evidently Csiki labelled all of the specimens that he saw as "type." Thus, a lectotype designation is required, and we have provided one.

Recognition.—In addition to features presented in the key, adults have testaceous to castaneous antennomeres and mouthparts and the sutural angle of the elytron is nearly rectangular (Fig. 3). Standardized Body Length ranges as follows: 6.00–7.36 mm (males) and 5.92–7.16 mm (females).

Notes about habitat and life history.—Specimens of this species have been taken in a variety of habitats, as indicated by data on locality labels: in bases of bromeliad leaves (*sic*); beating trees; moss forest; undergrowth, secondary forest; and near fermenting tapioca.

Specimens have been collected throughout the year, but only from June to September north of the equator, and July to October south of the equator, at white or ultra-violet light. We have seen teneral specimens which were collected in June, July, and August in New Guinea, and in October and November in Australia.

Darlington (1968: 135) suggested that adults of *Celaenephes* may have reached

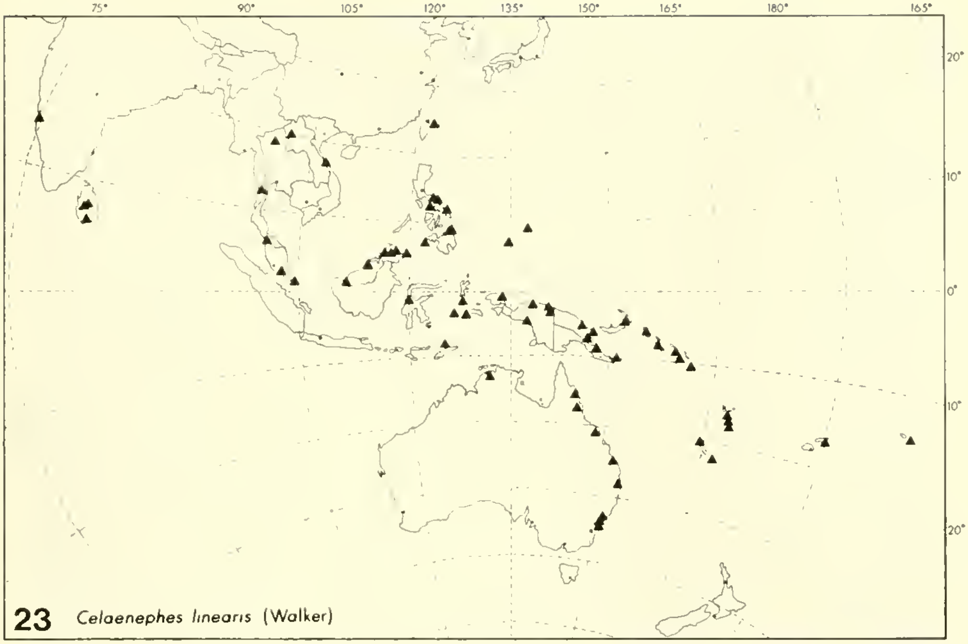


Fig. 23. Geographical distribution of *Celaenephes linearis.*

the Pacific islands by transportation in thatching material, this being a consequence of an arboreal way of life. Not recognizing that two species were included in the genus, he referred to *C. parallelus* only, though it is *C. linearis* that ranges into the Pacific Islands.

Geographical distribution.—The range of this species extends from Sri Lanka and India (Shimoga, Agumbe Ghat [B. P. Moore, CSIRO, personal communication]) in the Oriental Region eastward throughout the Indo-Australian Archipelago to the Samoan islands of Upolu and Savaii; southward to the northern and eastern coasts of Australia (including Cardstone, N. Queensland [B. P. Moore, CSIRO, personal communication]), and to New Caledonia. Northward, the range of *C. linearis* extends to Iriomote, the southernmost island of the Ryukyu Archipelago. The last-named record is based on fig. 425 (Habu, 1967: 252), which illustrates the apical portion of an elytron. Although Habu identifies the specimen as *C. parallelus,* the form of the elytron is characteristic of *C. linearis.* This species is also known from the Western Caroline Islands, the records being under the name *C. parallelus* (Darlington, 1970: 43).

Chorological affinities.—See this topic under *C. parallelus.*

Material examined.—We have seen 388 specimens including types. Non-type material was seen from the following localities: AUSTRALIA. New South Wales: Illawarra (BMNH); Newport, N. Sydney (BMNH); Ryde, W. Sydney (BMNH). Northern Terr., Stuart Hwy., Coomalie Ck. (CAS). Queensland: Cedar Ck. Falls, Tamorine (CAS); Eubenangee (BMNH); 8 mi NE Eungella, 950 m (CAS); 17 mi W Monto, 500 m (CAS). BURMA. Tenasserim (BMNH). FIJI ISLANDS. Taveuni (BMNH). Wainganitu (MCZ). INDONESIA Celebes. (BMNH). Lesser Sundas.

Poera, Ins. Allor, 3000–4000 ft. (BMNH). Moluccas. Amboina (BMNH). Buru (BMNH). Laiwui (BMNH). Sumatra. Riouw Arch. (BMNH). West Irian-New Guinea. Bodem, Saroni area (MCZ). Cyclops Mts., Sabron, 930 & 1200 ft. (BMNH) (MCZ). Hollandia (BMNH) (MCZ). Launch Camp, Setakwa Utakwa Exped. (BMNH); Maffin Bay (BMNH) (MCZ). Maffin Bay, Mt. Leamington, 1300–1500 m (MCZ). Njau-limon, S of Mt. Bougainville, 300 ft. (BMNH). Santani (MCZ). Vogelkop, Kebar Valley, w Manokwari, 550 m (MCZ). Waris, 450–500 m (MCZ). MALAYSIA Malaya. Casteln (BMNH). Malacca (BMNH). Talan Lintok, N. Kedah (BMNH). Sabah-Borneo. Borneo North (BMNH). R. Karamauk, 7 mi SSE Telupid, 200 ft (BMNH). Sandakan (BMNH)(USNM). Sook., 17 mi SE Keningau, 1500 ft. (BMNH). Tawai Plat., 8 mi S Telupid, 1300 ft. (BMNH). Sarawak-Borneo. (BMNH). DRTU's ROAD (BMNH). Kuching (BMNH). Mt. Dulit (BMNH). foot of Mt. Dulit, jct. of rivers Tinjar & Lejok (BMNH). Mt. Matang., 500–1000 ft. (BMNH). NEW CALEDONIA. (BMNH). Boulopuari, Oenghklu R. (MCZ). Plaine des lacs (BMNH). Puebo coast, 1500 ft. (BMNH). Tinchialit, 2020 ft. (BMNH). PAPUA Bougainville Island. Piva River (MCZ). New Britain Island. Gazelle Peninsula, Upper Warangoi, 220 m. (MCZ); Matupi (MCZ). New Guinea. Binigusi, Gwariu R., 150 m (MCZ). Cape Killerton (MCZ). Dobadura (MCZ). Erima, Astrolabe Bay (MCZ). Finschafen (CAS)(MCZ). Ishurava, 3000 ft. (BMNH). Kokoda, 1200 ft. (BMNH). Morobe District: Kunai Creek (MCZ); Surprise Creek (MCZ); Wau (MCZ)(RTB); forestry road north of Wau (CAS). Wabag (RTB). Noramanby Island, Waikuna, Sewa Bay (MCZ). Popondetta (MCZ). PHILIPPINE ISLANDS. Basilan I. (BMNH)(USNM). Island Samar (USNM). Island Sibuyan (BMNH)(USNM). Luzon I.: Calabangan (CAS); Malinao, Tayabas (BMNH). Mindanao I.: Kabasalan, Zamboanga (CAS); Surigao (BMNH)(MCZ)(USNM). Sanga Sanga, Moorjawa (BMNH). SAMOA. Upolu, Apia (BMNH). SOLOMON ISLANDS. Guadalcanal I.: (MCZ); Honiara (BMNH)(CAS); Matanikau River (MCZ); Tapenanje, 1100 ft. (BMNH); Tenaru River (MCZ). Kolombangara I., Ringi Cove, 23–24 km up main road (CAS). San Cristobal Island, Wainoni (BMNH). San Jorge (BMNH). SRI LANKA. Balangoda (BMNH). Gal District, Udugama Kanneliya Jungle, 240 m. (USNM). Mon. District, Monaragala (USNM). Pol District, Sigirya (USNM). THAILAND. E slope, Doi Sutep, 260 m (CAS). VANUATU (= New Hebrides). Aneityum (BMNH). Malekula I. (BMNH). Tanna (BMNH). VIET NAM. Quang Tri Prov., Cam Lo, 7 mi W Dong Ha (USNM). WESTERN CAROLINE ISLANDS. Palau-Babelthaup (BMHH). Yap (BMNH). COUNTRY NOT DETERMINED: Borneo. (BMNH)(USNM). New Guinea—country not found. Fenichel (MCZ). Lao (MCZ).

Relationships of *Celaenephes* Schmidt-Göbel

The authors have not been able to achieve consensus about the relationships of *Celaenephes*. Two of us (D.S. and G.E.B.) believe that *Celaenephes* is not closely related to other extant genera of lebiines. One of us (R.B.M.) believes that this genus is related to *Cymindis* (*sensu stricto*) Latreille. Because of the nature of a hierarchical system of classification, such differences of opinion are not easily accommodated: the former hypothesis leads to placing *Celaenephes* in a monobasic subtribe, as Habu (1982) has done. The latter hypothesis, in a phylogenetic system of classification, requires inclusion of *Celaenephes* in the subtribe Cymindina. Evidence for each hypothesis follows, though the hypothesis favored by Shpeley and Ball prevails in formally classifying *Celaenephes*.

CELAENEPHES AND THE SUBTRIBE CELAENEPHINA

Elements of the defining combination of character states of the subtribe Celaenephina are assessed below in terms of those states of lebiine subtribes in which the genus *Celaenephes* has previously been included (Pericalina, Cymindina, and Dromiina), using as an out-group the tribe Platynini. Choice of platynines as out-group is based on their generally more plesiotypic structures and on the likelihood of a close phylogenetic relationship between Platynini and Lebiini (Liebherr, 1983).

CHARACTERS AND CHARACTER STATES

Eighteen characters, diagnostic for lebiine subtribes, are used in assessing relationships. States of these characters are classified phylogenetically, and taxa are compared in terms of synapotypic states. The sequence of characters in the presentation is that in which their apotypic states would appear in a reconstructed phylogeny of the Lebiini.

The basis of classification of each state as plesiotypic (ancestral) or apotypic (derived) is out-group comparison, as explained by Wiley (1981: 139–146) and Watrous and Wheeler (1981).

01. Abdominal tergum VIII, lateral margin.—Two states: plesiotypic, lateral margins rounded, not produced as lobes (Fig. 24); apotypic, lateral margins produced as lobes (Figs. 7, 25, and 26). Each lobe is associated with the opening of a duct of the paired pygidial defense glands.

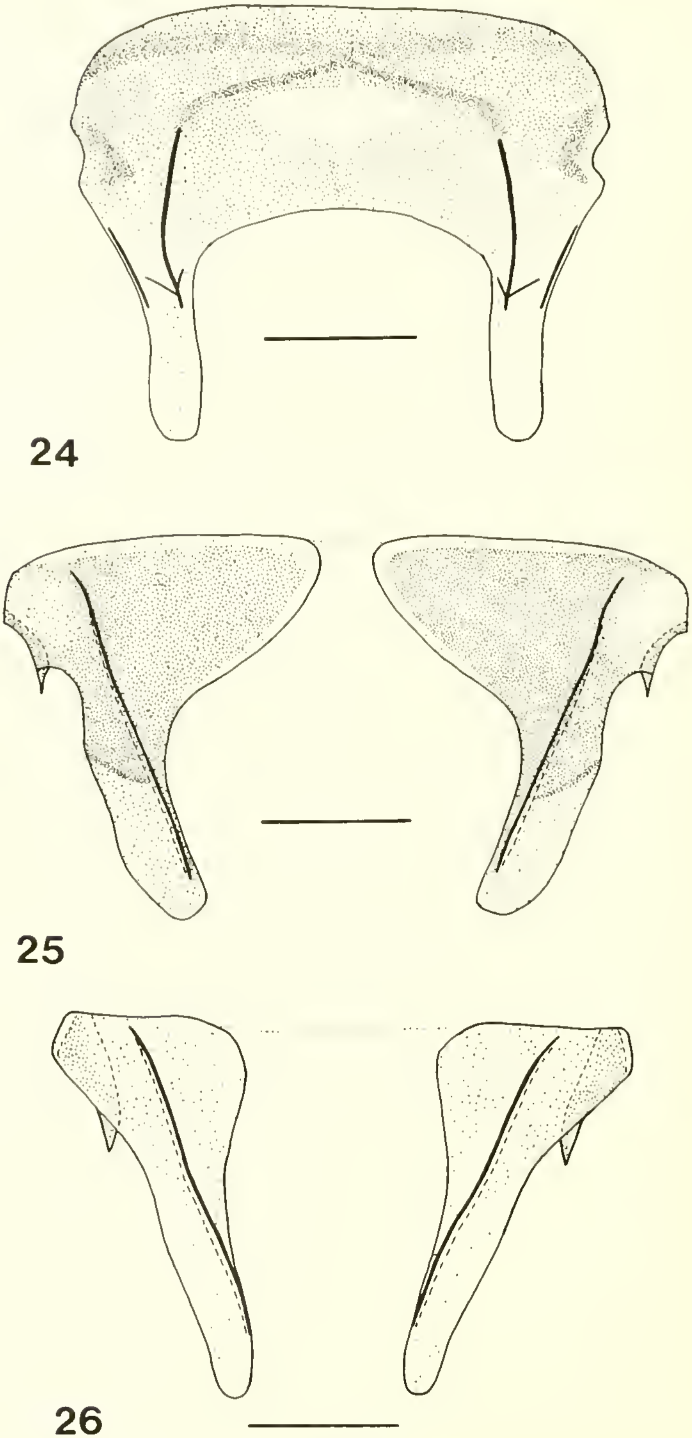
02. Mandibles, secretory groove.—Three states: plesiotypic, absent; two apotypic states—a, well developed, almost as long as terebra (Figs. 15B, 16B, and 17A, B); b, much shorter (*cf.* Ball and Hilchie, 1983: 140, figs. 41C, D, and 43C, D). Such grooves are widely distributed among lebiine genera, though in many, the grooves are lacking. We interpret this as a loss, based on phylogenetic analysis using celaenephines and pericalines as functional out-groups (Watrous and Wheeler, 1981) in relation to the generally more derived cymindines and dromiines.

03. Antennomeres 4–11, sensory pits.—Two states: plesiotypic, absent; apotypic, present (Figs. 12A, B). These pits and their associated sense organs are known among carabids only in adult lebiines of *Celaenephes* and of the seemingly unrelated genera *Euproctinus* Leng and Mutchler, and *Parena* Motschulsky (both genera tentatively assigned to subtribe Metallicina [see Basilewsky, 1984: 542–543, for a diagnosis of the group]).

04. Left mandible, anterior retinacular tooth.—Two states: plesiotypic, absent; apotypic, present (Figs. 15A, B).

05. Abdominal sternum X, extent of sclerotization.—Two states: plesiotypic, principally membranous; apotypic, principally sclerotized (Fig. 10). Although sternum X was no doubt sclerotized in ancestral carabids, this sclerotization is reduced in the more derived groups, including platynines. The condition in *Celaenephes* is interpreted as a reversal to a seeming plesiotypic condition. However, the sclerotization is in the form of a spicule rather than more or less rectangular, as a plesiotypic sclerite would have been (i.e., the ventral counter-part of the rectangular tergum X, Fig. 9).

06. Left mandible, terebral tooth.—Two states: plesiotypic, present; apotypic, absent (Figs. 15A, B). Although the Pericalina and Dromiina are classified as plesiotypic for this character, this is only because at least some members of each of these subtribes exhibit a terebral tooth. The tooth is lacking from many mem-



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Figs. 24–26. Line drawings of tergum VIII of selected platynine and lebiine females. 24, *Platynus decentis* Say. 25, *Cymindis chevrolati* Dejean. 26, *Lebia urania* Bates. (Scale bars = 0.50 mm.)

bers of these groups, and the absence is interpreted as a loss following origin of each subtribe.

07. Elytron, apical microsetae.—Two states: plesiotypic, absent; apotypic, present.

08. Elytron, form of apex.—Two states: plesiotypic, tapered preapically, apex a blunt point; apotypic, truncate (Figs. 2, 3, and 18B).

09. Ovipositor, stylomere 2, length of nematoid setae.—Four states: plesiotypic, length normal, about 10–50 per cent of length of stylomere 2 (*cf.* Ball and Hilchie, 1983: 100, figs. 2A–C); three apotypic states—a, hypertrophied, as long or longer than stylomere 2 (Figs. 21A–C); b, reduced, about 5 per cent of length of stylomere 2 (*loc. cit.*, 142, fig. 10B); c., absent.

10. Abdominal tergum VIII, extent of sclerotization of dorsal surface.—Four states: plesiotypic, sclerotization continuous medially at anterior margin, desclerotized more posteriorly in a narrow longitudinal or transverse band (Fig. 24); three apotypic states—a, hypertrophied, tergum VIII completely sclerotized medially (Fig. 7); b, medial desclerotized area more extensive, though lateral sclerotized areas with extensive medial projection (Fig. 25); c, medial desclerotized area still more extensive, sclerotized areas reduced to narrow lateral strips (Fig. 26).

The pattern for this character parallels that of sternum X, in that re-sclerotization seems to have taken place in celaenephine adults.

11. Anterior coxal cavities.—Two states: plesiotypic, uniperforate; apotypic, biperforate. The derived character state has been regarded as diagnostic of lebiines by most authors who have written about carabid classification (see, for example, Ball and Hilchie, 1983: 108). Thus, it was something of a surprise to find that adults of the supposedly lebiine genus *Celaenephes* are characterized by uniperforate cavities. It was even more surprising to find both uniperforate and biperforate anterior coxal cavities among the genera of Cymindina (coxal cavities biperforate in *Trichis* Klug and *Hystrichopus* Boheman; uniperforate in *Cymindis* [subgenera *Pinacodera* Schaum and *Cymindis sensu stricto*]). Withough a thorough examination of the distribution of states of this character among lebiines, it is impossible to determine unequivocally how to classify the former. Because of the many plesiotypic states exhibited by *Celaenephes* adults, it seems reasonable to hypothesize that the uniperforate cavities of its adults were inherited from the common ancestor of the lebiines, whereas for the subgenera of *Cymindis* (moderately highly derived taxa within a moderately highly derived subtribe) the coxal cavities have probably become uniperforate secondarily, the result of an evolutionary reversal. In fact, however, the uniperforate condition is listed in Table 1 as only plesiotypic.

12. Relative size of right paramere.—Two states: plesiotypic, right paramere about as long as left (see Habu, 1967: 252, fig. 489); apotypic, right paramere much smaller than left, adnate or not to basal part of median lobe.

13. Male genitalia, median lobe, sclerotization of dorsal surface.—Two states: plesiotypic, dorsum almost completely membranous (Figs. 5A and 6A); apotypic, much of dorsal surface sclerotized, membranous portion near preapical orifice, only.

14. Elytron, umbilical series, penultimate puncture.—Two states: plesiotypic, in line with adjacent punctures (Fig. 18B); apotypic, displaced laterally (*cf.* Ball and Hilchie, 1983: 119, fig. 27B).

15. Head: suborbital setae.—Two states: plesiotypic, absent; apotypic, present.

16. Ovipositor, stylomere 2, number of dorsal ensiform setae.—Three states: plesiotypic, two (or more) (Fig. 21B); two apotypic states—a, one; b, zero.

17. Ovipositor, form of stylomere 2.—Two states: plesiotypic, more or less falcate, dorsal margin curved (Fig. 21B); apotypic, not falcate (*cf.* Ball and Hilchie, 1983: 188, figs. 121A, 122A, 123A).

18. Left mandible, premolar tooth.—Two states: plesiotypic, tooth present; apotypic, tooth absent.

DISTRIBUTION OF CHARACTER STATES

Basilewsky (1984: 528) stated that *Celaenephes* is a platynine. Although his conclusion is based on symplesiotypy (characters 12, 13, 16, and 17) and is thus not valid in a phylogenetic system, we concede that the evidence for including *Celaenephes* in the Lebiini based on synapotypy (characters 01 and 02) is not very strong. (Added to the synapotypic features, we note the mid-tibial notches and sensory antennal pits of *Celaenephes,* which, being convergent with some lebiines, might be taken as slight evidence of an underlying similar genetic potential, and hence relationship). Furthermore, the Platynini, as generally diagnosed in terms of adult features, seems to lack synapotypic character states, and so might be a paraphyletic assemblage, one line of which might be the sister group of the Lebiini. Be that as it may, acquisition of the full complement of apotypic features of the Lebiini was likely additive, with new states developing and being incorporated one by one. Thus, a platynine lineage with the features of *Celaenephes* could very well have been the founder stock of the Lebiini, and we believe that this is so. Consequently, we regard *Celaenephes* as a lebiine, without denying its platynine affinities.

The distribution of apotypic character states (Table 1) shows that *Celaenephes* is markedly different from the groups of lebiines with which it has been associated. The characters with apotypic states in *Celaenephes* are over-represented in this study, however, simply because attention is focused on this group. Nonetheless, *Celaenephes* is basically a primitive lineage as shown by the states of characters 11–18. The long secretory groove of the mandibles is also interpreted as plesiotypic within lebiines, though it is apotypic compared to platynines. All features considered, Habu (1982) was well justified in deciding to place *Celaenephes* in a subtribe remote from the Dromiina, and removed from other lebiine subtribes as well.

RELATIONSHIPS OF THE CELAENEPHINA

To establish fully our conclusion that the subtribe Celaenephina exhibits a predominantly plesiotypic combination of character states within its tribe, it might seem necessary to undertake a phylogenetic analysis of the tribe Lebiini. We cannot do so now, though we can offer reference to some published evidence which we think offers adequate support for our conclusion. The single best source is Basilewsky's (1984) remarkable paper that provides figures of the stylomeres for all the groups with which he was familiar (and this includes almost all of the known lebiine stocks), plus reference to other character systems; nonetheless, we do not endorse fully his classification nor his basically typological methods for establishing it. His presentation shows that all of the lebiine groups not referred to in

Table 1. Selected characters and phylogenetic classification and distribution of their states among Platynini and selected subtribes of Lebiini.

Characters		Taxa and Character States[1]				
			Lebiini			
No.	Designation	Platyn.	Celaen.	Perical.	Cymind	Dromina
18	L. Mand: premolar tooth	o	o	o	a^-	o
17	♀ Stylomere 2: form	o	o	o	a^-	a^{--}
16	♀ S2: No. dors. ens. setae	o	o	o	a^-	a^{--}
15	Head: suborbital setae	o	o	a	o	o
14	El: umbil. set. punct.	o	o	a	o	o
13	♂ Med. lobe: scl. dors. surf.	o	o	a	a	a
12	♂ Parameres: relative size	o	o	a^-	a^-	a^-
11	Ant. Coxal Cavities	o	o	a	a,o[2]	a
10	Tergum VIII: sclerotization	o	a^+	a^-	a^-	a^-
09	♀ S2: length nematoid setae	o	a^+	o	a^-	a^-
08	Elytra: form of apex	o	a	o	a	a
07	El: apical marg. microsetae	o	a	o	o,a[3]	o
06	L. Mand: terebral tooth	o	a^{--}	o	a^{--}	o
05	Sternum X: sclerotization	o	a	o	o	o
04	L. Mand: ant. ret. tooth	o	a	o	o	o
03	Ant. 4–11: sensory pits	o	a	o	o	o
02	Mandibles: secretory groove	o	a	a	a^-	a^-
01	Tergum VIII: form lat. margin	o	a	a	a	a

[1] Designation of character states: o plesiotypic; a apotypic; a^+ apotypic, hypertrophy; a^- apotypic, reduction; a^{--} apotypic, loss.

[2] Genus *Cymindis*, only.

[3] Subgenus *Cymindis*, only.

detail above, are structurally more highly derived than the celaenephines, and that none of the former exhibit combinations of character states that would serve to link them closely to the Celaenephina.

Evolution of Structural Features

Although *Celaenephes* may represent an early lineage of Lebiini, adults have acquired some striking features. Perhaps most interesting is the series of sensory pits on the antennomeres. Possible antecedents for such have not been observed in the Lebiini, though the same sorts of structures are characteristic of adults of *Euproctinus* (Shpeley, manuscript in preparation), and *Parena* (tentatively, subtribe *Metallicina*).

A feature that has evolved within *Celaenephes* rather than in the ancestral stock of the genus is the notched middle tibia (Fig. 19), which is characteristic of males of *C. parallelus*. Such tibiae are also characteristic of males of several other lebiine groups, none of which seem to be closely related to one another. Ball and Shpeley (1983: 800) suggested that these tibial notches might be fitted to the edges of female elytra during copulation, thereby improving the ability of a male to cling to the female with which it is mating. Whatever their function, these notches have evolved a number of times in the course of lebiine phylogeny.

The mandibles, though retaining a basically primitive number of teeth and arrangement of ridges, have become distinctive by development of one extra projection on the left mandible, designated as the anterior retinacular tooth. The terebral tooth, on the other hand, has been lost, a feature shared with cymindines and many other lebiine genera. On the ventral surface of each mandible is a secretory groove in which pores are located. From the latter, filaments project, which appear to be secretions. Such grooves occur on the mandibles of other groups of carabids, such as the Harpalini and Oodini. Evidently, this character has evolved independently in each of the taxa in which it occurs.

The maxillae are remarkable in development of setae on galeomere 2. This seems to be an autapotypic feature of *Celaenephes*. The ligula has also become specialized, with development of the broad and broadly adnate paraglossae.

Taken together, these features indicate rather markedly modified mouthparts. Since this structural complex is involved in obtaining and ingesting food, it seems reasonable to infer that adults of *Celaenephes* either have evolved a markedly distinctive diet, or have a distinctive manner of obtaining and manipulating particles of food.

Additional sclerotization characterizes the posterior part of the body (tergum VIII and sternum X). This seems to be a reversal of a trend in lebiines to reduce sclerotization. Significance of this reversal is not understood.

The stylomeres of the ovipositor, which retain a basically plesiotypic form, have evolved very long nematoid setae. These may be involved with a distinctive mode or place of oviposition, though we cannot offer more detailed suggestions about this topic. The reproductive tract (Fig. 11) is also peculiar, with its very short *bursa copulatrix* and markedly enlarged spermatheca. These structural features are suggestive of a distinctive mode of sperm transfer or storage, but details are not known.

At a more general level, Table 1 shows that of 18 characters studied in detail, most of the derived states involve reduction or loss. Within lebiines, such changes have occurred many times. We suggest, in fact, that evolution of this tribe has been concerned principally with changes in food, feeding, elaboration of defensive mechanisms, and oviposition. (Development of an arboreal way of life is another major trend, but we need not address it because the features considered in this study seem not to be correlated with life above the ground.) We believe that most of the losses and reductions are manifestations of changed, rather than lost, functions. (See, for example, Ball and Hilchie [1983: 110–111] for comments about evolution of the ovipositor.) Consequently, we think that such manifestations are as valuable as obvious structural evolutionary gains, and are thus of substantial use in working out phylogenetic relationships.

CELAENEPHES AND *CYMINDIS* (*SENSU STRICTO*)

An alternative view of the relationships of *Celaenephes* favored by one of us (R.B.M.), is that this genus is a highly aberrant derivative of *Cymindis*. This situation has probably been caused by some unusual, and as yet unknown, habits.

The sensory pits of the antennae, the long nematoid seta, and the extra ensiform setae on the second stylomere, the abundant setae on the first stylomere, and the covering of short bristles on the 10th abdominal sternum are very specialized, particularly in regard to oviposition. The changes in the female genitalia could have been reflected in the male median lobe by desclerotization. They may also account for the unusually large differences in the shape of the apex of the median lobe of the two species. Secondary fusion of the hemitergites of the eighth abdominal tergum could be part of the same process. Changes in structure of the mandibles and maxillae are also seen as an adaptation to a different way of life. Both the mouthparts and the genitalia are regarded as being highly responsive to changing circumstances, and thus of limited value in classification.

In general structure *Celaenephes* seems to be markedly similar to *Cymindis* (*sensu stricto*), as illustrated by the following features: brown color, pronotal shape, uniperforate front coxal cavities, pubescent elytra, and simple tarsomere 4. The simple tarsal claws are not far removed from the slightly serrate claws of *Cymindis.* Especially interesting is the rounded, non-sinuate elytral apex of *Celaenephes* and some *Cymindis,* and the apical fringe of microsetae, which in the Lebiini, apparently only these two groups possess.

Concluding Statement

We believe that the data presented demonstrate that the genus *Celaenephes* includes two species, rather than a single one. The combination of character states of *Celaenephes* shows that this taxon probably cannot be included with those lebiine subtribes with which it was associated by authors prior to Habu (1982). So, some of the dark clouds enshrouding the genus seem to have been dispersed. However, a new series of questions has emerged, another layer of cloud, involving environmental partitioning by the closely related species of the genus, and the functional correlates of the remarkable structural features of the adults. The immature stages remain unknown, and their character states will no doubt be of value in testing the hypotheses of relationships proposed here. If *Celaenephes* represents the earliest-evolved extant stock of lebiines, further study of the group ought to provide evidence about the nature of the first stages of the lebiine radiation, and clues about the still earlier ancestral stock of this strikingly diverse tribe of carabids. Because of the potential phylogenetic importance of *Celaenephes,* further study along the lines indicated above ought to prove very rewarding. We hope that some resident of the vast area encompassed by the range of this genus will extend this study.

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LITERATURE CITED

Allen, R. T. and G. E. Ball. 1980. Synopsis of Mexican taxa of the *Loxandrus* series (Coleoptera: Carabidae: Pterostichini). Trans. Am. Entomol. Soc. 105: 481–576.

Andrewes, H. E. 1919. On the types of Oriental Carabidae in the British Museum, and in the Hope Department of the Oxford University Museum. Trans. R. Entomol. Soc. Lond. Pp. 119–217.

———. 1923. On the types of Carabidae described by Schmidt-Goebel in his *Faunula Coleopterorum Birmaniae.* Trans. R. Entomol. Soc. Lond. Pp. 1–63.

———. 1927a. Papers on Oriental Carabidae—XX. Ann. Mag. Nat. Hist. Series 9, 20: 263–272.

———. 1927b. Carabidae, *in* Insects of Samoa, Part IV. Coleoptera. Pp. 1–14.

———. 1929. Fauna Sumatrensis. (Beitrag Nr. 64). Carabidae (Col.). Tijdschr. Entomol. 72: 303–340.

———. 1930a. Catalogue of Indian Insects. Part 18—Carabidae. Government of India. Pp. 1–389.

———. 1930b. Fauna Buruana, Coleoptera, Fam. Carabidae. Treubia 7, suppl.: 331–347.

———. 1947. Entomological results from the Swedish expedition 1934 to Burma and British India. Ark. Zool. 38A (20): 1–49, plates I–VI.

Ball, G. E. 1975. Pericaline Lebiini: notes on classification, a synopsis of the New World genera, and a revision of the genus *Phloeoxena* Chaudoir (Coleoptera: Carabidae). Quaest. Entomol. 11: 143–242.

Ball, G. E. and G. J. Hilchie. 1983. Cymindine Lebiini of authors: redefinition and reclassification of genera (Coleoptera: Carabidae). Quaest. Entomol. 19: 93–216.

Ball, G. E. and D. Shpeley. 1983. The species of eucheiloid Pericalina: classification and evolutionary considerations (Coleoptera: Carabidae: Lebiini). Can. Entomol. 115: 743–806.

Basilewsky, P. 1984. Essai d'une classification supragénérique naturelle des Carabides Lébiens d'Afrique et de Madagascar. (Coleoptera Carabidae Lebiinae). Rev. Zool. Afr. 98(3): 525–559.

Bates, H. W. 1886. On the Geodephagous Coleoptera collected by Mr. George Lewis in Ceylon. Ann. Mag. Nat. Hist. Series 5, 17: 68–81, 143–156, 199–212.

———. 1892. Viaggio di Leonardo Fea in Birmania e regioni vicine. LXIV. List of the Carabidae. Ann. Mus. Civ. Stor. Nat. Genova Serie 2 12: 340–428.

Blackburn, T. 1894. Notes on Australian Coleoptera with descriptions of new species. Part XV. Proc. Linn. Soc. N. S. W. Series 2, 9: 85.

Bouchard, J. 1903. Insectes recueillis par M. le professeur Dr Förster à Bornéo, Java et Sumatra (Palembang) Coléoptères Carabiques. Ann. Soc. Entomol. Fr. 72: 169–176.

Csiki, E. 1915. Carabidae von den Samoainseln. Denkschriften der Kaiserlichen Akademie der Wissenshaften Mathematisch Naturwissenschaftliche Klasse. Wien 91: 164.

———. 1932. Carabidae: Harpalinae VII, pars 124. Pp. 1279–1598 (Vol. III). *In* W. Junk and S. Schenkling (1909–1940), Coleopterorum Catalogus, 170 parts, 30 vols. Berlin and 's-Gravenhage.

Darlington, P. J., Jr. 1968. The carabid beetles of New Guinea Part III. Harpalinae (continued): Perigonini to Pseudomorphini. Bull. Mus. Comp. Zool. 137(1): 1–253.

———. 1970. Coleoptera: Carabidae including Cicindelinae. Insects of Micronesia 15(1): 1–49.

Erwin, T. L. 1974. Studies on the subtribe Tachyina (Coleoptera: Carabidae: Bembidiini), Part II: a revision of the New World—Australian genus *Pericompsus* LeConte. Smithson. Contrib. Zool., No. 12, Washington, D.C. iv + 96 pp.

Habu, A. 1960. Notes and descriptions of the Carabidae from Mt. Hiko and its vicinity (Coleoptera). Esakia 2: 3–6.

———. 1967. Fauna Japonica. Carabidae Truncatipennes Group (Insecta: Coleoptera). Biogeographical Society of Japan, Tokyo Electrical Engineering College Press. Pp. 1–338, 27 plates.

———. 1982. Revised and supplementary notes on and descriptions of the Truncatipennes group of Japan (I). (Coleoptera, Carabidae). Entomol. Rev. Japan 36(2): 85–142.

Jedlička, A. 1963. Monographie der Truncatipennen aus Ostasien. Lebiinae—Odacanthinae—Brachyninae (Coleoptera, Carabidae). Entomologische Abhandlungen und Berichte aus den staatlichen Museum für Tierkunde in Dresden, pp. 269–579, plates.

Lacordaire, J. T. 1854. Histoire Naturelle des Insectes. Genera des coléoptères ou exposé méthodique et critique de tous les genres proposés jusqu'ici dans cet ordre d'insectes, vol. 1. Paris 486 pp., illus.

Landin, B.-O. 1955. Entomological results from the Swedish expedition 1934 to Burma and British India. Coleoptera: Carabidae collected by René Malaise. Ark. Zool. (N.S.) 8: 399–472, plates I–III.

Liebherr, J. K. 1983. A cladistic analysis of *Agonum* and allied genera, with a systematic revision of the *A. extensicolle* species group (Coleoptera: Carabidae). Ph.D. Dissertation, Department of Entomology, The University of California, Berkeley.

Schmidt-Göbel, H. M. 1846. Faunula Coleopterorum Birmaniae, adjectis nonnullis Bengaliae indigenis. Lieferung 1. Prag. viii + 94 pp., plates 1–3.

Walker, F. 1858. Characters of some apparently undescribed Ceylon insects. Ann. Mag. Nat. Hist. Series 3, 2: 202–209, 280–286 [continued in Volume 3].

Watrous, L. E. and Q. D. Wheeler. 1981. The outgroup comparison method of character analysis. Systematic Zoology 30(1): 1–11.

Wiley, E. O. 1981. Phylogenetics. The theory and practice of phylogenetic systematics. John Wiley and Sons, New York, Chichester, Brisbane, Toronto xvi + 439 pp.

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87(2), 1985, pp. 308–316

A NEW GENUS AND NEW SPECIES OF DERAEOCORINAE FROM MEXICO AND PANAMA (HEMIPTERA: MIRIDAE)

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Abstract.—The following new taxa are described: ***Colimacoris occidentalis*** n. gen. and n. sp. from the state of Colima, Mexico; *Florus* ***englemani*** n. sp. and *Lundiella* ***panamensis*** n. sp. from Panama. The adult habitus and male genitalia are illustrated. A key to the members of the genus *Florus* is presented.

Studies on the mirid fauna of Mesoamerica continue to uncover many new and interesting forms. Members of the subfamily Deraeocorinae seldom occur in numbers in collections and consequently are not particularly well known. Recent collecting in Mexico by the senior author has revealed an undescribed genus and species belonging to the tribe Hyaliodini which are described herein. Two additional species belonging to other genera of this subfamily are described from Panama from material made available to us by Dr. Dodge Engleman.

Colimacoris NEW GENUS

Hyaliodini, Deraeocorinae. Characterized by the eyes located well remote from margin of pronotum, pronotum constricted in middle, hemelytron with a row of punctures along claval vein and on embolar suture, presence of 2 areolar cells, and the smooth membrane.

Body shining, bearing erect and semierect hairs. Head smooth, wider than long; eyes small, located anteriorly on head, removed from pronotum by distance equal to almost length of eye; vertex, frons and clypeus convex; vertex with narrow, shallow middorsal sulcus which forks anteriorly with each arm extending to antennal socket; frons projecting slightly anterior to antennal sockets as seen from above; jugum, lorum and clypeus in lateral view projecting conspicuously anterior to antennal socket; gena reduced; buccula prominent. Antennal socket touching eye; antennal segments linear, segment I distinctly longer than head width, segments III and IV shorter than I. Rostrum reaching midcoxae.

Pronotum shallowly punctate, constricted at middle; collar about as long as diameter of antennal segment I; calli contiguous, raised, smooth; lateral margins of pronotum rounded, posterior margin more or less straight. Mesoscutum exposed. Scutellum prominent. Hemelytron hyaline, embolium glabrous except for row of hairs along outer margins, wider than diameter of antennal segment I and delimited over ½ its length by row of prominent punctures; another row of similar punctures running along claval vein; length of cuneus less than 1½ × width; membrane clear, not appearing granulate with 2 cells with the larger one with a short

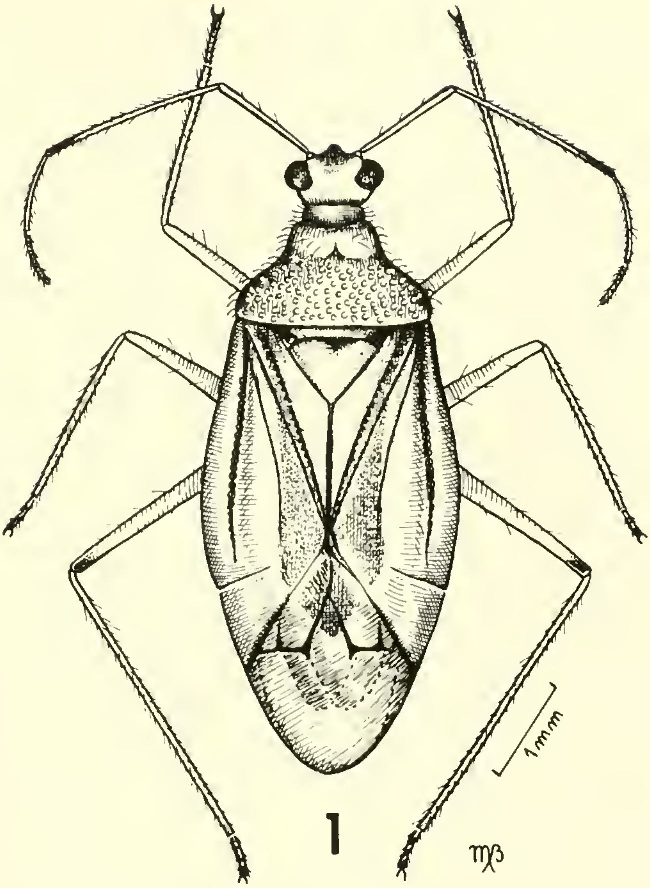


Fig. 1. *Colimacoris occidentalis* n. sp., male.

vein extension or diffused area on external side of apical angle. Legs long, femora and tibiae cylindrical.

Type species: *Colimacoris occidentalis* n. sp.

Colimacoris most closely resembles the well known genus *Hyaliodes* Reuter. Dorsally, the head of *Colimacoris* has the frons rounded and clearly extending anteriorly beyond the anterior margin of the eye. Species of *Hyaliodes* have the frons more flattened and it does not project beyond the anterior margin of the eye. The anterior part of the pronotum of *Colimacoris* is flatter and not as narrow as that of *Hyaliodes.* The hemelytron of *Colimacoris* has a row of punctures running along the entire length of the claval vein, the relatively wider embolium has hairs only along the margins, the membrane is not granulate and there are two areolar cells in the membrane. In contrast, species of *Hyaliodes* lack the row of punctures along the claval vein, have hairs in the middle of the relatively narrower embolium, the membrane is granular in appearance and only one areolar cell is present. A single female from near Jilotepec, Veracruz, representing an undescribed second species of *Colimacoris,* agrees in all features although the vein between the two areolar cells is not as well formed.

The genus is named after the state in Mexico in which the type species was collected. The name is masculine.

Colimacoris occidentalis New Species

Figs. 1–4

Male (measurements taken from 17 specimens; those of holotype given first followed in parentheses by average and ranges): Length, 6.10 mm (5.61 mm, 5.02–6.20 mm); width, 2.24 mm (2.06 mm, 1.92–2.28 mm). Head length, 0.52 mm (0.54 mm, 0.50–0.58 mm); width through eyes, 0.86 mm (0.85 mm, 0.80–0.88 mm); vertex width, 0.46 mm (0.46 mm, 0.44–0.48 mm). Length of antennal segment I, 1.22 mm (1.15 mm, 1.08–1.26 mm); II, 1.80 mm (1.72 mm, 1.56–1.84 mm); III, 1.02 mm (1.00 mm, 0.88–1.12 mm); IV, 0.40 mm (0.46 mm, 0.40–0.52 mm). Pronotal length, 1.06 mm (1.07 mm, 1.00–1.16 mm); width, 1.68 mm (1.57 mm, 1.48–1.68 mm). Cuneal length, 0.90 mm (0.91 mm, 0.82–1.02 mm); width, 0.68 mm (0.64 mm, 0.58–0.76 mm).

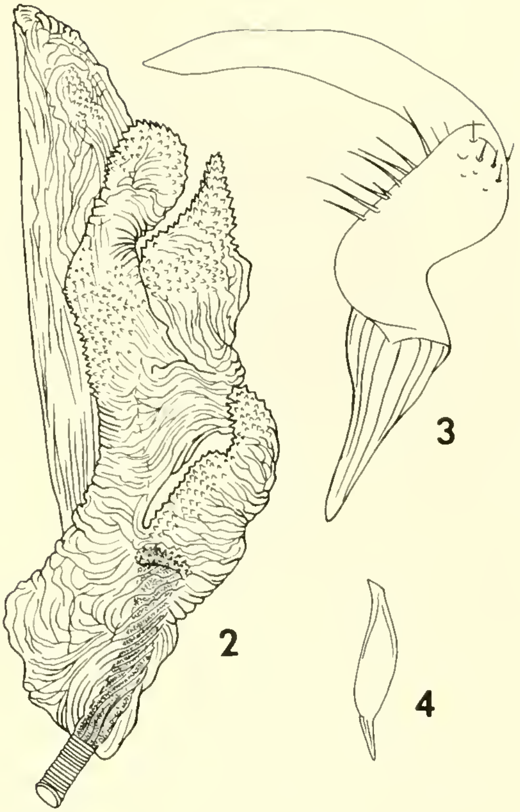
General coloration pale with light fuscous markings. Head pale to light brown with anterior grooves of sulcus fuscous thereby forming light inverted V on frons; apex of antennal segment II and sometimes basal inner margin of segment I fuscous, remainder of antenna pale; rostrum pale. Pronotum pale, punctures slightly darker; collar almost white; spot on humeral angle, line along posterior margin of collar and horizontal line above coxal cleft fuscous; lateral margins of mesoscutum dark fuscous, remainder pale. Scutellum pale, occasionally with small fuscous spot near apex. Hemelytron clear with faint spot at base, another larger one or two located near center of corium; row of punctures along claval vein; claval commissure and inner margin of corium extending along inner margin of cuneus fuscous; membrane clear, occasionally with veins fuscous; spot above base of mesocoxa dark fuscous, remainder of thoracic pleural and sternal areas and abdomen pale.

Genitalia: Aedeagus (Fig. 2) with four lobes; left paramere (Fig. 3) elongate, curved, with elongate dorsal setae; right paramere (Fig. 4) small, pointed apically.

Female (measurements taken from 10 specimens; the average is given first followed in parentheses by the ranges): Length, 5.97 mm (5.56–6.50 mm); width, 2.28 mm (2.14–2.54 mm). Head length, 0.56 mm (0.52–0.62 mm); width through eyes, 0.86 mm (0.84–0.92 mm); vertex width, 0.46 mm (0.42–0.50 mm). Length of antennal segment I, 1.02 mm (0.78–1.16 mm); II, 1.63 mm (1.36–1.88 mm); III, 0.97 mm (0.82–1.08 mm); IV, 0.49 mm (0.42–0.52 mm). Pronotal length, 1.09 mm (1.06–1.16 mm); width, 1.67 mm (1.60–1.82 mm). Cuneal length, 0.96 mm (0.90–1.06 mm); width, 0.73 mm (0.62–0.74 mm).

Similar to male in form and color.

Holotype: MEXICO: Jalisco, Nevado de Colima road, 7 mi. w hwy. junct. (near Atenquique), August 5, 1978, Plitt & Schaffner. Deposited in the collection of the Instituto de Biologia, Universidad Nacional Autonoma de Mexico, Mexico City, D. F. *Paratypes:* 8 ♂, 3 ♀, same data as holotype; ♂, MEXICO: Jalisco, 16 km. n. Autlan, July 31–August 2, 1978, Plitt & Schaffner; 2 ♂, ♀, Colima, 9 mi. ne. Comala, July 17–18, 1983, Kovarik, Harrison, Schaffner; 7 ♂, 6 ♀, Colima, 10 mi. ne. Comala, July 17–19, 1983, Kovarik, Harrison, Schaffner. Deposited in the National Museum of Natural History, Washington, D.C.; the collection of the De-



Figs. 2–4. *Colimacoris occidentalis* n. sp. 2, Aedeagus. 3, Left paramere. 4, Right paramere.

partment of Entomology, Texas A&M University, College Station, Texas; and the J. C. M. Carvalho collection, Rio de Janeiro, R. J., Brazil.

Florus englemani New Species
Figs. 5–9

Male (holotype): Length, 3.02 mm; width, 1.56 mm. Head length, 0.10 mm; width through eyes, 0.64 mm; vertex width, 0.32 mm. Length of antennal segment I, 0.23 mm; II, 0.84 mm; III & IV missing. Pronotal length, 0.74 mm; width, 1.22 mm. Cuneal length, 0.40 mm; width, 0.56 mm.

General coloration pale and dark brown. Head brown, clypeus, antennae and rostrum pale. Thorax dark brown, evaporative area pale; hemelytron with clavus and adjacent area of corium down to apex of scutellum, outer edge of embolium including embolar suture, cuneus dark brown, remainder of wing pale; legs pale. Abdomen pale white.

Body glabrous dorsally, underside of embolium and cuneus with short scattered hairs. Second antennal segment linear, somewhat incrassate, hairs more or less scattered equally along length of segment. Rostrum reaching mid coxae. Pronotum convex, strongly punctate.

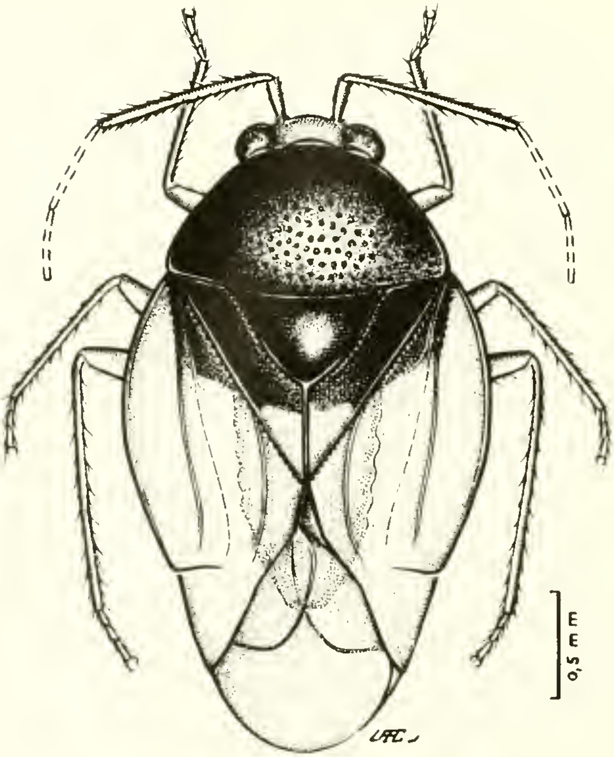


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Fig. 5. *Florus englemani* n. sp., male.

Genitalia: Aedeagus (Fig. 6) with branched membranous lobes; left paramere (Fig. 7) elongate, recurved apically, with dorsal setae; right paramere (Fig. 8) small; pygophore (Fig. 9) with characteristic anal tube.

Female (paratype): Length, 3.54 mm; width, 1.68 mm. Head length, 0.10 mm; width through eyes, 0.66 mm; vertex width, 0.32 mm. Length of antennal segment I, 0.22 mm; II, 0.60 mm; III and IV missing. Pronotal length, 0.84 mm; width, 1.28 mm. Cuneal width, 0.42 mm; length, 0.52 mm.

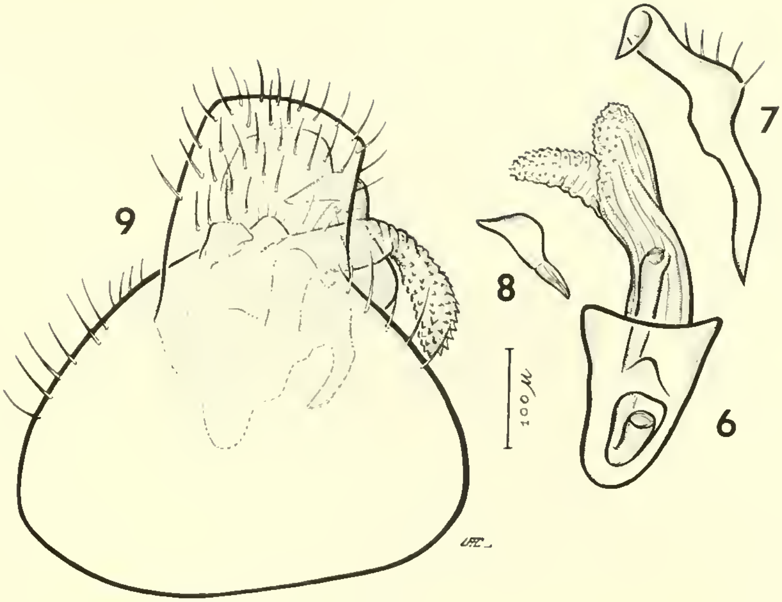
Similar to male in color and morphology. Second antennal segment slender at base becoming thicker apically, hairs more concentrated on apical half.

Holotype: ♂, PANAMA—Chiriqui, Fortuna, 1050 m., 8°44′N; 82°15′W, 2-IV-1978, Henk Wolda. Deposited in the National Museum of Natural History, Washington, D.C. *Paratype:* ♂, Panama, CZ, Fortuna, V′77, H. Wolda coll. Deposited in the collection of the Department of Entomology, Texas A&M University, College Station, Texas.

This species is named in honor of Dodge Engleman who generously made this and other material available to us for study.

Following is a key to the known species of the genus *Florus*:

1. Scutellum more or less uniformly brownish or black in color 2
– Scutellum not uniformly brown or black in color 4



Figs. 6–9. *Florus englemani* n. sp. 6, Aedeagus. 7, Left paramere. 8, Right paramere. 9, Pygophore, ventral view.

2. Pronotum uniformly dark brown; corium lacking a medially located transverse fascia . . . . *englemani* n. sp.
– Pronotum not uniformly dark colored; corium with a transverse fascia . 3
3. Corial fascia continuous; pronotum pale only along posterior margin . . . . *insolitus* Distant
– Corial fascia broken at middle; pronotum mostly pale with two transverse dark fasciae . . . . *vitreus* (Stal)
4. Scutellum with black middorsal line; clavus with four small black spots . . . . *vittiscutellatus* Carvalho
– Scutellum lacking a black middorsal line; clavus without four small black spots 5
5. Cuneus with dark spot; disc of pronotum with middle line located posteriorly and hind margin pale . . . . *vittifrons* Carvalho
– Cuneus unicolorous; disc of pronotum with median line, two oblique spots and hind margin pale . . . . *bolivianus* Carvalho & Gomes

Lundiella panamensis NEW SPECIES

Figs. 10–13

Male (measurements taken from 13 specimens; those of holotype given first followed in parentheses by average and ranges): Length, 2.94 mm (2.86 mm, 2.70–3.00 mm); width, 1.62 mm (1.57 mm, 1.44–1.70 mm). Head length, 0.14 mm (0.14 mm, 0.12–0.18 mm); width through eyes, 0.78 mm (0.78 mm, 0.76–0.80 mm); vertex width, 0.32 mm (0.32 mm, 0.30–0.34 mm). Length of antennal segment I, 0.24 mm (0.24 mm, 0.22–0.26 mm); II, 0.80 mm (0.78 mm, 0.74–

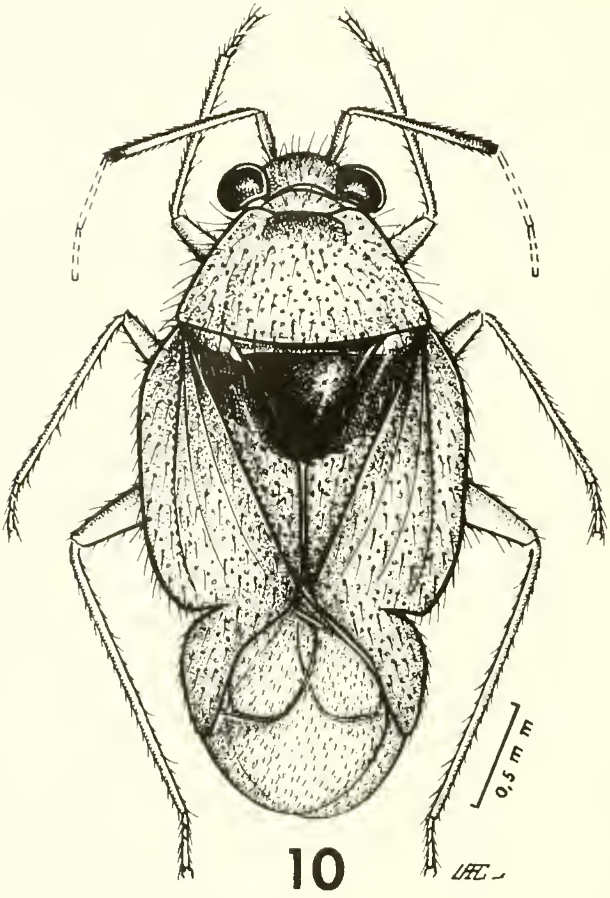
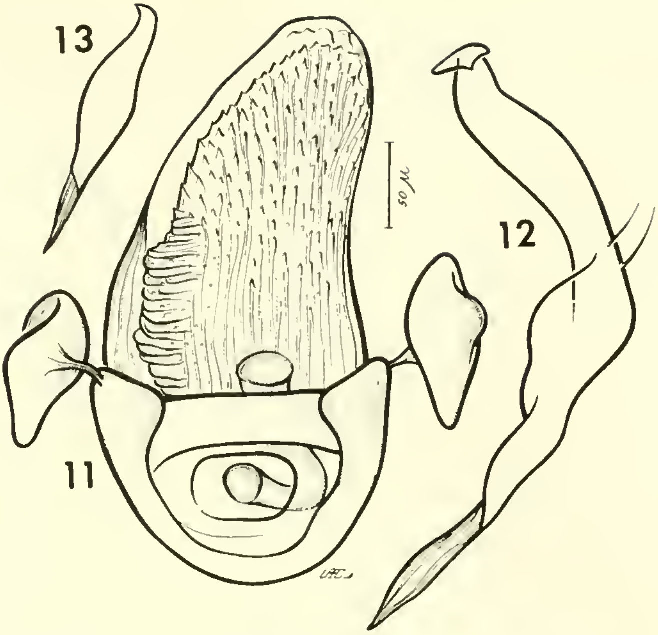


Fig. 10. *Lundiella panamensis* n. sp., male.

0.80 mm); III, 0.40 mm (0.38 mm, 0.36–0.40 mm); IV, 0.34 mm (0.34 mm, 0.26–0.38 mm). Pronotal length, 0.82 mm (0.79 mm, 0.74–0.82 mm); width, 1.22 mm (1.22 mm, 1.18–1.28 mm). Cuneal width, 0.56 mm (0.56 mm, 0.52–0.60 mm); length, 0.40 mm (0.39 mm, 0.36–0.42 mm).

General coloration light brown and lutescent with dark fuscous to black markings. Head, antennae, pronotum except for posterior margin, pro-, meso- and metathoracic legs apical to base of femur pale to light brown; posterior margin of pronotum and occasionally posterior edge of lateral margin, hemelytron except for area immediately adjacent to scutellum, lutescent; scutellum, area of hemelytron immediately adjacent to scutellum, meso- and metapleura, meso- and metacoxae, meso- and metatrochanters and bases of femora immediately adjacent to trochanters and posterior area of abdomen dark fuscous to black; basal ⅔ of wing membrane light fuscous, remainder pale.

Pubescence of body consisting of elongate erect and semierect hairs; a few hairs on antennal segment I, most hairs on segments III and IV longer than diameter of segment, those of segment II about as long or shorter than diameter of segment; hairs of pro- and mesotibiae longer than diameter of segment, those of metatibiae



Figs. 11–13. *Lundiella panamensis* n. sp. 11, Aedeagus. 12, Left paramere. 13, Right paramere.

as long as or shorter than diameter of segment; membrane of hemelytron with closely set, short but conspicuous hairs. Second antennal segment linear. Rostrum reaching apices of mesocoxae.

Genitalia: Aedeagus (Fig. 11) simple, with membranous lobes bearing sclerotized minute teeth; left paramere (Fig. 12) elongate, curved, with characteristic apical end; right paramere (Fig. 13) small.

Female: Unknown.

Holotype: ♂, PANAMA, Bocas d.T., Corriente Grande 100 m, 9°17′30″N; 82°32′41″W, March 18–23, 1980, Henk Wolda. Deposited in the National Museum of Natural History, Washington, D.C. *Paratypes:* 2 ♂, same data as holotype; 2 ♂, same data as holotype except April 2–8, 1980; 3 ♂, same data as holotype except April 12–14, 1980; 2 ♂, same data as holotype except April 20–25, 1980; 2 ♂, same data as holotype except April 27–28, 1980. Deposited in the National Museum of Natural History, Washington, D.C.; the collection of the Department of Entomology, Texas A&M University, College Station, Texas; and in the J.C.M. Carvalho collection, Rio de Janeiro, R. J., Brazil.

By virtue of its coloration, *Lundiella panamensis* exits at couplet 5 in the key to members of the genus (Carvalho and Capriles, 1982) along with *L. amazonica* Carvalho and *L. peruana* Carvalho and Capriles. The width of the head and the length of antennal segment II are approximately the same in *L. panamensis* and *L. amazonica* whereas the second antennal segment of *L. peruana* is twice the length of the head width. The black coloration on the hemelytron of *L. amazonica* extends onto the embolium but is limited to no more than the base of the clavus in the case of *L. panamensis.* The genitalia of the three species also differ.

ACKNOWLEDGMENTS

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LITERATURE CITED

Carvalho, José C. M. and J. Maldonado Capriles. 1982. Neotropical Miridae, CCXXVIII: Genus *Lundiella* Carvalho with descriptions of new species (Hemiptera). Rev. Brasil. Biol. 42(1): 55–61.

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MALE BEES SPORT BLACK MUSTACHES FOR PICKING UP PARSNIP PERFUME (HYMENOPTERA: ANTHOPHORIDAE)

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Abstract.—Groups of males of the nearctic *Anthophora abrupta* Say (Apoidea: Anthophorini) chew parsnip tissue, collect the odorous juice in unique adsorptive labral mustaches of fine, flattened hairs, and apply it to surrounding objects, apparently mixed with their mandibular gland secretion. Such perfumed areas outline an oval flight path. This resembles the fragrance-collecting and territorial behavior of male neotropical orchid bees (Apidae: Euglossinae).

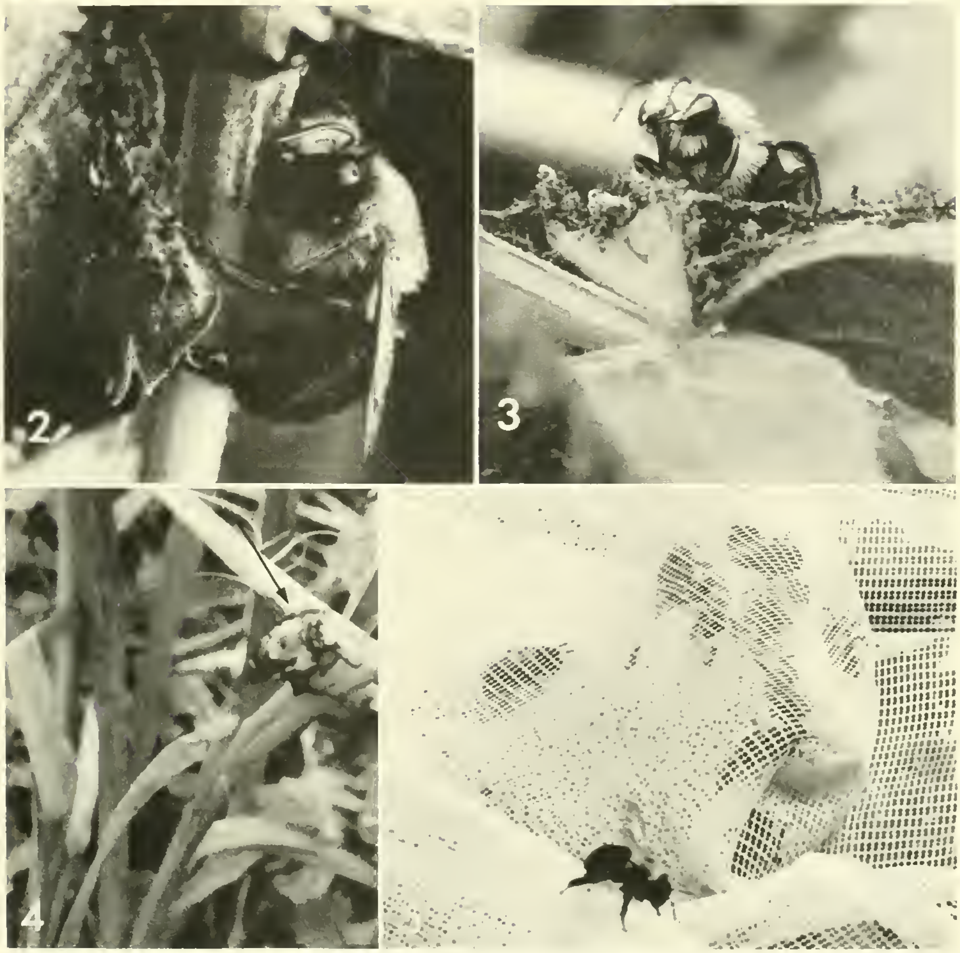
The neotropical orchid bees (Apidae: Euglossinae) are well known for the unusual behavior of the males that collect fragrances from flowers and elsewhere. Using special pads of adsorptive hairs on their front feet, they brush the surface, then pack the collected fragrance into special hair-lined cavities in their hind tibiae. These perfumes are evidently used to maintain territories (Dodson, 1973; Dressler, 1982). The fragrances may also be sequestered for use in producing male mandibular gland attractant pheromones (Williams and Whitten, 1983). Similar behavior, not previously known among any other bees, is here reported to occur in the nearctic species, *Anthophora abrupta* Say (Anthophoridae: Anthophorinae).

A large solitary bee, *A. abrupta* nests in dense aggregations in vertical clay banks or adobe walls (Frison, 1923; Rau, 1929; Norden et al., 1980; Norden, 1984). Little is known of the sexual behavior of this species. Mating was not seen at the nesting site, although occasional males followed and pounced on females returning from the field. Caged insects mated on flowers (Norden, 1984).

For several years, Jean Worthley (pers. comm.) noticed *A. abrupta* visiting a patch of naturalized parsnips at her farm in Owings Mills, Baltimore County, Maryland. On the sunny mornings of June 15 and 17, 1982, and June 11, 14, and 21, 1984, we visited the site, where we observed and filmed the unique male behavior described here. Both years, male *A. abrupta* were clustering on a parsnip plant (*Pastinaca sativa* L.) growing in partial shade under a loblolly pine about 75 m from the nest site and 18 m from a small pool where females were ingesting water. Neighboring plants that had been previously defoliated by the bees bore many brown, necrotic lesions on their stems. Neither male nor female bees were visiting the flowers of these parsnips; nor were any bees of either sex seen on several cultivated parsnips growing in a sunny garden 50 m away. In 1983, males also visited parsnips at the shady site, but not those in the garden (J. Worthley, pers. comm.). Males, individually marked while on the parsnip, were observed to return to the plant after 1–1.5 hours.

Fig. 1. Cluster of four male *A. abrupta* chewing on parsnip leaves and petioles. Note portions of leaves that have been shredded by the bees.

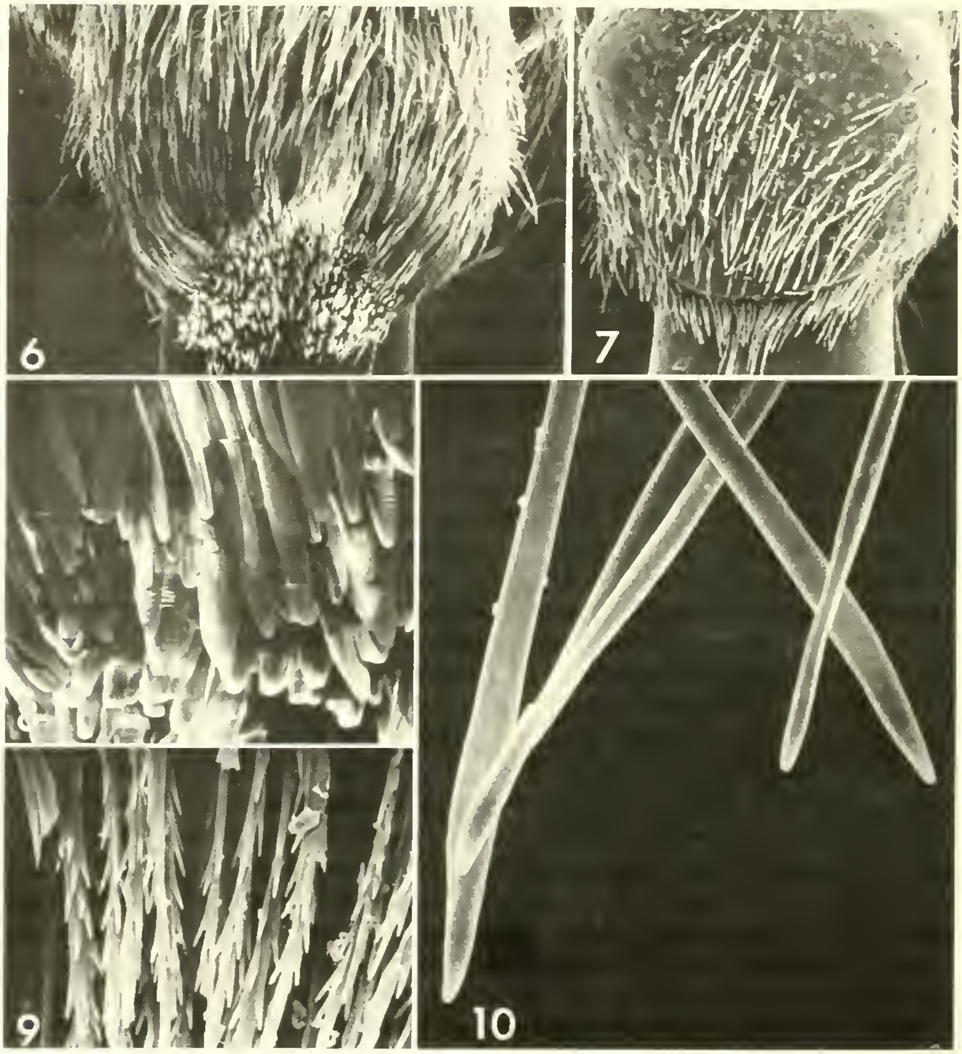
The male bees alternately chewed the parsnip tissue for 11–86 s and periodically raised their heads for 2–7 s. Chewing bouts were often terminated when incoming bees butted or alighted nearby. Previously chewed areas were preferentially visited. When a much-chewed parsnip was removed and replaced with a fresh plant, bees visiting the area did not chew on the new plant, but instead located broken, chewed sprigs of the old plant lying on the ground. As many as 65 males at a time were seen simultaneously chewing on the parsnip's leaves, petioles, or stem (Fig. 1). During the chewing phase, the bee's antennae were directed toward the substrate (Fig. 2); these normally alert, active bees lost their wariness and could be touched by hand. This resembles the oblivious behavior of certain fragrance-collecting



Figs. 2–5. Behavior of *A. abrupta.* 2, Male with deflected antennae, intently chewing on a parsnip petiole. 3, Male on bee-damaged leaf, with his head raised and proboscis partly unfolded as he champs his mandibles while packing parsnip juice into his labral mustache. 4, Male (arrow) applying parsnip odor to grass stem. 5, Female attracted to a netful of females.

male orchid bees (Dressler, 1982). Males marking objects were much more alert than those that were chewing on parsnip, and could not be touched or approached within about 30 cm. During the brief head-lifting phase (Fig. 3), the mandibles were rapidly vibrated or champed and the proboscis was partly unfolded, apparently to help drive the plant's juices in among the mustache hairs.

Males also chewed on the broken ends of dry, dead stems (Fig. 4) in a clump of *Panicum* growing in partial shade about 4 m from the parsnip. Another cluster of males was found among grasses in full sun about 30 m from the parsnip. The *Panicum* stems that had been chewed smelled distinctly of parsnip odor; unchewed stems had no such odor. When a chewed stem was moved 15 cm away, several males located and chewed on it. Males also marked two auto bumpers, an *Amaryllis* plant, and a honeysuckle bush. They followed the bumpers and *Amaryllis*



Figs. 6–10. Labrum and labral hairs of *Anthophora* spp. 6, Labrum of male *A. abrupta* bearing dense mustache (×40). 7, Mustachcless labrum of male *A. occidentalis* as typical of other Anthophorini (×40). 8, Densely packed hairs of *A. abrupta* mustache (×550). 9, Branched, nonspecialized labral hairs of male *A. occidentalis* (×550). 10, Isolated mustache hairs of *A. abrupta* (×750). These smooth hairs have flattened tips that may enhance adsorption by capillarity.

when they were moved 1–3 m. The group of parsnips, bumpers, *Amaryllis*, honeysuckle, and grass locations formed an oval area measuring approximately 190 m × 25 m. This oval area was upwind (prevailing) of most female activity. All marked objects were within 1 m of the ground. No females were attracted to the males on the parsnip or to those marking elsewhere; however, females (but not males) were attracted to other females confined in a net near the parsnips (Fig. 5), and two females were attracted to a group of netted males taken to the pool.

Dissection of several males revealed that their mandibular glands produced a distinct, sweet fragrance. A similar-smelling, geraniol-like mandibular gland se-

Fig. 11. Male *A. abrupta* marking the rubber bumper of an automobile. The dark patches (arrows) are droplets observed to be deposited when males abrade the surface with their mandibles and then rub the area with their saturated mustaches.

cretion of *Anthophora occidentalis* Cresson attracts other males (Batra, 1978). Male *A. abrupta* are unique in possessing a labral mustache of fine black hairs (Figs. 6–10 and Brooks, 1983). This mustache smelled strongly of parsnip odor in specimens that were collected as they chewed on the parsnip, bumpers, or grass. Some tattered and presumably old males bore mustaches that had a central bald area where hairs had evidently worn off during chewing and marking. The specialized mustache hairs are densely packed and apically flattened, apparently to increase capillary adsorption of the parsnip juice. Certain oil-collecting bees also have flattened or otherwise specialized hairs (Vogel, 1971, 1981; Simpson et al., 1977; Roberts and Vallespir, 1978; Neff and Simpson, 1981; and Dressler, 1982).

An examination of males and females of 81 species of Anthophorini (76 *Anthophora,* two *Habropoda,* two *Clisodon,* and one *Microanthophora*) in the collection of the U.S. National Museum of Natural History revealed no other mustache-bearing species. Males of 52 species, however, bore sometimes elaborate brushes on their mid- and hindtibiae or tarsi that may serve a similar perfume gathering and distributing function. Thus, it appears that *A. abrupta* males are unique among Anthophoridae and second only to the Euglossinae in their use of plant fragrances in probable combination with mandibular gland pheromones to demarcate territories (Fig. 11).

Because parsnip is a recent immigrant of Eurasian origin, the preference of male *A. abrupta* for this plant is puzzling. Perhaps these native bees originally used a native species of Umbelliferae. However, they did not visit *Daucus* or *Cryptotaenia* growing in the garden. Specialized phytophagous insects apparently use the toxic furanocoumarins of Umbelliferae as host-recognition cues (Berenbaum, 1981a). It is interesting that *A. abrupta* prefers parsnips growing in shade, which produce fewer furanocoumarins than those growing in the sun (Berenbaum, 1981b). Rau (1929) observed groups of male *A. abrupta* persistently chewing on rusty slag at a barren patch of ground about 100 m from a nest site. These males quite possibly were marking a territory similar to the one we have observed.

ACKNOWLEDGMENTS

We thank Jean and Elmer Worthley for calling our attention to the bees visiting parsnip, for their observations, and their hospitality. We also thank Norita Chaney, Agricultural Research Service, USDA, who provided expert assistance with the SEM studies, and Jack Neff, Central Texas Melittological Institute, Austin for reviewing the manuscript.

LITERATURE CITED

Batra, S. 1978. Aggression, territoriality, mating and nest aggregation of some solitary bees (Hymenoptera: Halictidae, Megachilidae, Colletidae, Anthophoridae). J. Kans. Entomol. Soc. 51: 547–559.

Berenbaum, M. 1981a. Patterns of furanocoumarin production and insect herbivory in a population of wild parsnip (*Pastinaca sativa* L.). Oecologia 49: 236–244.

———. 1981b. Patterns of furanocoumarin distribution and insect herbivory in the Umbelliferae: plant chemistry and community structure. Ecology 62: 1254–1266.

Brooks, R. 1983. Systematics and bionomics of *Anthophora*: the *bomboides* group and species groups of the New World. Univ. Calif. Publ. Entomol. 98: 1–86.

Dodson, C. 1973. Co-evolution of orchids and bees. Pp. 91–99. *In* L. Gilbert and P. Raven, eds., Coevolution of animals and plants. Univ. Texas Press, 246 pp.

Dressler, R. 1982. Biology of the orchid bees (Euglossini). Ann. Rev. Ecol. Syst. 13: 373–394.

Frison, T. 1923. Notes on the life history, parasites and inquiline associates of *Anthophora abrupta* Say, with some comparisons with the habits of certain other Anthophorinae (Hymenoptera). Trans. Am. Entomol. Soc. 48: 137–156.

Neff, J. and B. Simpson. 1981. Oil-collecting structures in the Anthophoridae (Hymenoptera): morphology, function, and use in systematics. J. Kans. Entomol. Soc. 54: 95–123.

Norden, B. 1984. Nesting biology of *Anthophora abrupta* (Hymenoptera: Anthophoridae). J. Kans. Entomol. Soc. 57: 243–262.

Norden, B., S. Batra, H. Fales, A. Hefetz, and G. Shaw. 1980. *Anthophora* bees: unusual glycerides from maternal Dufour's glands serve as larval food and cell lining. Science 207: 1095–1097.

Rau, P. 1929. The biology and behavior of mining bees, *Anthophora abrupta* and *Entechnia taurea*. Psyche 36: 155–181.

Roberts, R. and S. Vallespir. 1978. Specialization of hairs bearing pollen and oil on the legs of bees (Apoidea: Hymenoptera). Ann. Entomol. Soc. Am. 71: 619–627.

Simpson, B., J. Neff, and D. Seigler. 1977. *Krameria*, free fatty acids and oil-collecting bees. Nature 267: 150–151.

Vogel, S. 1971. Ölproduzierende Blumen, die durch ölsammelnde Bienen bestäubt werden. Naturwissenschaften 58: 58–59.

———. 1981. Abdominal oil-mopping—a new type of foraging in bees. Naturwissenschaften 67: 627–628.

Williams, N. and W. Whitten. 1983. Orchid floral fragrances and male euglossine bees: methods and advances in the last sesquidecade. Biol. Bull. 164: 355–395.

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A NEW SPECIES OF *AMPLYPTERUS* FROM THE CHISOS MOUNTAINS, TEXAS (LEPIDOPTERA: SPHINGIDAE)

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Abstract.—Amplypterus **blanchardorum,** new species, is described from the Chisos Mountains, Texas. It is differentiated from its nearest allies, *A. donysa* (Druce) and *A. globifer* Dyar. This is the first record of the genus *Amplypterus* from the United States.

André Blanchard (1973: 103) incorrectly reported *Amplypterus donysa* (Druce) as a new U.S. record for the genus and species from Big Bend National Park. In early June 1973, I had an opportunity to work in the same area and collected additional specimens of the same species. Some time after my return I tried to associate them with *A. donysa* and found that they differed from *donysa* and from *Amplypterus globifer* Dyar, another closely similar species, both from Central America. Subsequently, I have studied genital preparations of the three species and have found differences in these characters. Thus, I feel warranted in proposing a name for this showy, and apparently extremely uncommon, moth resident of the United States.

The 11 described species of *Amplypterus* occur variously from Mexico (Tampico and Baja California), Cuba, and Hispaniola south to Argentina (Schreiber, 1978: 47).

My limited observation (three specimens on two nights) on the species may indicate why it has been infrequently collected. It appears to be attracted to black light on the bright side of dusk. When D. C. Ferguson (Systematic Entomology Lab., USDA, Washington, D.C.) and I had set up our sheets with the lights going before dusk, moths came to the sheets. As the light decreased, no specimens were seen. Additional observation of the species is needed before any generalization about its attraction to light can be made.

It gives me great pleasure to name this species after André and May Elise Blanchard who first collected it and who have added so much to our knowledge of the Lepidoptera of Texas.

Amplypterus blanchardorum Hodges, New Species
Figs. 1–16

Description.—Color pattern as in Figs. 1 and 4. Upper surface of forewing mainly gray green, extreme base pale yellowish gray, lunule dark greenish brown, posterior margin just beyond medial line bluish gray; base of hindwing red be-

Figs. 1–3. Maculation of *Amplypterus* species. 1, *A. blanchardorum*, holotype male. 2, *A. donysa*, male. 3, *A. globifer*, holotype male.

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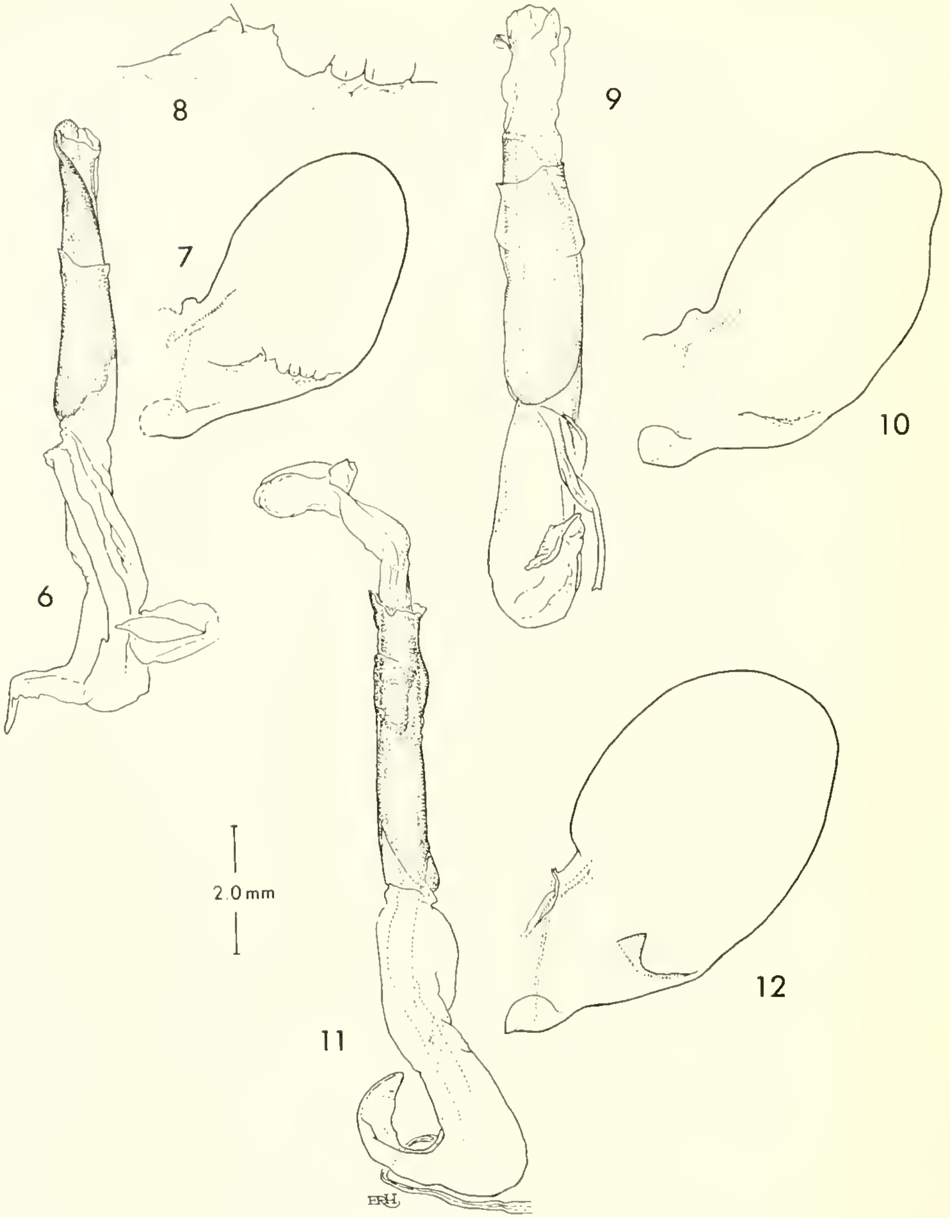
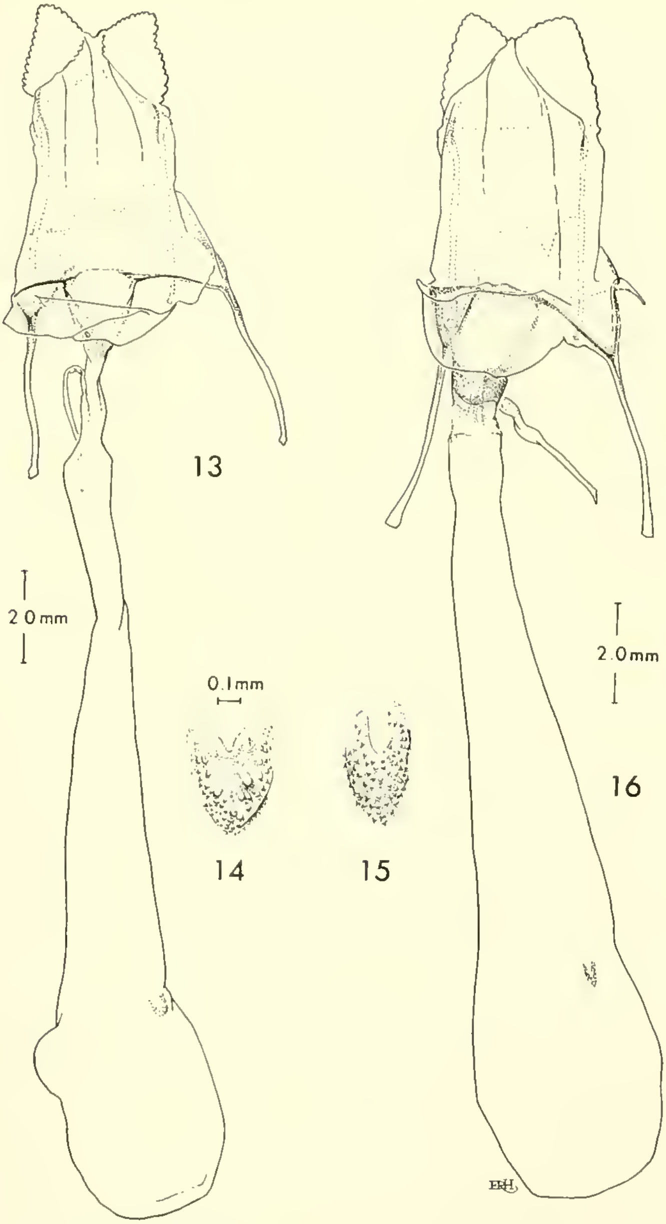
Figs. 4–5. Maculation of *Amplypterus* species. 4, *A. blanchardorum*, paratype female. 5, *A. donysa*, female.



Figs. 6–12. Male genitalia of *Amplypterus* species. 6–8, *A. blanchardorum*: 6, aedeagus, 7, right valva, 8, enlargement of sacculus. 9, 10, *A. donysa*: 9, aedeagus, 10, right valva. 11, 12, *A. globifer*: 11, aedeagus, 12, right valva.

coming paler toward outer margin, dark mark in anal area dark greenish brown, immediately preceded and followed by pale yellowish gray. Ventral surface of wings mainly pale grayish green with yellow or gold cast at anal angles, forewing pale red from near base to half wing length medially. Head mainly pale yellowish gray, labial palpus greenish brown on ventral surface, a greenish-brown zone from



Figs. 13–16. Female genitalia of *Amplypterus* species. 13–14, *A. blanchardorum*: 13, genitalia, 14, enlargement of signum. 15–16, *A. donysa*: 15, enlargement of signum, 16, genitalia.

base of antenna to vertex. Thorax pale yellowish gray dorsally, dark areas greenish brown. Abdomen greenish brown followed by pale yellowish gray then pale grayish green, a faint medial line on segments 2–6. Legs with coxa, trochanter, and femur concolorous with ventral surface of thorax; tibia and tarsus pale grayish yellow with pink cast. Wing length: ♂, 43–45 mm; ♀, 49–53 mm. Genitalia as in Figs. 6–8, 13, 14.

Types.—Holotype: ♂; Texas, Brewster Co., Chisos Mts., Panther Pass, 6000′; 4 June 1973; R. W. Hodges. USNM. Paratypes: 1♂, 1 ♀; Texas, Brewster Co., Chisos Mts., Green Gulch, 5500′; R. W. Hodges. 1 ♂; same locality, 5400′; 13 May 1972; J. G. Franclemont. 3 ♂, 1 ♀; same locality; 3, 6, 12 May 1972, 2 June 1973; A. & M. E. Blanchard. BMNH, USNM.

Discussion.—*Amplypterus blanchardorum* can be separated from *donysa* and *globifer* by the combination of characters: In *blanchardorum* the upper surface of the forewing has the medial line continuous, extending to the posterior margin and the antemedial line running to the medial line; the hindwing has a dark greenish-brown mark in the anal area followed, toward the apex, by a diffuse area of dark-gray, almost black scales. In *donysa* the forewing (Figs. 2, 5) has the antemedial and medial lines extending to the posterior margin; the hindwing has the greenish-brown mark followed by black scales in a distinct pattern that extends along the veins to the margin. In *globifer* (Fig. 3) the forewing has the medial line incomplete, not reaching the posterior margin and the antemedial line running to the medial line; the hindwing is similar to that of *blanchardorum*. In the male genitalia of *blanchardorum* (Figs. 6–8) the costal margin of the valva is nearly evenly rounded from the base to the apex; the sacculus is developed as a short ridge with setae or setal bases on the terminal margin. In *donysa* (Figs. 9, 10) the valva is evenly rounded; the sacculus is scarcely developed as a slight fold. In *globifer* (Figs. 11, 12) the costal margin of the valva is straight at the base then abruptly arched and curved to the apex; the sacculus is well developed as a flange that lacks setae or setal bases. The female of *blanchardorum* (Figs. 13, 14) has the base of the ductus bursae narrow, less than half the width of the ostium bursae; the signum is broadly arrow shaped and has large and small, narrowly conical, inwardly directed projections. In *donysa* (Figs. 15, 16) the base of the ductus bursae is broad, about ⅔ the width of the ostium bursae; the signum is more narrowly arrow shaped, and the inwardly directed cones are evenly graduated from short to very short. The female of *globifer* is unknown. The immature stages of *blanchardorum* are unknown.

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I thank my wife, Elaine R. S. Hodges, for the line drawings that illustrate diagnostic features of the moths, and I thank Victor Kranz, Smithsonian Institution, for the photographs of the moths.

LITERATURE CITED

Blanchard, A. 1973. Record and illustration of some interesting moths flying in Texas (Sphingidae, Ctenuchidae, Noctuidae, Notodontidae, Geometridae, Pyralidae, Cossidae). J. Lepid. Soc. 27: 103–109.

Schreiber, H. 1978. Dispersal centres of Sphingidae (Lepidoptera) in the Neotropical Region. Biogeographica 10: [i]–vi, 1–195, f. 1–68.

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CLASTRIEROMYIA, A NEW NEOTROPICAL GENUS OF PREDACEOUS MIDGES RELATED TO *PALPOMYIA* AND *BEZZIA* (DIPTERA: CERATOPOGONIDAE)

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Abstract.—***Clastrieromyia*,** a new neotropical genus of predaceous midges related to *Palpomyia* and *Bezzia* is described and illustrated from female specimens. Males and immature stages are unknown. This new genus includes two new species, ***schnacki*** from Ecuador as type-species, and ***kremeri*** from Brazil.

All of the genera of the predaceous midge tribe Palpomyiini inhabiting North and South America have recently been reviewed: Dow and Turner (1976), Wirth (1983a, 1983b), Wirth and Grogan (1983), and Wirth et al. (1984) on *Bezzia*; Grogan and Wirth (1979) on *Palpomyia*; Grogan and Wirth (1980) on *Pachyhelea*; Wirth and Grogan (1982) on *Phaenobezzia*; and a new genus, *Amerohelea*, was recently described by Grogan and Wirth (1981). In addition, the senior author and Willis W. Wirth have nearly completed a review of the neotropical *Bezzia* and the present authors are engaged in a study of the neotropical *Palpomyia*.

During the present study of the neotropical *Bezzia* and *Palpomyia* in the collection of the National Museum of Natural History, Washington, D.C., we encountered two undescribed species from Ecuador and Brazil that cannot be placed in any of the ceratopogonid genera in the tribe Palpomyiini. Because they possess a combination of characters and some new characters not present in any of the other Palpomyiini genera we propose a new genus for them in this paper.

For an explanation of general ceratopogonid terminology see Downes and Wirth (1981); for special terms dealing with genera in the tribe Palpomyiini, see Grogan and Wirth (1979, 1981).

The holotypes of the two new species are deposited in the collection of the National Museum of Natural History (USNM), in Washington, D.C. Paratypes will be deposited in the Canadian National Collection, Ottawa; British Museum (Natural History), London; Museum National d'Histoire Naturelle, Paris; Museo de La Plata, La Plata, Argentina; the Museu de Zoologia da Universidade de Sao Paulo, Brazil; the California Academy of Science, San Francisco; and the Florida Collection of Arthropods, Gainesville.

We thank Willis W. Wirth of the Systematic Entomology Laboratory, Agricultural Research Service, USDA, and Wayne N. Mathis of the Department of Entomology, Smithsonian Institution, for the opportunity to study the collections under their care. To Dr. Wirth we are further indebted for critically reviewing the manuscript. The senior author (GRS) gratefully acknowledges support from the Consejo Nacional de Investigaciones Cientificas y Tecnicas de la Republica Argentina. We thank also the Salisbury State Foundation for a publication grant.

Clastrieromyia Spinelli and Grogan, New Genus

Type-species, *Clastrieromyia schnacki* Spinelli and Grogan, by present designation.

Diagnosis.—A genus of medium sized predaceous midges of the tribe Palpomyiini distinguished from all other ceratopogonid genera by the following combination of characters: Wing with two radial cells, the second 3.7–4.4 times longer than the first, arcuate distally and extending 0.92–0.98 of wing length; media barely sessile, forking at r-m crossvein; anal lobe broad and angulate; cell R_5 with intercalary vein. Scutum without anterior spine or tubercle. Fourth tarsomeres subcylindrical, not cordate. Claws equal, without basal inner teeth. Abdomen of female with only a single pair of gland rods arising mesally from the posterior margin of sternite 6 and extending to the anterior margin of sternite 6; 2 spermathecae with minute hyaline perforations; sternite 10 with a single pair of large setae at posterior margin. Palpus very short, barely extending beyond tip of proboscis. Flagellum of antenna short, 1.2–1.3 times longer than breadth of head. Male and immature stages unknown.

Comparison with other genera.—The most unique and distinctive characters of *Clastrieromyia* that distinguish it from other Palpomyiini genera are to be found in its wing. The barely sessile media that forks at the r-m crossvein is identical to the barely sessile media of many groups of *Bezzia* Kieffer, i.e., the *bivittata* group. However, the wings of all species of *Bezzia* differ from those of *Clastrieromyia* in having a single radial cell, a gently rounded anal lobe and lacking an intercalary vein in cell R_5 (Dow and Turner, 1976; Wirth and Grogan, 1983).

The wing of *Palpomyia* Meigen and *Pachyhelea* Wirth are similar to *Clastrieromyia* in possessing two radial cells, and in fact some of the species in the *tibialis* group of *Palpomyia* have a long second radial cell that extends beyond 0.9 of wing length, for example *P. subaspera* (Coquillett), and *P. aspina* Grogan and Wirth. However, the wings of *Pachyhelea* and all species of *Palpomyia* differ from those of *Clastrieromyia* in having a broadly sessile M (Grogan and Wirth, 1979, 1980).

All species of the recently described New World genus *Amerohelea* Grogan and Wirth possess only a single pair of gland rods in the female abdomen, but these gland rods differ from those of *Clastrieromyia* in arising from the lateral margins of sternite 6 and extending more than one segment in length. *Amerohelea* also differs from *Clastrieromyia* in having a single spermatheca, a wing with a broadly sessile media, a gently rounded anal lobe, shorter costal ratio and lacking an intercalary vein in cell R_5 (Grogan and Wirth, 1981).

Phaenobezzia Haeselbarth differs from *Clastrieromyia* in possessing a wing with a single radial cell, a broadly sessile M, a gently rounded anal lobe and lacking an intercalary vein in cell R_5 (Wirth and Grogan, 1982).

The subcylindrical fourth tarsomeres of *Clastrieromyia* further serve to distinguish it from the above mentioned genera in the Palpomyiini, all females of which have cordate fourth tarsomeres.

Etymology.—The genus is named in honor of our good friend and colleague Dr. Jean Clastrier of the Laboratoire d'Entomologie, Muséum National d'Histoire Naturelle, Paris, France. His excellent illustrations and descriptions of palearctic *Palpomyia* (Clastrier, 1962) proved invaluable to one of us (WLG) during an earlier study of the nearctic species of that genus.

***Clastrieromyia* schnacki Spinelli and Grogan, New Species**

Fig. 1

Diagnosis.—Distinguished from its only known congener *C. kremeri* n. sp., by its non-spinose fore femur, smaller size (wing length 1.36–1.42 mm), longer second radial cell (extending 0.98 of wing length), and smaller antennal ratio (1.06–1.11). *C. kremeri* differs from *C. schnacki* in having a spinose fore femur, larger size (wing length 1.55–1.65 mm), shorter second radial cell (extending 0.92–0.96 of wing length), and larger antennal ratio (1.29–1.46).

Female.—Wing length 1.38 (1.36–1.42, n = 5) mm; breadth 0.58 (0.56–0.62, n = 5) mm.

Head: Dark brown. Eyes bare, broadly separated (Fig. 1c) for a distance equal to the diameter of 3.5 ommatidial facets. Antennal flagellum (Fig. 1a) short, uniformly dark brown; lengths of flagellomeres in proportion of 25-14-13-13-13-13-13-14-23-25-24-25-34; antennal ratio 1.08 (1.06–1.11, n = 5). Palpus very short (Fig. 1b), dark brown, apices of segments whitish; lengths of segments in proportion of 8-15-13-12-11; palpal ratio 1.45 (n = 5); third segment with a few scattered mesoapical sensilla. Mandible (Fig. 1d) with 8 large coarse teeth.

Thorax: Uniformly dark brown; scutum without anterior spine or tubercle. Legs (Fig. 1f) slender, uniformly dark brown, except tarsomeres 1 and 2 (Fig. 1g) of mid and hindlegs yellowish brown; ventral palisade setae absent on fore and mid tarsi (Fig. 1g), in one row on basitarsus and distal ½ of tarsomere 2 of hindleg; a pair of strong ventral spines at apices of first three tarsomeres on midleg, smaller and paler on fore and hindlegs; hindtibial comb with 5 spines; hindtarsal ratio 2.35 (2.30–2.40, n = 5); fourth tarsomeres (Fig. 1h) subcylindrical; fifth tarsomeres (Fig. 1g) unarmed; claws equal (Fig. 1g, h), without internal basal tooth, longest on hindleg (Fig. 1h). Wing (Fig. 1e) whitish hyaline, anterior veins brownish, the others nearly imperceptible; 2 radial cells present, the 2nd very long and arcuate and extending nearly to wing tip; media just barely sessile, forking at r-m crossvein; cell R_5 with posterior branch of intercalary fork; anal lobe very well developed, broad and angulate; costal ratio 0.98 (n = 5). Halter pale brown.

Abdomen: (Fig. 1i) Dark brown, tapering abruptly distally. One pair of gland rods arising mesally from posterior margin of sternite 6 and extending only to anterior margin of sternite 6; sternites 8 and 9 as in *C. kremeri* (Fig. 2f); sternite 10 with a single pair of large setae as in *C. kremeri* (Fig. 2f). Two spermathecae (Fig. 1j) slightly unequal, the larger spheroid, the smaller ovoid with short necks and minute hyaline perforations, measuring 0.050 mm by 0.040 mm, and 0.045 mm by 0.035 mm including necks; a small vestigial third spermatheca present.

Male.—Unknown.

Distribution.—Ecuador.

Types.—Holotype female, Ecuador, Napo Prov., 20 km. W. Cuyabeno, 24-IV-1976, J. Cohen, light (Deposited in USNM). Paratypes, 29 females, as follows:

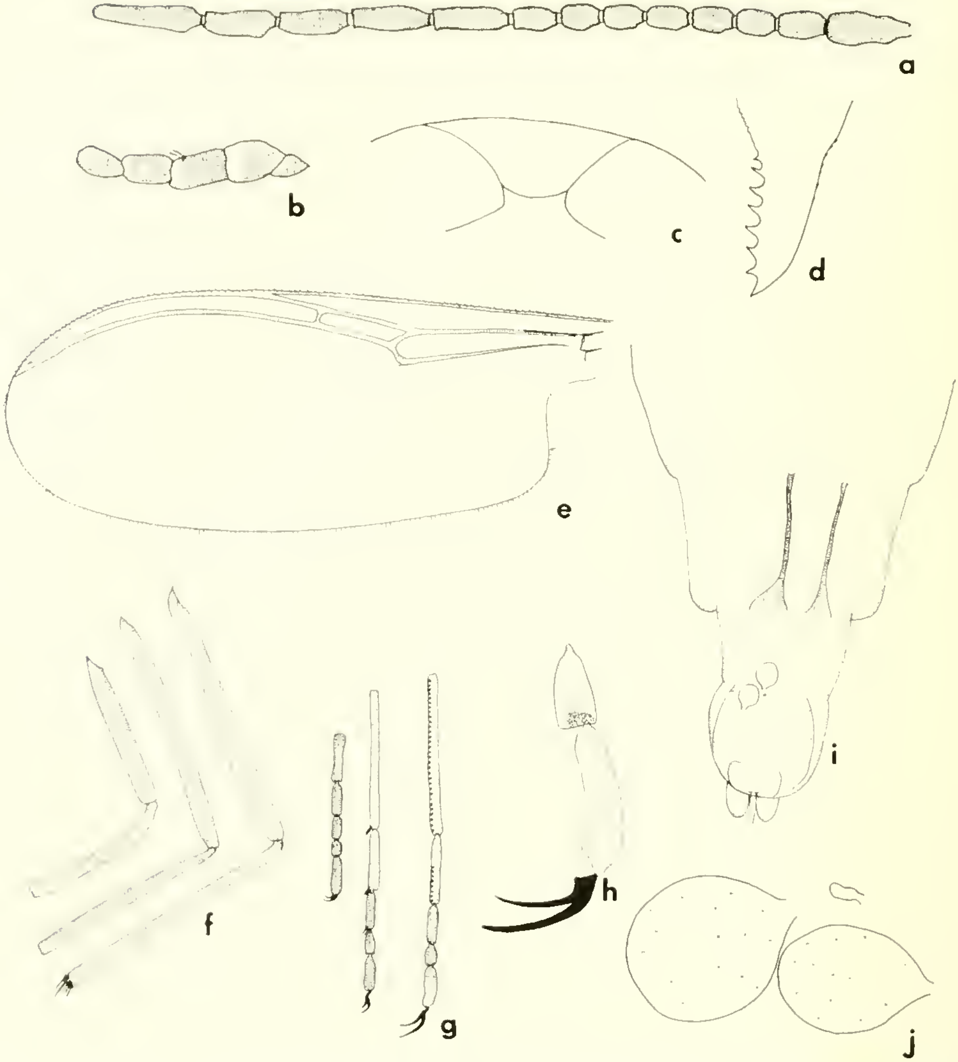

Fig. 1. *Clastrieromyia schnacki*, female. a, Flagellum. b, Palpus. c, Eye separation. d, Mandible. e, Wing. f, Femora and tibiae, from left to right fore, mid, and hindlegs. g, Tarsi, from left to right fore, mid, and hind tarsi. h, Hind fourth and fifth tarsomeres and claws. i, Abdomen. j, Spermathecae.

ECUADOR: same data as type, 15 females; Napo, Limoncocha, 15-VI-1977, P. J. Spangler and D. R. Givens, 14 females.

Discussion.—We are pleased to name this species in honor of Dr. Juan A. Schnack, Director of the Instituto de Limnologia "Dr. Raul A. Ringuelet," La Plata, Argentina.

Clastrieromyia kremeri Spinelli and Grogan, New Species

Fig. 2

Diagnosis.—Distinguished from its only known congener *C. schnacki* n. sp., by its spinose fore femur, larger size (wing length 1.55–1.65 mm), shorter second radial cell (extending 0.92–0.96 of wing length), and larger antennal ratio (1.29–

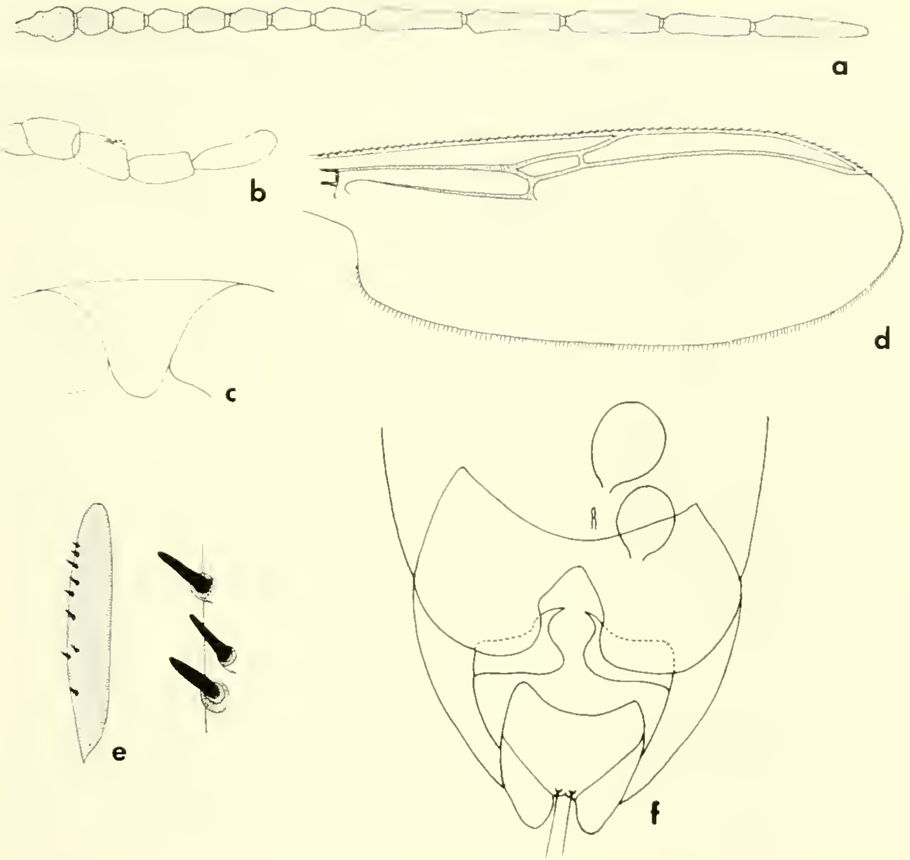

Fig. 2. *Clastrieromyia kremeri*, female. a, Flagellum. b, Palpus. c, Eye separation. d, Wing. e, Fore femur and enlargement of spines of fore femur. f, Genitalia.

1.46). *C. schnacki* differs from *C. kremeri* in having a non-spinose fore femur, smaller size (wing length 1.36–1.42 mm), longer second radial cell (extending 0.98 of wing length), and smaller antennal ratio (1.06–1.11).

Female.—Wing length 1.60 (1.55–1.67, n = 5) mm, breadth 0.63 (0.62–0.65, n = 5) mm.

Head: Brown. Eyes bare, separated (Fig. 2c) for distance equal to the diameter of 2.5 ommatidial facets. Antennal flagellum (Fig. 2a) short, uniformly brown; lengths of flagellomeres in proportion of 21-12-13-13-14-14-14-16-34-34-34-32-41; antennal ratio 1.42 (1.29–1.46, n = 5). Palpus short (Fig. 2b), uniformly pale brown; lengths of segments in proportion of 8-15-13-12-14; palpal ratio 1.70 (1.50–2.00, n = 5); third segment with scattered mesoventral sensilla. Mandible with 9–11 large coarse teeth.

Thorax: Brown, scutellum slightly paler; scutum without anterior spine or tubercle. Legs slender, uniformly dark brown except tarsomeres 1 and 2 of mid and hindlegs yellowish; fore femur (Fig. 2e) armed with 6–10 ventral spines; ventral palisade setae absent on foretarsus, in one row on basitarsus of midleg, in two rows on tarsomeres 1 and 2 of hindleg; a pair of strong ventral spines at apices of first three tarsomeres on midleg, smaller and paler on fore and hindlegs; hindtibial comb with 5 spines; hindtarsal ratio 2.30 (2.10–2.55, n = 5); fourth tarsomeres subcylindrical; claws equal without internal basal tooth, longest on hindleg. Wing (Fig. 2d) whitish hyaline, anterior veins pale yellow, the others nearly imperceptible; venation as figured, anal lobe very well developed, broad and angulate; cell R_5 with intercalary vein; costal ratio 0.94 (0.92–0.96, n = 5). Halter pale yellow.

Abdomen: Pale brown, tapering abruptly distally. One pair of gland rods, extending only to anterior margin of sternite 6 as in *C. schnacki* (Fig. 1i). Genitalia as Fig. 2f; sternite 8 concave on anterior margin, deeply notched posteriorly; sternite 9 with each arm pointed but well separated; sternite 10 with a single pair of large setae. Two oval spermathecae, unequal with short necks and minute hyaline perforations, measuring 0.069 mm by 0.055 mm, and 0.046 mm by 0.039 mm including necks; a small vestigial third spermatheca present.

Male.—Unknown.

Distribution.—Brazil (Amazonas).

Types.—Holotype female, Brazil, Amazonas, Rio Negro (Rio Itu), E. J. Fittkau, 11-II-1962, at light (Deposited in USNM). Paratypes, 15 females, as follows: same data as holotype, 13 females; same data except Rio Negro, 5-II-1962, 2 females.

Discussion.—We are pleased to name this new species in honor of Dr. Michel Kremer of the Institut de Parasitologie, Faculté de Médicine, Strasbourg, France.

LITERATURE CITED

Clastrier, J. 1962. Notes sur les Cératopogonidés. XVII. Nouveaux *Palpomyia* Meig. et *Johannsenomyia* Mall. de la Région Paléarctique. Arch. Inst. Pasteur Alger. 40: 225–288.

Dow, M. I., and E. C. Turner, Jr. 1976. A taxonomic revision of the Nearctic species of the genus *Bezzia* (Diptera: Ceratopogonidae). Va. Polytech. Inst. State Univ. Res. Div. Bull. 103: 1–162.

Downes, J. A. and W. W. Wirth. 1981. Chapter 28. Ceratopogonidae. Pp. 393–421. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Deptera. Vol. 1, Agric. Canada Monogr. 27. Ottawa. 674 pp.

Grogan, W. L., Jr. and W. W. Wirth. 1979. The North American predaceous midges of the genus *Palpomyia* Meigen (Diptera: Ceratopogonidae). Mem. Entomol. Soc. Wash. 8: 1–125.

———. 1980. The taxonomic status of the predaceous midge *Pachyhelea pachymera* (Williston) (Diptera: Ceratopogonidae). Proc. Entomol. Soc. Wash. 82: 74–80.

———. 1981. A new American genus of predaceous midges related to *Palpomyia* and *Bezzia* (Diptera: Ceratopogonidae). Proc. Biol. Soc. Wash. 94: 1279–1305.

Wirth, W. W. 1983a. A review of the North American predaceous midges of the *Bezzia nobilis* group (Diptera: Ceratopogonidae). Proc. Entomol. Soc. Wash. 85: 670–685.

———. 1983b. The North American species of the *cockerelli* and *dorsasetula* groups of the predaceous midge genus *Bezzia*, subgenus *Homobezzia* (Diptera: Ceratopogonidae). Proc. Entomol. Soc. Wash. 85: 762–782.

Wirth, W. W. and W. L. Grogan, Jr. 1982. The predaceous midges of the genus *Phaenobezzia* in North America (Diptera: Ceratopogonidae). Mem. Entomol. Soc. Wash. 10: 179–192.

———. 1983. The Nearctic species of the *Bezzia bivittata* group (Diptera: Ceratopogonidae). Proc. Biol. Soc. Wash. 96: 489–523.

Wirth, W. W., S. M. Palchick, and L. Forster. 1984. The North American predaceous midges of the *Bezzia annulipes* group (Diptera: Ceratopogonidae). Proc. Entomol. Soc. Wash. 86: 155–175.

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ASSOCIATIONS OF MITES AND TIGER BEETLES (COLEOPTERA: CICINDELIDAE) IN SOUTHEASTERN ARIZONA

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Abstract.—This study presents evidence of associations between mites and tiger beetles. Adult females of *Trochometridium tribulatum* Cross were found on larvae of *Cicindela willistoni* LeConte and *C. fulgoris* Casey. Hypopodes of *Sancassania* sp. were found on larvae of two species and adults of one species of *Cicindela*. Though not confirmed, the specific associations are probably phoretic. These associations may be due, in part, to the co-occurrence of these tiger beetle larvae in salt-flat habitats with ground-nesting bees which may be more common hosts.

Although associations between carabid beetles and mites are known (Regenfuss, 1968; Nickel and Elzinga, 1969; Green, 1975; Thiele, 1977; Olynyk and Freitag, 1979a, b), the occurrence of mites on tiger beetles, which are closely related to carabids, has been less commonly reported. In his significant study of the Cicindelidae of the central United States, Willis (1967) mentioned only three cases of mite associations, all with adult tiger beetles. He found many adults of *C. circumpicta* LaFerte with heavy infestations of larval trombidiids under the elytra and uropodid mites on the legs and thorax of two museum specimens of *C. sexguttata* Fabricius. He also cited Ingram's (1934) report of mites on the legs and thorax of adult *C. haemorrhagica* LeConte. Nagano (1980) found erythraeid mites of the genus *Leptus* on this same species, also in southern California. Three other mites reported from tiger beetles are *Andrevella parkeri* André (Erythraeidae), *Hoplothrombium* sp. and *H. cicindelae* Floch and Abonnenc (Trombidiidae) (Welbourn, 1983). These studies provide little or no information on the nature of the mite-beetle relationships, and are associations involving adult beetles.

The paucity of reports of mites on tiger beetle larvae is probably because this stage has been much less studied than adults. Larvae may be more suitable hosts for mites than adults because they have long life cycles (1–3 years) and live in permanent burrows in the ground. In such habitats they may co-exist with ground-nesting bees, which have frequently been reported as hosts of mites (Krombein, 1962; Batra, 1965; Cross, 1965; Cross and Bohart, 1969; Eickwort, 1979). Relationships between mites and bees are quite diverse and include parasitism, phoresy and saprophagy. For example, many acarids have a specialized heteromorphic deutonymphal instar, the hypopus, which is resistant to extreme environments (Krantz, 1978). *Pyemotes* are phoretic on adult bark beetles and may feed on any or all of the host immature stages (Cross and Moser, 1971; Moser et al., 1971). Some phoretic species feed on fungi growing on dead bees (Cross and Bohart, 1969) or pollen (Eickwort, 1979).

Table 1. Tiger beetle larvae and associated mites from the Sulphur Springs Valley, Arizona.

Host Species	Habitat Type	No. of Sites	No. Host Indiv.	Mites*	
				Troc.	Sancas
C. willistoni	Playa	3	148	+	0
C. fulgoris	Playa	4	131	+	+
C. viridisticta	Ditch edge	2	46	0	+
C. ocellata	Ditch edge	3	188	0	0
C. haemorrhagica	Pond edge	2	81	0	0
C. pulchra	Saltbush flat	3	59	0	0
C. lemniscata	Saltbush flat	4	85	0	0
C. debilis	Grassland	3	23	0	0
C. obsoleta	Grassland	2	106	0	0
C. marutha	Sand ridge	8	213	0	0

* + = mites present; 0 = not present.

During studies on the ecology of tiger beetles in southeastern Arizona, mites were found attached to larval and adult tiger beetles collected in the field. This paper presents results of these field surveys and laboratory observations. It adds to an initial report of *Trochometridium tribulatum* Cross on some larvae of this tiger beetle community (Knisley and Pearson, 1981).

MATERIALS AND METHODS

Most host beetles were collected during July and August of 1979–1983 in the Sulphur Springs Valley (Cochise Co.) of southeastern Arizona. This long, isolated valley is an area of internal drainage with a large, dry lake bed, the Willcox Playa, which drains the surrounding mountains (see Rumpp, 1977; Knisley and Pearson, 1984, for a more detailed description). With 20 species of tiger beetles this area has one of the highest cicindelid species densities in the United States.

Larvae of ten species of tiger beetles were surveyed in various habitats by visual search for larval burrows. A grass stem was placed into the burrow and the soil dug away to expose the larva. The larvae were placed in vials with soil, stored in the laboratory at 8–20°C for several hours, and subsequently examined under a dissecting microscope (at 20–50×) for attached mites. Most larvae were killed and fixed in hot 10% formalin (Maser, 1971) and stored in 75% ethanol. Other larvae were transferred to clear acryllic tubes (3 × 20 cm) filled with soil, for rearing and observation.

Adult tiger beetles were also collected, placed in killing jars, examined for attached mites and either pinned or preserved in ethanol. Representative mites were removed from adult and larval hosts and mounted in a modified Berlese medium (Krantz, 1978).

RESULTS

Over 1000 larvae representing ten or more individuals for each of ten species of *Cicindela* were collected from 30 sites and examined for mites (Table 1). Twenty or more adult tiger beetles of each of 17 *Cicindela* species totaling over 600 specimens were collected from 28 sites and examined for mites.

Two species of mites were found on larvae of three and on adults of one cicindelid species and from three sites (Table 2). Adult females of *Trochometrid-*

Table 2. Summary of number of mite species and hosts in southeastern Arizona.

Mite sp.	Host Species	Host Stage[1]	Site[2]	Year	Hosts No.	Hosts % Infec.	Mites No.	Mites No./Host	Mites Range
T. tri.	*fulg.*	2	a	80	7	0	0	0	0
T. tri.	*fulg.*	3	a	80	26	38.5	125	12.5	1–45
T. tri.	*fulg.*	2	c	80	12	0	0	0	0
T. tri.	*fulg.*	3	c	80	22	0	0	0	0
T. tri.	*will.*	2	a	80	34	26.5	85	10.6	2–26
T. tri.	*will.*	3	a	80	32	9.4	2.9	15.8	2–16
T. tri.	*will.*	2	b	80	15	0	0	0	0
T. tri.	*will.*	3	b	80	13	0	0	0	0
Sancas.	*fulg.*	3	c	80	9	11.1	3	3	3
Sancas.	*fulg.*	3	c	82	34	26.5	86	10.5	1–56
Sancas.	*pime.*	AM	c	79	22	0	0	0	0
Sancas.	*pime.*	AF	c	79	25	24.0	20	3.0	1–6
Sancas.	*pime.*	AM	c	80	22	4.5	1	1	1
Sancas.	*pime.*	AF	c	80	16	0	0	0	0
Sancas.	*viri.*	3	d	83	17	77.3	149	11.4	1–52

[1] AM = adult males, AF = adult females.

[2] Sites are all in Cochise County, Arizona as follows: a. 8.0 km WSW of Willcox (on Willcox Playa); b. 8.8 km WSW of Willcox (on Willcox Playa); c. 13 km WSW of Willcox (edge of Willcox Playa); d. 4 km N Kansas Settlement.

ium tribulatum Cross were found only at one site (a), the Willcox Playa, and only in one year, 1980, when both *C. willistoni* LeConte and *C. fulgoris* Casey were infested. Second and third instars of the former species and third instars of the latter species had mites. Interestingly, both species occurred together in the same microhabitat, though in other years *C. fulgoris* was along the playa edge and over 100 m from *C. willistoni.* Several other populations of these species at nearby similar sites (a, b) did not have mites (Table 2).

Hypopi of an acarid mite, *Sancassania* sp. were found at two sites on larvae of two and adults of one species of *Cicindela* (Table 2). Nine of 34 *C. fulgoris* third instars in 1982 and one of nine third instars in 1980 from a playa site different from that described above were infested with mites. At this same site several adults of *C. pimeriana* LeConte also had mites. In March 1983, *Sancassania* was also found on 17 of 22 third instars of *C. viridisticta* Bates collected along an irrigation ditch. Larval density at this site was very high, from 6–20 larvae/m.

The mean numbers of mites per host for these two species of mites on the four species of beetles were similar, but the range per individual host and the host attachment sites were not (Tables 2, 3). Preferred attachment sites for *T. tribulatum* were the dorsal surface and the abdomen. Most of the *Sancassania* sp. were attached ventrally and on all body regions, though relatively few were on the thorax. The legs of *C. viridisticta* and the head capsule of the *C. fulgoris* also had many *Sancassania* sp. The mites on the adult *C. pimeriana* were primarily on the ventral surface of the abdomen and on the legs.

Among the mite-infested larvae of *C. willistoni* and *C. fulgoris* that were reared, no adverse effects were apparent. The survival time and mortality rates (25–35%) were similar to larvae without mites. Most mites died or were lost from the larvae

Table 3. Attachment sites of mites on tiger beetles from Southeastern Arizona.

	Host				No./Attachment Sites					
Mite sp.	Sp	Stage	No. of Mites	No. Mites/ Host	Head	Thor.	Legs	Abdo.	Dor.	Vent.
T. tri.	*will.*	L	104	5.5	9	19	10	66	83	21
T. tri.	*fulg.*	L	128	11.6	11	26	5	86	110	18
Sancas.	*fulg.*	L	86	9.6	32	8	8	38	28	58
Sancas.	*viri.*	L	141	8.8	23	8	60	50	51	90*
Sancas.	*pime.*	A	21	3.0	2	1	6	12	2	19

* Mites on legs recorded as ventral.

after several months of rearing. All of the third instar *C. viridistica* were reared and closely observed until their emergence as adults in June or July. Most (>80%) of both mite-infested and control larvae emerged. No differences in survival, behavior, or developmental times were noted. The two larvae with the heaviest mite burdens, 56 and 24, survived and emerged as adults. The latter individual had two attached mites present on the newly emerged adult.

DISCUSSION

Results of this study give evidence of an association, probably phoretic, between mites and tiger beetles in southeastern Arizona. The observed associations may have developed from or be coincidental to the co-occurrence of tiger beetles in the same salt-bush habitats with ground-nesting bees. *Trochometridium tribulatum* is widespread in the United States and known primarily from the nests of various ground-nesting bees (Cross, 1965; Cross and Bohart, 1969). These mites are fungivores that can develop in colonies with dead bee larvae, then disperse in the adult female stage on adult bees (Cross and Bohart, 1978). The movement of *T. tribulatum* from bees to tiger beetle larvae seems likely since bees were especially abundant on the playa the year that mites were found on tiger beetle larvae. Cross and Bohart (1978) suggested the presence of this mite species on scarab beetles in the Sudan was due to dispersal from ground bees.

Mites could exist for extended periods on tiger beetle larvae or in their burrows. Food in the form of fungi growing on dead larvae or larval prey remains is abundant since larval mortality is high. Dispersal would be possible as larvae leave their burrows during flooding and dig new ones.

The numbers of *T. tribulatum* per host, percent of hosts with mites, and attachment sites were generally similar to what Cross and Bohart (1969) found on alkali bees in Utah. Such levels, they suggested, may indicate a permanent relationship.

The somewhat broader host (adults and larvae) and habitat range of *Sancassania* on tiger beetles may suggest this species is an opportunistic phoretic and only accidental or transitory on tiger beetles. Such relationships frequently exist for phoretic species (Cross and Bohart, 1969). Homann (1933) found few of the 18 species of phoretic mites of honey bees had any permanent relationship to individuals or to the colony. *Sancassania* is well known as a phoretic or saprophage of beetles and commonly feeds on dead hosts (Jarvis, 1964; Chmielewski and Lipa, 1967; Saminsak, 1971; OConnor, 1982; Eickwort, 1983). The presence of these mites on tiger beetles may result from their dispersal through the soil (B.

M. OConnor, pers. comm.) and be enhanced by the favorable habitat and high mortality of the larvae. Mites on adult *C. pimeriana* may have moved onto adult beetles during oviposition or burrowing by the beetles.

The phoretic associations suggested here are somewhat unusual in that they involve the non-parasitic stage of mites and the larvae of holometabolous insects. Most phoretic mites are associated with adult insects or are parasitic on immature stages. Tiger beetle larvae or their burrows are apparently favorable for mite survival, and may perhaps allow for development and occasional dispersal. Further studies on the specific interrelationships involved here are needed to determine if mites live their entire lives in association with tiger beetles.

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LITERATURE CITED

Batra, S. W. T. 1965. Organisms associated with *Lasioglossum zephyrum* (Hymenoptera: Halticidae). J. Kans. Entomol. Soc. 38: 367–389.

Chmielewski, W. and J. J. Lipa. 1967. Biological and ecological studies on *Caloglyphus* mites (Acarina: Acaridae) associated with Scarabeidae. Acta Parasit. Pol. 14: 179–186.

Cross, E. A. 1965. The generic relationships of the family Pyemotidae (Acarina: Trombidiformes). Univ. Kans. Sci. Bull. 45: 29–275.

Cross, E. A. and G. E. Bohart. 1969. Phoretic behavior of four species of alkali bee mites as influenced by season and host sex. J. Kans. Entomol. Soc. 42: 195–219.

———. 1978. Some observations of the habits and distribution of *Trochometridium* Cross, 1965 (Acarina: Pyemotidae). Acarologia 20: 286–293.

Cross, E. A. and J. C. Moser. 1971. Taxonomy and biology of some Pyemotidae (Acarina: Tarsonemoidea) inhabiting bark beetle galleries in North American conifers. Acarologia 13: 47–64.

Eickwort, G. C. 1979. Mites associated with sweat bees (Halictidae). *In* Rodriquez, J. G., ed., Recent Adv. Acarol. 1: 575–581. Academic Press, New York.

———. 1983. Potential use of mites as biological control agents of leaf-feeding insects. *In* Hoy, M. A., G. L. Cunningham and L. Knutson, eds., Biological control of pests by mites. Univ. Calif., Berkeley. Special Publ. 3304.

Greene, A. 1975. Biology of five spp. of Cychrini (Coleoptera: Carabidae) in the steepe region of southeastern Washington. Melanderia 19: 1–43.

Homann, H. 1933. Die Milben in gesunden Bienenstocken. Z. Parasitenkunde Berlin 6: 350–415.

Ingram, W. M. 1934. Field notes of five species of the genus *Cicindela* of the family Cicindelidae from Balboa Bay, Orange County, California. J. Entomol. and Zool. 26: 51–52.

Jarvis, J. L. 1964. An association between a species of *Caloglyphus* (Acarina: Acaridae) and *Phyllophaga anxia* (Coleoptera: Scarabaeidae). J. Kans. Entomol. Soc. 37: 207–210.

Knisley, C. B. and D. L. Pearson. 1981. The function of turret building behaviour in the larval tiger beetle, *Cicindela willistoni* (Coleoptera: Cicindelidae). Ecol. Entomol. 6: 401–410.

———. 1984. Biosystematics of larval tiger beetles of the Sulphur Springs Valley, Arizona. Descriptions of species and a review of larval characters of *Cicindela* (Coleoptera: Cicindelidae). Trans. Am. Entomol. Soc. 110: 465–551.

Krantz, G. W. 1978. A manual of acarology, ed. 2. Oregon State Univ. Bookstores, Corvallis. 509 p.

Krombein, K. V. 1962. Biological notes on acarid mites associated with solitary wood-nesting wasps and bees (Acarina: Acaridae). Proc. Entomol. Soc. Wash. 64: 11–19.

Maser, C. 1971. A simple method for preserving larval Cicindelidae. Cicindela 3: 79.

Moser, J. C. and E. A. Cross. 1975. Phoretomorph: a new phoretic phase unique to the Pyemotidae (Acarina: Tarsonemoidea). Ann. Entomol. Soc. Am. 68: 820–822.

Moser, J. C., E. A. Cross, and L. M. Roton. 1971. Biology of *Pyemotes parviscolyti* (Acarina: Pyemotidae). Entomophaga 16: 367–379.

Nagano, C. D. 1980. Population status of the tiger beetles of the genus *Cicindela* (Coleoptera: Cicindelidae) inhabiting the marine shoreline of southern California. Atala 8: 33–42.

Nickel, P. A. and R. J. Elzinga. 1969. *Caraboacarus karenae*, a new mite from carabid beetles, with notes on its biology (Acari: Pyemotidae). J. Kans. Entomol. Soc. 42: 222–229.

OConnor, B. M. 1982. Evolutionary ecology of astigmatid mites. Annu. Rev. Entomol. 27: 385–409.

Olynyk, J. E. and R. Freitag. 1979a. Some phoretic associations of ground beetles (Coleoptera: Carabidae) and mites (Acarina). Can. Entomol. 111: 333–335.

———. 1979b. Examination of overwintering adult carabid beetles for associated mites. Can. Field Nat. 93: 79–81.

Regenfuss, H. 1968. Untersuchungen zur Morphologie, Systematik und Okologie der Podapolipidae (Acari, Tarsonemini). Zeitschr. Wissenschaftl. Zool. 177(3/4): 183–282.

Rumpp, N. L. 1977. Tiger beetles of the genus *Cicindela* in the Sulphur Springs Valley, Arizona, with descriptions of three new subspecies (Cicindelidae-Coleoptera). Proc. Calif. Acad. Sci. 41: 169–182.

Samšinák, K. 1970. Zwei neue Arten der Gattung *Sancassania* Oudemans, 1916 (Acari: Acaridae). Zool. Anz. 184: 403–412.

Thiele, H. -U. 1977. Carabid beetles in their environment. Springer-Verlag Berlin, Heidelberg, N.Y. 369 pp.

Willis, H. L. 1967. Bionomics and zoogeography of tiger beetles of saline habitats in central United States (Coleoptera: Cicindelidae). Univ. Kans. Sci. Bull. 47: 145–313.

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A REVISION OF THE GENUS *STALARIA* HARRINGTON (HEMIPTERA: LYGAEIDAE)[1]

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Abstract.—The genus *Stalaria* is revised. A key to species is given. *Stalaria* ***lestoni*** (West Africa) and *S.* ***nana*** (East and South Africa) are described as new species. The misidentification of the type species is noted. It is concluded that the designated type species *Pamera ferruginosa* Stål was based on specimens of *Pachybrachius kisseis* Linnavuori. There is discussion of the systematic relationships of *Stalaria* to several other myodochine genera. Figures are given of anatomical details of the male genitalia and a dorsal view of *S.* ***lestoni.***

The genus *Stalaria* was erected by Harrington (1980) with *Pamera ferruginosa* Stål as type species and to include *Pachybrachius kisseis* Linnavuori and *Pachybrachius nysias* Linnavuori.

As we have previously pointed out (Slater and Zheng 1985) unfortunately the genus is based upon a misidentified type species. Harrington's *P. ferruginosa* Stål actually consisted of a series of specimens of *P. kisseis* that had previously been reported by Slater (1972) as probably a new species near *Pachybrachius ferruginosus.* This situation under the International Rules of Zoological Nomenclature must be referred to the International Commission for resolution. Accordingly, in order not to add an additional name to the literature we will be asking the commission to set aside *Pamera ferruginosa* Stål as type species of *Stalaria* and to replace it with *Pachybrachius kisseis* Linnavuori. If the commission approves this action it will retain *Stalaria* in the sense intended by Harrington. It is in this sense that we treat the species in the following discussion.

Harrington (1980) defined the genus as a myodochine taxon with her "Type 1 phallus"; a narrow impunctate ring-like pronotal collar; a body length more than 3½ times the pronotal width; with numerous elongate dorsal body hairs; single ranked fore femoral spines; multi-branched holding sclerite; four or more rows of claval punctures; a v-shaped buccular junction; closed epimeron, and unspined male fore tibiae.

Harrington (ibid.) indicated that *Stalaria* is part of a very closely related group of genera that include *Pamerapa, Pamerarma, Remaudieriana* and probably *Pachybrachius* (*sensu* Harrington).

Stalaria is not such a well defined genus as this might suggest as only the type

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species has the "comb-like holding sclerite" (Fig. 12). (It is not a holding sclerite). Further, all of the species examined, including the proposed type species, have double-ranked spines, although sometimes weakly so. However, the genitalia do have synapomorphic features such as the shape of the holding sclerites and especially the unique single, slender median sclerite situated dorsad of the ejaculatory duct. For the present, we believe these species should be placed together in a single genus. One of the superficial but interesting features of these species is that the pale annulus on the fourth antennal segment is located distally or mesally rather than at the base as it is in so many rhyparochromine genera.

The relationships of several of these myodochine genera seems to us to warrant additional study. Some species of *Stigmatonotum* have the enveloping sclerotization of the vesica (= the "casing sclerotization"? of *Pachybrachius* of Harrington, 1980) almost exactly the same as that found in *Stalaria lestoni*. In addition *Stalaria* species usually have several small hairs along the apical corial margin that are somewhat similar to the punctures along this margin that Harrington considers diagnostic for *Stigmatonotum*.

We have studied the male genitalia of an unidentified species of *Pamerarma* Malipatil, a genus Harrington says is closely related to *Stalaria*. This species has genitalia quite different from Harrington's "Type I" in that holding sclerites are absent, there is a pair of conjunctival plates (perhaps homologous with the conjunctival spine?) and there are fine marginal serrations on the thin proximal part of the helicoid process. These features resemble those of the "Type II" phallus. Harrington (1980) noted this but still considered *Pamerarma* to represent "Type I." We feel that the most essential feature of the "Type I" phallus is the presence of holding sclerites and the most crucial feature of "Type II" is their absence. If this is true *Pamerarma* should belong in a clade with *Paromius*, *Horridipamera* etc.

The essence of the question is that *Stalaria* (and perhaps *Pamerarma*) have a somewhat intermediate position in what would seem to be a polarity trend from a "Type I" to a "Type II" phallus. If this true the sister group relationships of *Stalaria* will certainly benefit from additional analysis.

Distribution: Confined to tropical Africa, one species extending southward into the tropical corridor of Zululand, South Africa.

All measurements are in millimeters.

KEY TO SPECIES OF *STALARIA*

1. Posterior pronotal lobe nearly uniformly pale, strongly contrasting with dark anterior lobe. Phallus without conjunctival spines, only a pair of holding sclerites present. Small species not over 4.5 mm. .... *nana*
– Posterior pronotal lobe chiefly reddish brown often nearly unicolorous with anterior lobe, sometimes with alternating pale and dark ferrugineous longitudinal stripes. Phallus with conjunctival spines. Usually more than 4.5 mm in length. 2
2. Large species at least 6 mm in length; antennal segment IV usually chiefly dark brown with only a narrow pale annulus near middle, sometimes entirely dark, rarely with a broad pale central area. Aedeagus with a pair of comb-like dorsal conjunctival sclerites. (Fig. 12) .... *kisseis*
– Smaller species not over 5.5 mm in length. Antennal segment IV either

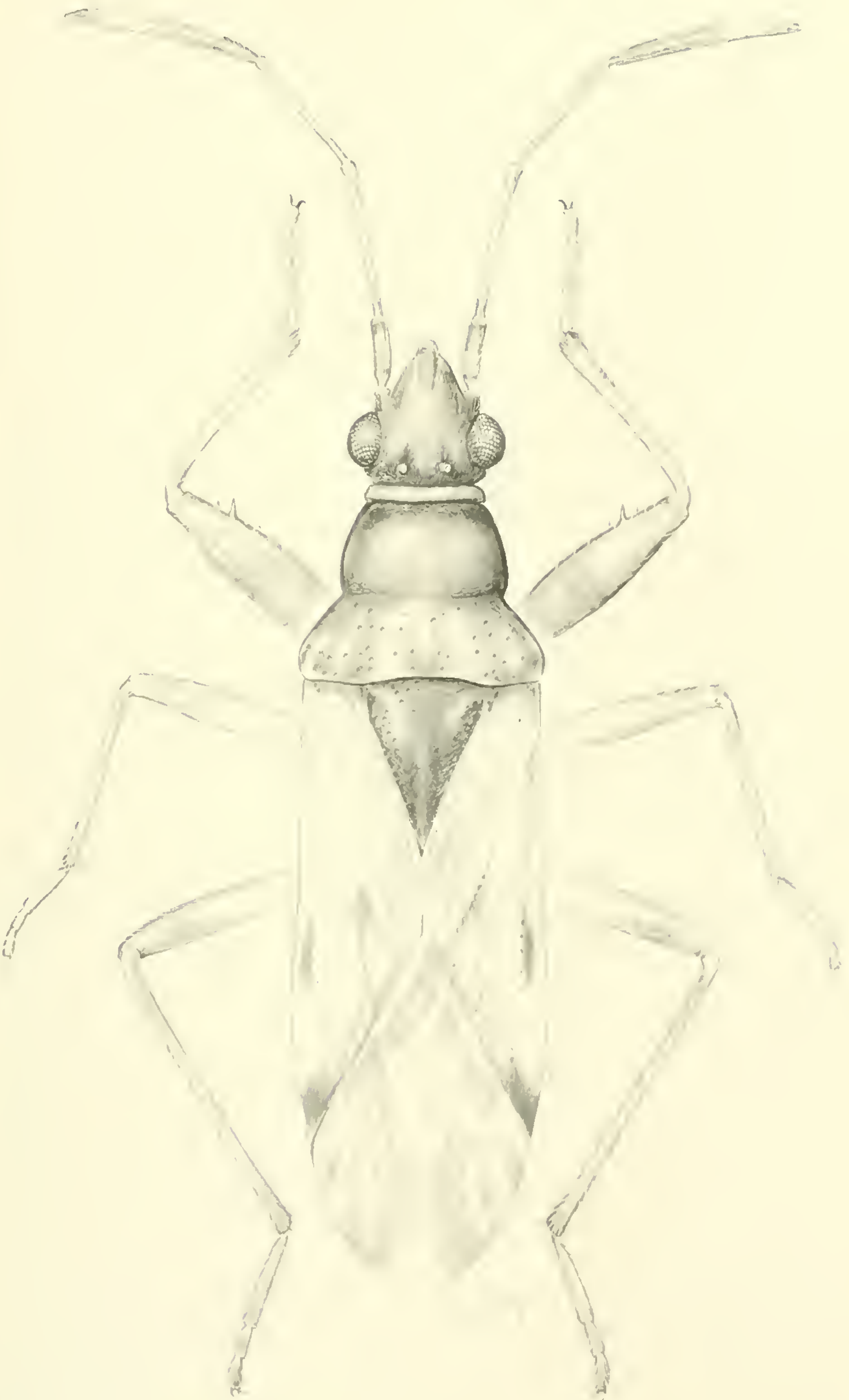

Fig. 1. *Stalaria lestoni* n. sp., dorsal view.

chiefly pale, darkened only at proximal and distal ends, or with only a subapical pale annulus present. Aedeagus lacking a pair of comb-like dorsal conjunctival sclerites. 3

3. Apex of corium with a well developed black macula; fourth antennal segment pale on apical ½ to ⅓ with exception of extreme apex; lateral plate-like structure on vesica weak, small, sharp, and narrow (Fig. 8); inner basal area of paramere lacking a secondary tooth (Fig. 14). .... *lestoni*
– Without a conspicuously differentiated dark macula at apex of corium; fourth antennal segment chiefly pale, dark only near proximal and distal ends; lateral vesical plate broad, triangular and well defined (Fig. 7); inner basal area of paramere with a slender tooth (Fig. 9). .... *nysias*

***Stalaria lestoni* New Species**

Figs. 1, 5–6, 8, 14

Body narrow, elongate, parallel-sided. Head, pronotum, and scutellum chestnut brown. Antennal segments I–III yellow, segment III infuscated at distal end. Fourth antennal segment dark brown with a broad yellow subapical annulus. Pronotal collar and posterior pronotal margin yellowish, latter with a pair of small yellow spots submedially. Scutellum with an elongate lighter longitudinal reddish stripe. Ground color of hemelytra dull yellow, with some punctures and a submedian and apical corial macula dark brown. A diffuse dark streak around inner portion of triangular pale macula that is present at inner angle of corium. Membrane gray brown, with light veins and a white apical spot. Legs yellowish. Femora, especially fore femora, with a brown submedian annulus, (sometimes incomplete and broken into a series of dark spots). Venter yellowish to light brown, with a sublateral longitudinal dark brown stripe on each side. Anterior pronotal lobe as well as collar impunctate. Posterior pronotal lobe and scutellum shallowly and inconspicuously punctate.

Head length 0.75, width 0.75, interocular space 0.37. Pronotum dull or subshining, not pruinose. Clothed with short decumbent, sericeous pubescence (on anterior lobe mainly surrounding large calli area) and sparse erect long hairs. Pronotal length 0.95. Anterior and posterior lobes subequal in length, width anterior lobe 0.80, width posterior lobe 1.2. Scutellar length 0.75, width 0.65, with a low Y-ridge present. Clavus with 4 rows of punctures, the second inner row incomplete, only occupying posterior half of scutellum. Length claval commissure 0.50. Midline distance apex clavus-apex corium 1.05. Midline distance apex corium-apex membrane 0.65. Fore femur ventrally with one dark spine distally on outer side. Inner side of fore femur distally with 1 large and 3 small spines, 2 of latter proximad of and 1 distad of the large spine. Male tibiae straight, without a tooth or spine. Labium extending to middle of mesosternum but remote from mesocoxae. Length labial segments I 0.48, II 0.48, III 0.30, IV 0.32. Antennae conventionally terete. Length antennal segments I 0.48, II 0.86, III 0.72, IV 0.96. Male genital capsule similar to that of *S. nysias* (Linnavuori), but proximal opening a little longer and narrower (Fig. 16). Parameres lacking an accessory tooth along inner margin of shaft (Fig. 14). Holding sclerite slender, apex more sclerotized than in *nysias* and curved (Figs. 5, 6). Very weak sclerotization enveloping ventral and lateral sides of proximal portion of vesica; when viewed laterally, a pair of weakly sclerotized, narrow triangular plates vaguely evident, representing holding sclerites. Total body length 4.80.

Figs. 2–17. Figs. 2–6. Holding sclerites. 2, *Stalaria kisseis* Linnavuori, right side view. 3, *Stalaria nysias* Linnavuori, ventral view. 4, *Stalaria nysias* Linnavuori, right side view. 5, *Stalaria lestoni* n. sp., ventral view. 6, *Stalaria lestoni* n. sp., right side view. Figs. 7–8. Dorsal conjunctival sclerites. 7, *Stalaria nysias* Linnavuori. 8, *Stalaria lestoni* n. sp. Figs. 9–10. Parameres. 9, *Stalaria nysias* Linnavuori. 10, *Stalaria nana* n. sp. Fig. 11. *Stalaria kisseis* Linnavuori, aedeagus. Fig. 12. *Stalaria kisseis* Linnavuori, dorsal conjunctival sclerite. Fig. 13. *Stalaria kisseis* Linnavuori, lateral conjunctival sclerite. Figs. 14–15. Parameres. 14, *Stalaria lestoni* n. sp. 15, *Stalaria kisseis* Linnavuori. Figs. 16–17. Pygophores. 16, *Stalaria lestoni* n. sp., dorsal view. 17, *Stalaria nana* n. sp., dorsal view.

Holotype.—♂: GHANA: Tafo, 7.X.1967, (J. A. & S. Slater, Toby Schuh). In American Museum of Natural History.

Paratypes.—3 ♂, 2 ♀, same data as holotype. 3 ♂, same, 4–9.X.1967. 1 ♀, same, 8.X.1967, (UV light). 1 ♀, same, 9.X.1967, (UV light). 1 ♀, same, 5.X.1967, (UV light). 1 ♀, Accra, 14.XI.1969, (Blacklight Trap) (G. W. Campbell). 1 ♀, Wiowso, 3.IV.1969, (D. Leston). 1 ♀, Kankan, 7.XII.1965, (Leston). 1 ♀, Legon, (Light trap) (Leston). 1 ♀, Mt. Atewa, 7.XII.1968, (D. Leston). NIGERIA: Ile-Ife, 4 ♂, 2 ♀, 10.III.1969, (J. T. Medler). 1 ♀, Oban RH SE State, 7.IV.1976, (J. T. Medler). 1 ♀, Umuahia CRIN EC State, 9.IV.1975, (J. T. Medler). 1 ♂, Lagos, Lagos-Badagry Road, 25.I.1975, (A. Hamid). 1 ♂, R. St. Ebubu nr. Bori, 2.VII.1973, (Linnavuori). 4 ♂, W. St. Ife, 7–8. VII–14.VII.1973, (Linnavuori). 1 ♂, W. St., Olokemeji Forest, 9.VII.1973, (Linnavuori). CENTRAL AFRICAN REPUBLIC: 7 ♂, 1 ♀, La Maboke, 6–9.VI.1973, (Linnavuori). IVORY COAST: 1 ♂, Adiopodoume, 29.IX–7.X.1973, (Linnavuori). 1 ♂, Goumere, 19.IX.1973, (Linnavuori). CAMEROON: 1 ♀, Bota, 19–20.VI.1973, (Linnavuori). 1 ♂, 50 KM W Douala, Moliwe, 22.*I*.1978, (at light) (secondary forest and plantation) (Lund University Expedition). GAMBIA: 3 ♂, 1 ♀, Abuko Nature Reserve 18 .30′–20 .30′, 18.XI.1977, (at light at bamboo pool) (Lund University Expedition). SENEGAL: 1 ♂, 1 KM NE Djibelor (about 7.5 KM SW Ziguinchor) (19.00–21.00) 9.XI.1977, (at light) (Lund University Expedition).

This species is named for the late Dr. Dennis Leston in recognition of his many distinguished contributions to Hemipterology.

Stalaria lestoni is closely related to *S. nysias* Linnavuori. It tends to be a more slender, relatively elongate species and externally may be distinguished by the characters given in the key (see *nysias* discussion.) The lack of a secondary tubercle on the inner shaft of the paramere and the shape of the conjunctival appendages on the phallus are diagnostic.

It appears to be common at light in West Africa.

***Stalaria nysias* (Linnavuori)**

Figs. 3–4, 7, 9

1978. *Pachybrachius nysias* Linnavuori, 153:89.
1980. *Stalaria nysias* Harrington, 167:91.

We have examined a single male paratype of this species. While the paratype examined differs considerably in color from all specimens of *lestoni* (even those from the Central African Republic) we would not consider these color differences alone to be significant. However, both the parameres and conjunctival appendages are definitely different. *Stalaria nysias* has a secondary tooth on the inner side of the paramere shaft (Fig. 9) which is absent in all of the specimens of *lestoni* which we have examined (Fig. 14). The holding sclerites of *S. nysias* are relatively thicker than are those of *lestoni* and are not hooked at the distal end (Figs. 3, 4). The dorsal conjunctival sclerite is also broader in *nysias* than it is in *lestoni* (Figs. 7, 8).

Stalaria lestoni gives the impression of being a more elongate slender species than does *nysias,* but without a series of the latter available we have not been able to establish this.

Linnavuori's (1978) original description indicates that, in females, the third antennal segment is longer than either the second or fourth segments "12:25:30: 25 (female)." This may be a lapsus for this would be an unusual situation.

Stalaria nysias was described from Malakal on the Upper Nile (Sudan). The only other published record is that of Scudder (1982) from Senegal. This record may well be correct. We have examined a single female from Nigeria (Olatunde Ayoola Ave., Lagos, 6.III.1975 (Abdul Hamid)) which although having much longer antennae than the paratype noted above appears to be conspecific.

Stalaria nana New Species
Fig. 10

Body relatively short and stout, nearly parallel sided. Head, anterior pronotal lobe, scattered punctures, and triangular area at base of scutellum dark red brown, strongly contrasting with pale yellow ground color of rest of body including pronotal collar, posterior lobe and appendages. Fourth antennal segment brown with distal ¼ yellowish. Hemelytra lacking distinct dark maculae, somewhat infuscated distally on clavus and along apical corial margin. Membrane pale translucent with areas between veins striped with pale brown and a pale white streak mesally on posterior half. Pronotum and scutellum with a few elongate upright hairs. Head, pronotum and scutellum with numerous appressed sericeus hairs, most numerous on head and laterally and mesally on anterior pronotal lobe. Anterior pronotal lobe impunctate, punctures on posterior lobe large and dark, but sparse and widely scattered.

Head little declivent anteriorly; tylus reaching or slightly exceeding middle of first antennal segment. Eyes set only slightly away from anterior margin of pronotum. Head length 0.78, width 0.78, interocular space 0.40. Anterior pronotal lobe rounded and moderately swollen, slightly broader than head across eyes, posterior lobe not elevated above anterior lobe, posterior margin very shallowly concave. Pronotal length 1.14, width 1.26. Scutellar length 0.74, width 0.50. Hemelytra narrowly explanate laterally, the margins straight. Midline distance apex clavus-apex corium 1.0. Midline distance apex corium-apex membrane 0.68. Mesosternum with a strongly shining median plate. Labium extending onto middle of mesosternum, but remote from mesocoxae. Length labial segments I 0.44, II 0.44, III 0.30, IV 0.30. Length antennal segments I 0.40, II 0.80, III 0.62, IV 0.76. Total body length 4.40.

Paramere with inner projection very broad and strongly down curved; shaft lacking a secondary tooth on inner margin (Fig. 10). Genital capsule similar to that of *lestoni,* but more ovoid with inner projection much thicker and sides of capsule opening nearly evenly concave (Fig. 17). Only one pair of holding sclerites present.

Holotype.—♂, TANZANIA: Ilonga, 26.II.1964 (light trap) (I. A. D. Robertson). In American Museum of Natural History.

Paratypes.—TANZANIA: 5 ♂, 4 ♀, same data as holotype. 12 ♂, 5 ♀, same 14.IV.1965. 1 ♂, same, 27.II.1964. 1 ♂, Ukiriguru, 13.VI.1961, (light trap) (I. A. D. Robertson). SOUTH AFRICA: *Natal.* 1 ♂, St. Lucia Park, Zululand, 26.I.1968, (E. Brinkman). 1 ♂, same, 24.I.1968. 1 ♂, same, 20.I.1968. In National Insect Collection (Pretoria, South Africa) and J. A. Slater collection.

There is relatively little variation in the type series. Most specimens appear to have a completely dark brown fourth antennal segment. Rarely there is a narrow fuscous stripe on the posterior pronotal lobe on either side of the midline. One specimen has additional dark streaking on the posterior pronotal lobe midway between the meson and lateral margins. The coloration of the scutellum is somewhat variable, usually there are two wide diagonal pale stripes but frequently these coalesce posteriorly so that only the median dorsal part of the scutellum is dark.

Stalaria nana is a readily recognizable species by its contrastingly pale yellow posterior pronotal lobe and small size as well as by details of the parameres and genital capsule. It is somewhat isolated in *Stalaria* as is indicated by the presence of a single pair of holding sclerites.

***Stalaria kisseis* (Linnavuori)**

Figs. 2, 11–13

1972. *Pachybrachius* nr. *ferruginosus* Slater (*nec* Stål), 72:2:61.
1978. *Pachybrachius kisseis* Linnavuori, 153:88.
1980. *Stalaria kisseis* Harrington, 167:91.

This is the largest species of *Stalaria*, some specimens reaching 7 mm in length. It is chiefly a dark red brown to almost chocolate colored insect with the hemelytra somewhat lighter. The posterior pronotal lobe is at most only slightly lighter than the anterior so that in most specimens the entire dorsal surface of the pronotum appears to be uniformly dark red brown. The fourth antennal segment usually has a pale annulus near the middle. The head, pronotum and scutellum bear numerous upstanding hairs. Linnavuori (1978) gives an excellent description and figures the antennal hairs which are much longer than are those of the other species of *Stalaria* (considerably exceeding the diameter of the segment).

As noted earlier, this is the species that Harrington (1980) considered to be *Pamera ferruginosa* Stål which she made the type species of *Stalaria*.

Stalaria kisseis has a pair of unique heavy branched conjunctival structures (Fig. 12). Harrington (1980) used this as part of the definition of *Stalaria*, but it has thus far been found only in *S. kisseis*.

Actually the aedeagus of this species has four kinds of sclerotized structures on the vesical conjunctiva (Fig. 11). In addition to the "typical comb-like structure" there is a pair of slender holding sclerites that are acutely pointed and strongly hooked apically (Fig. 2); a pair of distinct conjunctival spines (Fig. 13), one on each side of the sperm reservoir that are long and simple and a single slender rod-like sclerotization dorsad of the ejaculatory duct and lying parallel to it. The vesica appears to lack any distinct enveloping sclerotization.

Slater (1972) reported *kisseis* as "*Pachybrachius* nr. *ferruginosus*" from Upemba National Park, Zaire. Linnavuori's (1978) type material was from "Equatoria" Sudan on the Aloima Plateau. It has not been taken in West Africa.

Additional material examined: TANZANIA: 9 ♂, 20 ♀, Ilonga, 14.IV.1965, (light trap) (I. A. D. Robertson). 2 ♂, 1 ♀, same, 26.II.1964. 1 ♂, Ukiriguru, 21.XII.1961 (light trap) (I. A. D. Robertson). UGANDA: 1 ♂, 1 ♀, Kawanda 4.II.1958 (at light) (T. R. Odiambo). 1 ♂, same, 19–20.II.1958. 1 ♀, same, 1.III.1958. 1 ♀, same, 17.V.1958.

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LITERATURE CITED

Harrington, B. J. 1980. A generic level revision and cladistic analysis of the Myodochini of the world (Hemiptera, Lygaeidae, Rhyparochrominae). Bull. Am. Mus. Nat. Hist. 167: 49–116.

Linnavuori, R. 1978. Hemiptera of the Sudan, with remarks on some species of the adjacent countries 6. Acta Zool. Fennica 153: 108 pp.

Scudder, G. G. E. 1982. Recherches scientifiques dans les parcs nationaux du Sénégal IX. Hemiptera Lygaeidae du Parc National du Niokolo-Koba. Mém. Inst. Fond. d'Afrique Noire No. 92: 141–154.

Slater, J. A. 1972. The Lygaeidae of Upemba National Park (Hemiptera: Heteroptera). Parc National de l'Upemba-Mission G. F. de Witte. Fasc. 72(2): 17–77.

Slater, J. A. and L. Y. Zheng. 1985. A revision of the genus *Horridipamera* Malipatil. (Hemiptera: Lygaeidae). J. N. Y. Entomol. Soc. 92: 316–341.

PROC. ENTOMOL. SOC. WASH.
87(2), 1985, pp. 350–355

SOME NOMENCLATURAL CHANGES IN THE CHALCIDOIDEA (HYMENOPTERA)

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Abstract.—The following new synonymies and nomenclatural changes are proposed for taxa in several families of Chalcidoidea. Eurytomidae: *Eurytoma appendigaster* of American authors (*nec* Swederus, 1795) = *Eurytoma verticillata* (Fabricius, 1789); *Eurytoma gossypii* Bugbee, 1967 = *Eurytoma herrerae* (Ashmead, 1902). Torymidae: *Megastigmus grandiosus* Yoshimoto, 1979 = *Megastigmus albifrons* Walker, 1869; *Torymus bakeri* Cameron, 1904 = *Torymus hainesi* Ashmead, 1893. Pteromalidae: *Systellogaster* Gahan, 1917 = *Tritneptis* Girault, 1908; *Paradibrachys* Girault, 1917 = *Pseudocatolaccus* Masi, 1908; Dvaliniinae Hedqvist, 1978 = Colotrechninae Thomson, 1876.

From time to time nomenclatural changes are necessary to correct previous misapplications of names. The changes given in this paper are the result of various studies which have provided names for workers engaged in studies of ecology and biological control. Because these changes alter or reinterpret previously used names which will be used in reports and/or publications, I take this opportunity to document them.

The treatment of taxa follows the format used for species synonymies in the 1979 edition of the "Catalog of Hymenoptera in America North of Mexico." Thus, literature citations for taxa names are incorporated in the synonymies but citations other than these are listed at the end of the paper. The following abbreviations are used in the text: UZMC = Universitetets Zoologiske Museum, Copenhagen; USNM = United States National Museum; BMNH = British Museum (Natural History); CNC = Canadian National Collection.

EURYTOMIDAE

Eurytoma verticillata (Fabricius)

Ichneumon verticillatus Fabricius, 1789. Suppl. Entomol. Syst., p. 232. Lectotype ♂, UZMC.
Eurytoma costata Ratzeburg, 1848. Ichn. Forstins., v. 2, p. 177. ♂. Type destroyed.
Eurytoma appendigaster of American authors (*nec* Swederus 1795, Sven. Vetensk. Acad. Handl. 16: 217).

The identities of *Eurytoma appendigaster* (Swederus) and *E. verticillata* in Europe were studied and clarified by Claridge (1959, 1960). Peck (1963), in his Nearctic catalog, cited Claridge (1960) and transferred all Nearctic references of *appendigaster* (of authors) to *verticillata.* Bugbee (1967: 485–86) omitted *verti-*

cillata from his revision of *Eurytoma* of America north of Mexico, but included *appendigaster* based on several specimens in the Canadian National Collection, Ottawa. Burks (1979) listed *appendigaster* as occurring throughout the northeastern Nearctic seacoast, but did not refer to *verticillata*.

Through the courtesy of Drs. J. S. Noyes and Z. Bouček (British Museum, Natural History) I have examined specimens of *E. appendigaster* (det. by Claridge) and *E. verticillata* (det. by Bouček). I have also examined all the specimens in the U.S. National Museum (165 Holarctic determined as *appendigaster*), and the Canadian National Collection material seen by Bugbee (1967) and determined as *appendigaster*. All of this material is *verticillata*. Thus, *Eurytoma appendigaster* does not occur in North America.

Because Claridge (1959: 2–6) redescribed, figured, and gave key characters for separating *appendigaster* from *verticillata*, the reader is referred to that paper for methods of identification.

This species has been recorded from cocoons of various Braconidae (e.g., *Apanteles*) and Ichneumonidae through Lepidoptera (especially the gypsy moth in the Nearctic Region).

***Eurytoma herrerae* (Ashmead)**

Bruchophagus herrerae Ashmead, 1902. Psyche 9: 324. ♀. Holotype ♀, USNM. [Examined]

Eurytoma gossypii Bugbee, 1967. Proc. U.S. Natl. Mus. 118: 493–494. ♀, ♂. Holotype ♀, USNM. [Examined]

Burks (in Bugbee, 1975: 251–252) synonymized the species *Eurytoma gossypii* Bugbee under the new combination *Eurytoma herrerae* (Ashmead). Bugbee acknowledged this synonymy but mistakenly continued to use the name *gossypii* for this species (1975, and personal communication). The 1979 edition of the Hymenoptera catalog does not reflect this synonymy because of its pre-1975 cutoff date for the section Eurytomidae. I have examined the holotypes and agree with the synonymy proposed by Burks.

Eurytoma herrerae is a parasite of the cotton boll weevil.

TORYMIDAE

***Megastigmus albifrons* Walker**

Megastigmus albifrons Walker, 1869. Trans. R. Entomol. Soc. Lond. 1869: 314. ♂. Holotype ♂, BMNH.

Megastigmus grandiosus Yoshimoto, 1979. Can. Entomol. 111: 201–203. ♀, ♂. Holotype ♀, CNC. NEW SYNONYMY.

Megastigmus albifrons was described from a single male specimen reared from "a fir cone, from California." Burks examined the type (1975) and concluded that it was the species being reared in southwestern United States from seeds of *Pinus ponderosa* Douglas. This is a very large, distinctive *Megastigmus* and the only one known from *Pinus* seed. The species *M. pinus* Parfitt is reared from *Abies* species and the record (Milliron, 1949: 320–321) of it from seeds of *Pinus sylvestris* L. is very doubtful.

Megastigmus grandiosus was described from material collected in Mexico: from "*Pinus montezumae*" and "*P. rudis*" seed in Calpulalpam; from "*Pinus aya-*

chuite" seed in "Avila Gonadan" (locality not verified); and from "*Pinus hartwegii*" seeds in Santo Tomas Apipilhuasco.

There has been some concern that *grandiosus* might be introduced into the United States from Mexico and it was considered for placement on the list of Pests Not Known to Occur in the United States (U.S. Department of Agriculture). I have compared nearly 100 specimens of *albifrons* from *Pinus ponderosa* in California with 100 specimens of *grandiosus* from *P. montezumae* Lambert in Mexico (paratype and topotypic specimens) and conclude that only a single species is involved. The tabular differences listed by Yoshimoto (1979: 205) apparently are based upon the holotype of *grandiosus* and 2 specimens of each sex of *albifrons*. His limited comparison unfortunately does not take into account variability even within a population. Many of the separating characters are subjective at best (e.g., relative coarseness of sculpture, transverseness of carinae, shape of stigma), or if measurable, cannot be used because of variability. The ratios of ocellar distances, for example, indicate that the ocellocipital distance should be twice the distance between the frontal and the posterior ocelli in *grandiosus* and 1.5 times in *albifrons*. Measurements of 10 specimens of each species give an average of 1.44 for *grandiosus* (range 1.2–1.8) and 1.38 for *albifrons* (range 1.1–1.6). The ranges overlap so much that this character cannot be used.

The USNM collection contains specimens of *M. albifrons* from California, Arizona, New Mexico, Mexico, and Guatemala. This is the known distribution of the species, and all rearings have been made from seeds (or cones) of *Pinus* species.

Torymus hainesi **Ashmead**

Torymus hainesi Ashmead, 1893. Entomol. News 4: 278. ♀. Holotype ♀, USNM. [Examined]

Torymus Bakeri Cameron, 1904. Invert. Pac. 1: 58–59. ♀. Lectotype ♀, herein designated, BMNH. New Synonymy.

Callimome asphondyliae Gahan, 1919. Ann. Entomol. Soc. Am. 12: 161–162. ♂, ♀. (*nec asphondyliae* Kieffer and Jorgensen, 1910.) Holotype ♀, USNM. [Examined]

Torymus bakeri was described from at least four female specimens now housed at BMNH. I designate the specimen from San Marcos, Nicaragua (BMNH Hym. type 5.42) as lectotype. *Torymus bakeri* is identical to the wideranging, Neotropical species *hainesi*, and the range of this species is now extended south from El Salvador and Honduras to Nicaragua.

Torymus hainesi has been associated only with *Asphondylia websteri* Felt (Cecidomyiidae) on alfalfa. Its broad geographic range, however, from Nicaragua into southwestern United States, indicates a potentially larger range of cecidomyiid hosts on xeric plants.

Pteromalidae

Tritneptis **Girault**

Tritneptis Girault, 1908. Psyche 15: 92.

Type-species: *Tritneptis hemerocampae* Girault. Orig. desig.

Systellogaster Gahan, 1917. Proc. U.S. Natl. Mus. 53: 209. New Synonymy.

Type-species: *Systellogaster ovivora* Gahan. Orig. desig.

Gahan compared *Systellogaster* to the genus *Coelopisthia* of authors (= *Kranophorus* Graham) and also to *Dibrachys* Förster and *Coelopisthoidea* Gahan (= *Dibrachys*). *Systellogaster*, however, differs from these genera by the absence of an occipital carina. Wallace (1973), in his key to genera of the *Dibrachys* group, recognized this fact, and he separated *Systellogaster* from *Tritneptis* on the basis that the former had the "occiput-vertex boundary angled," whereas in *Tritneptis* it was "not meeting at an angle." Without an occipital carina, the degree of angulation is purely subjective as an examination of 6 of the 7 known species of *Tritneptis* (including the type of the genus) confirms.

Systellogaster has had only two described species, both of which are Nearctic. *Tritneptis gahani* (Wallace) n. comb. differs markedly from typical *Tritneptis* in having the marginal vein 6–7 times the length of the stigmal (3 times or less in *Tritneptis*) and in having the vertex of the head and most of the scutum and scutellum polished (sculptured in *Tritneptis*). It might better be placed in its own genus in the *Dibrachys* group, but I hesitate to create another new name, when we scarcely understand the names that are already available in the Pteromalidae.

Tritneptis ovivora (Gahan) n. comb. is closely related to *T. scutellata* (Muesebeck). In Burks' key (1971) to species of *Tritneptis*, *ovivora* and *scutellata* both run to the first couplet. They may be separated as follows: In *ovivora* the median propodeal carina is present (may be broken) and the posterior ocellar line is as long as, or longer than, the ocelloccipital distance. In *scutellata* there is no median propodeal carina and the posterior ocellar line is about ⅔ the length of the ocelloccipital distance. Additionally, *ovivora* is associated with cockroach oothecae whereas *scutellata* is associated with braconids in lepidopterous pupae.

Pseudocatolaccus Masi

Pseudocatolaccus Masi, 1908. Lab. Zool. Gen. Agric. Bol. Portici 3: 138–142.
Type-species: *Pseudocatolaccus asphondyliae* Masi. Monotypic.
(= *Ambylmerus nitescens* Walker, 1834)
Paradibrachys Girault, 1917. Descr. Hym. Chalcidoid. Variorum cum Observ. V, p. 1. New Synonymy.
Type-species: *Paradibrachys guizoti* Girault. Orig. des.

Although Girault (1917: 1) compared his genus *Paradibrachys* to *Dibrachys*, the genera have nothing in common with each other. *Paradibrachys* cannot even be placed in the *Dibrachys* group of genera (as defined by Wallace, 1973). *Paradibrachys* falls readily within the group of pteromalids which have a concave malar (genal) space (*Catolaccus* group, sensu Burks, 1954), and is inseparable from *Pseudocatolaccus*.

Pseudocatolaccus guizoti (Girault) N. Comb.

Paradibrachys guizoti Girault, 1917. Descr. Hym. Chalcidoid. Variorum cum Observ. V, p. 1. [♀]. Holotype ♀, USNM. [Examined]
Pseudocatolaccus americanus Gahan, 1919. Ann. Entomol. Soc. Am. 12: 164. ♀, ♂. Holotype ♀, USNM. [Examined]. New Synonymy.

Paradibrachys guizoti was described from 1 ♀ collected in the Argus Mountains of California, and *Pseudocatolaccus americanus* was described from 9 ♀ and 2 ♂ from Tempe, Arizona. The latter species was originally reared from *Asphondylia websteri* Felt (Diptera: Cecidomyiidae). Based upon an examination of the types and additional specimens recently reared by Brad Hawkins (University of California, Riverside, CA) and Gwendolyn Waring (Northern Arizona University, Flagstaff, AZ), I believe the above-mentioned species are synonyms. This species is wide spread throughout southwestern United States and is associated with cecidomyiid gall formers (especially *Asphondylia* spp.) on *Atriplex* (Hawkins, unpublished data), *Larrea* (Waring, unpublished data), and other host plants such as *Bidens* and *Medicago* (Burks, 1979). It is currently the only species of the genus recorded from North America.

Colotrechninae Thomson, 1876

Colotrechnides Thomson, 1876, Hym. Scand., v. 4, p. 217.
Dvaliniinae Hedqvist, 1978. Entomol. Scand. 8: 135. New Synonymy.

Thomson first listed the "subtribus" Colotrechnides in 1876 (p. 217) with a short description of its salient characters. Later, in 1878 (p. 46–47), he described the genus *Colotrechnus* and the species *subcoeruleus* which he placed in this tribe.

In 1977 Hedqvist described the genus *Dvalinia* which he placed near Eutrichosomatinae but did not actually attribute to a subfamily. In 1978 he proposed the new subfamily Dvaliniinae based upon his previously described genus. He added also *Elachertodomyia* Girault, 1917 and two new genera *Bofuria* and *Bomburia*.

Dvaliniinae has only one character in common with the eutrichosomatines, namely the forward projecting axillae, but differs in every other respect so that comparison of the two groups is entirely artificial and most likely has nothing to do with phylogenetic relationships. Dvaliniinae should have been compared originally with Colotrechninae, and its description could have been avoided.

For purposes of identification, Colotrechninae may be recognized most readily by a combination of the forward projecting axillae *and* two longitudinal submedian grooves on the scutellum. While other subfamilies have one or other of these two characters, none has both.

The currently recognized genera and species of Colotrechninae are:

Bofuria maculata Hedqvist, 1978. Neotropical.
    megastigmus (Ashmead), 1894. Neotropical.
Bomburia femorata Hedqvist, 1978. Neotropical.
Colotrechnus agromyzae Subba Rao, 1981. Oriental.
    ignotus Burks, 1978. Nearctic.
    subcoreuleus Thomson, 1878. Palearctic.
    viridis (Masi), 1921. Palearctic.
Dvalinia axillaris Hedqvist, 1977. Neotropical.
Elachertodomyia phloeotribi (Ashmead), 1896. Nearctic.

Of the above species I have examined specimens as follows: *Bofuria megastigmus* [Ashmead (1894: 155) described a male specimen from St. Vincent as the type of the species, and this specimen is in BM(NH). In USNM is a female from Grenada, which is the same specimen cited by Howard (1897) as *megastigmus* and in all probability was identified by Ashmead. This serves as a metatype for current purposes]; *Colotrechnus ignotus* (types examined), *C. subcoeruleus* (det. Bouček, Ruschka), *C. viridis* (det. Bouček); *Elachertodomyia phloeotribi* [female lectotype, herein designated, and newly reared material ex *Rhus glabra* L. stems containing *Pityophthorus lautus* Eichhoff (*new host* record) in Michigan (*new state* record), and ex *Phloeosinus cristatus* (LeConte) in *Cupressus* (*new host* record) from California]; *Dvalinia axillaris* (paratype).

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LITERATURE CITED

Ashmead, W. H. 1894. Report upon the parasitic Hymenoptera of the Island of St. Vincent. Report on the parasitic Cynipidae, part of the Braconidae, the Ichneumonidae, the Proctotrypidae, and part of the Chalcididae.—Part II. J. Linn. Soc. Lond. Zool. 25: 108–188.

Bugbee, R. E. 1967. Revision of chalcid wasps of genus *Eurytoma* in America north of Mexico. Proc. U.S. Natl. Mus. 118: 433–552.

———. 1975. *Eurytoma* species from Mexico and Guatemala with synonyms and keys. Ann. Entomol. Soc. Am. 68: 251–256.

Burks, B. D. 1954. Parasitic wasps of the *Catolaccus* group in the Americas. U.S. Dept. Agric. Tech. Bull. No. 1093: 1–19, +2 pl.

———. 1971. A new *Tritneptis*, with a revised key to the Nearctic species of the genus. Proc. Biol. Soc. Wash. 84: 1–5.

———. 1975. The species of Chalcidoidea described from North America north of Mexico by Francis Walker. Bull. Br. Mus. (Nat. Hist.) 32: 139–170.

———. 1979. Pteromalidae, pp. 768–835; Eurytomidae, pp. 835–860. *In* K. V. Krombein et al., eds., Catalog of Hymenoptera in America north of Mexico. Vol. I Symphyta and Apocrita (Parasitica). Smithsonian Institution Press. Washington, D.C., 1198 pp.

Claridge, M. F. 1959. The identity of *Eurytoma appendigaster* (Swederus, 1795), together with descriptions of some closely allied species bred from Graminae. Entomol. Mon. Mag. 95: 2–13.

———. 1960. Synonymy and lectotype selection for two Fabricius species of *Eurytoma*. Entomol. Medd. 29: 248–249.

Girault, A. A. 1917. Descriptiones Hymenopterorum Chalcidoidicarum Variorum cum Observationibus. V. Privately printed. 16 pp.

Hedqvist, K.-J. 1977. Two new genera and species of Pteromalidae from Brazil. Entomol. Scand. 8: 78–80.

———. 1978. A new subfamily and two new genera and species from the New World. Entomol. Scand. 9: 135–139.

Howard, L. O. 1897. On the Chalcididae of the Island of Grenada, B.W.I. J. Linn. Soc. Lond. Zool. 26: 129–178.

Milliron, H. E. 1949. Taxonomic and biological investigations in the genus *Megastigmus*. Am. Mid. Nat. 41: 257–420.

Peck, O. 1963. A catalogue of the Nearctic Chalcidoidea. Can. Entomol. Suppl. 30: 1092 pp.

Thomson, C. G. 1876. Hymenoptera Scandinaviae 4. *Pteromalus* (Svederus). p. 193–259. Lund.

———. 1878. Hymenoptera Scandinaviae. 5. *Pteromalus* (Svederus) continuatio. 307 pp. Lund.

Wallace, G. E. 1973. New Pteromalidae of the *Dibrachys* group with a key to genera. Ann. Carnegie Mus. 44: 171–181.

Yoshimoto, C. M. 1979. A new species of *Megastigmus* from Mexico. Can. Entomol. 111: 201–206.

PROC. ENTOMOL. SOC. WASH.
87(2), 1985, pp. 356–370

THE INSECT FAUNA OF NINEBARK, *PHYSOCARPUS OPULIFOLIUS* (ROSACEAE)

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Abstract.—The insect fauna of ninebark, *Physocarpus opulifolius* (L.) Maxim., a primitive rosaceous shrub, was studied in New York and Pennsylvania during 1978–84. Notes on phenology and habits and published records from *Physocarpus* are given for the specialist herbivores, for species that are potential specialists pending collection of additional data, and for those that appear to include ninebark as a preferred host. The specialists discussed are the mirids *Plagiognathus punctatipes* Knight and *Psallus physocarpi* Henry, the aphids *Utamphorophora humboldti* Essig and *Aphis neilliae* Oestlund, the chrysomelid *Calligrapha spiraeae* (Say), the geometrids *Eulithis molliculata* (Walker) and *Itame abruptata* (Walker), the tortricid *Ancylis spiraeifoliana* (Clemens), and the torymids *Megastigmus gahani* Milliron and *M. physocarpi* Crosby. Listed in tabular form are phytophagous insects associated with ninebark, including a separate list of species that visited inflorescences for nectar or pollen; predators and any associated prey species; and parasites reared from the plant and their hosts, if known.

We became interested in the insect fauna of ninebark, *Physocarpus opulifolius* (L.) Maxim., in 1977 when our attention was called to an outbreak of the chrysomelid *Calligrapha spiraeae* (Say) in an ornamental planting of this rosaceous shrub. In studying the life history of *C. spiraeae* (Wheeler and Hoebeke, 1979) we realized that ninebark, a primitive member of the Rosaceae, harbored a diverse insect fauna that included several host-specific, poorly known species. McGuffin (1977) mentioned ninebark as a plant neglected in surveys of Lepidoptera and as the apparent sole host of two geometrids, *Eulithis molliculata* (Walker) and *Itame abruptata* (Walker). Several other insects have been recorded from the plant, including two species that may cause significant injury. At Oak Park, Illinois, in 1909, *Aphis neilliae* Oestlund "became so abundant that the leaves were badly curled and the shoots stunted or even killed" (Davis, 1910). The buprestid *Dicerca pugionata* (Germar) develops in living stems of ninebark and may kill its host (Knull, 1925). We report here the results of a qualitative survey of ninebark insects conducted in New York and Pennsylvania during 1978–84.

THE HOST PLANT

Physocarpus opulifolius originally was placed in the genus *Spiraea*; hence, the epithet *spiraeae* applied by Say (1826) in describing a new species of *Calligrapha* associated with ninebark. The plant's common name is derived either from its bark, which peels off in numerous layers (Strausbaugh and Core, 1978), or from the medicinal cures the plant once was thought to produce (Stokes, 1981).

P. opulifolius is a member of the subfamily Spiraeoideae of the Rosaceae, a family belonging to the relatively primitive order Rosales. It is one of 10 species of a mainly North American genus of hardy deciduous shrubs (one Asian species is known). Often found along stream and river banks and in sandy soil at the edge of woods, it ranges from Quebec west to Michigan and south to Tennessee. In its several cultivars, ninebark is planted occasionally as an ornamental, and its movement in horticultural trade and escape from cultivation have broadened the native range. Ninebark is characterized by the exfoliating bark; alternate, toothed, usually 3-lobed leaves that resemble those of currants (*Ribes*) or those of *Viburnum opulus* L.; and white or pinkish flowers, having 5 petals and sepals and 20–40 stamens, which are borne in umbel-like clusters up to 5 cm wide. Pollination is unspecialized and is effected by a variety of insects that cannot avoid contacting the prominent anthers. The fruit is a small, firm-walled, inflated follicle, an attribute responsible for the generic name *Physocarpus*, derived from the Greek *physa* (bladder) and *karpos* (fruit). The seeds are smooth, roundish, and have a shining testa. This characterization of ninebark was drawn from Gleason and Cronquist (1963), Takhtajan (1969), Bailey and Bailey (1976), Stokes (1981), and Everett (1981).

STUDY SITES AND METHODS

In New York, collections of insects from ninebark were made during 1979–83 at irregular intervals from an extensive planting near Salmon Creek at Ludlowville, Tompkins Co. Additional collections and observations were made from a native stand growing in Taughannock Falls State Park about 13 km north of Ithaca (Tompkins Co.) and from a few ornamental plants on and near the Cornell University campus at Ithaca.

The main study site in Pennsylvania was a native stand growing along a creek near Route 443 about 15 km northeast of Harrisburg, Dauphin Co. In 1979 and 1980 this planting was surveyed for insects once or twice each week during April, weekly during May–June (except for a 10-day interval each season), and every 2–3 weeks during July and August. Late-season collections were made from late September to early November 1978; additional sampling was conducted at irregular intervals during 1981–84. On each sample date insects first were observed on the plants, and the species present and any feeding or host injury were recorded. Then branches were tapped over a small tray (24 × 30 cm) and the dislodged species noted or collected for identification. Notes on the relative abundance and stages present were recorded for some of the most common insects; notes on plant phenology also were made. Immature insects that could not be identified in the field were reared to maturity in the laboratory on sprigs of the host. Parasitized insects observed in the field were held for parasite emergence and subsequent identification. Seeds collected in early November 1978 were held for the emergence of seed predators. Additional collections of ninebark insects were made from native stands in 12 counties.

RESULTS AND DISCUSSION

The phytophagous insects that develop on ninebark or feed as adults on foliage and stems are listed in Table 1; species of apparent accidental occurrence have

Table 1. Phytophagous insects (excluding inflorescence feeders) associated with *Physocarpus opulifolius* in New York and Pennsylvania.

Species	Stages Collected[a]	Plant Part Affected[b]	No. of Collections	
			NY	PA
Orthoptera				
Acrididae				
Unidentified sp.	N	F, Lv	—[c]	2
Tettigoniidae				
Amblycorypha rotundifolia (Scudder)	A	Lv	1	—
Unidentified spp.	N	Lv	1	4
Gryllidae				
Oecanthus sp.	N	Lv, S	1	—
Thysanoptera				
Thripidae				
Thrips sp.	L, A	F	—	1
Hemiptera-Heteroptera				
Miridae				
Heterocordylus malinus Slingerland	N, A	F, Lv	—	2
Lopidea heidemanni Knight	N, A	Lv	—	3
L. media (Say)	N, A	F, Lv	—	8
Neurocolpus nubilus (Say)	N, A	F	1	9
Phytocoris salicis Knight	N, A	Lv	—	2
Plagiognathus punctatipes Knight	N, A	F	8	38
Poecilocapsus lineatus (F.)	E, N	Lv	—	2
Psallus physocarpi Henry	N, A	F	4	22
Taedia scrupea (Say)	N, A	F	2	5
Pentatomidae				
Acrosternum hilare (Say)	E, N, A	F	5	8
Euschistus servus euschistoides (Vollenhoven)	N	F	1	—
E. tristigmus tristigmus (Say)	N, A	F	2	10
Coreidae				
Acanthocephala terminalis (Dallas)	N, A	Lv	—	1
Hemiptera-Homoptera				
Membracidae				
Spissistilus borealis Fairmaire	A	Lv?	1	—
Stictocephala taurina (Fitch)	A	Lv?	1	—
Unidentified sp.	E	?	1	4
Cicadellidae				
Empoasca sp.	N	Lv	—	9
Erythroneura bitincta McAtee	A	Lv	—	1
E. bistrata var. *stricta* McAtee	A	Lv	1	—
Erythroneura sp., near *usitata* Beamer	A	Lv	—	1

Table 1. Continued.

Species	Stages Collected[a]	Plant Part Affected[b]	No. of Collections	
			NY	PA
Erythroneura sp.	N	Lv	—	5
Graphocephala coccinea (Forster)	N, A	Lv	4	7
Jikradia olitoria (Say)	N	Lv	—	4
Penthimia americana Fitch	N, A	Lv	2	10
Typhlocyba sp.	A	Lv	1	—
Cercopidae				
Clastoptera obtusa (Say)	A	Lv	—	2
Lepyronia quadrangularis (Say)	N, A	Lv	1	3
Flatidae				
Anormenis septentrionalis (Spinola)	N, A	Lv	—	3
Metcalfa pruinosa (Say)	N, A	Lv	5	4
Acanaloniidae				
Acanalonia conica (Say)	N, A	Lv	2	1
Aphididae				
Aphis neilliae Oestlund	N, A	Lv	—	9
Nearctaphis bakeri (Cowan)	N	F	—	2
Utamphorophora humboldti Essig	E, N, A	Lv	4	27
Coleoptera				
Scarabaeidae				
Dichelonyx diluta Fall	A	Lv	2	—
Macrodactylus subspinosus (F.)	A	F	—	1
Popillia japonica Newman	A	Lv	1	3
Buprestidae				
Dicerca pugionata (Germar)	A	Lv	—	2
Chrysomelidae				
Calligrapha spiraeae (Say)	E, L, P, A	Lv	1	40
Diabrotica undecimpunctata howardi Barber	A	Lv	—	6
Nodonota margaretae Schultz	A	Lv	—	4
N. puncticollis (Say)	A	Lv	—	7
Odontota dorsalis Thunberg	A	Lv	—	2
Paria fragariae Wilcox	A	Lv	1	4
P. quadrinotata (Say)	A	Lv	—	2
Lepidoptera				
Notodontidae				
Schizura unicornis (J. E. Smith)	L	Lv	1	1
Noctuidae				
Eupsilia morrisoni (Grote)	L	Lv	—	3
Eupsilia sp.	L	Lv	4	—
Lithophane oriunda Grote	L	Lv	1	—
Lithophane sp., near *hemina* Grote	L	Lv	—	1
Melanchra adjuncta (Guenée)	L	Lv	—	2

Table 1. Continued.

Species	Stages Collected[a]	Plant Part Affected[b]	No of Collections	
			NY	PA
Morrisonia evicta (Grote)	E, L	Lv	—	2
Orthosia hibisci (Guenée)	L	Lv	2	5
Zylena curvimacula (Morrison)	L	Lv	1	—
Lymantriidae				
Lymantria dispar (L.)	L	F	—	1
Thyatiridae				
Habrosyne gloriosa (Guenée)	L	Lv	3	8
Geometridae				
Erannis tiliaria (Harris)	L	Lv	—	3
Eulithis molliculata (Walker)	L	Lv	7	7
Eupithecia miserulata Grote	L	Lv	—	1
Hypagyrtis unipunctata (Haworth)	L	Lv	1	—
Itame abruptata (Walker)	L	Lv	6	11
Lomographa semiclarata (Walker)	E, L	Lv	—	11
L. vestaliata (Guenée)	L	Lv	2	—
Phigalia titea (Cramer)	L	F, Lv	1	1
Prochoerodes transversata (Drury)	L	Lv	1	—
Pyralidae				
Herpetogramma abdominalis (Zeller)	L	Lv	1	—
Tortricidae				
Ancylis spiraeifoliana (Clemens)	L, P, A	Lv	5	13
Choristoneura rosaceana (Harris)	L, A	Lv	4	—
Olethreutes permundana (Clemens)[d]	L, A	F, Lv	11	25
Cochylidae				
Aethes sp.	L, (A?)	S	1	10+
Diptera				
Cecidomyiidae				
Contarinia sp. 1	L	Lv	—	5+
C. sp. 2	L	Lv	—	5+
C. sp. 3	L	F	—	10+
Hymenoptera				
Torymidae				
Megastigmus gahani Milliron	L, A	S	3	10
M. physocarpi Crosby	A	S	1	—

[a] Stages collected: E, eggs; L, larvae; P, pupae; A, adults.

[b] Plant part affected: F, flowers/fruit; Lv, leaves/stems; S, seeds.

[c] — = not collected.

[d] Including an unidentified species of *Olethreutes*.

been omitted. Insects collected from the inflorescences where they appeared to feed on nectar or pollen are recorded in Table 2. Through the courtesy of Frank D. Fee (State College, PA), this list of flower visitors includes his extensive records of Diptera taken from ninebark inflorescences in Pennsylvania during 1978–81. Notes on seasonal history and habits are given for the ninebark specialists and for those herbivores that may prove specific to *Physocarpus opulifolius,* or to include this plant among their preferred hosts when additional information is obtained. The phenological data apply to populations observed near Harrisburg, PA unless stated otherwise; early-season development of plant and insect populations in New York generally was 1–2 weeks behind.

Hemiptera-Heteroptera.—*Plagiognathus punctatipes* Knight first was associated with ninebark in a list of Miridae from West Virginia (Wheeler et al., 1983). Knight (1923) described this phyline mirid mainly from a series (18 specimens) he collected at Ithaca, New York, "on flowers of an ornamental shrub"; with little doubt the plant was *Physocarpus opulifolius.*

Overwintered eggs of *P. punctatipes* began to hatch during the first week of May when flower buds were evident but tightly closed. Third- and fourth-instar nymphs were observed by the third week of May when white was becoming visible in the closed buds. The population consisted of fifth instars during early bloom (late May). The first appearance of adults coincided with full bloom, usually the first week of June; they were most numerous in mid-June when petals were beginning to fall. Each season at this time some adults dispersed to the inflorescences of nearby staghorn sumac, *Rhus typhina* L., at the main sample site. In most years, adults of this univoltine mirid were not observed on ninebark (or sumac) after late June or early July.

Psallus physocarpi Henry, a second mirid specializing on ninebark inflorescences, was described from specimens collected at the main study areas in New York and Pennsylvania (Henry, 1981). The habits of this univoltine phyline are similar to those of *Plagiognathus punctatipes,* but its populations develop 2–3 weeks later. Overwintered eggs began to hatch in late May, third instars were present by the first week of June, and the first adults were taken in collections of late June. Adults, which also dispersed to inflorescences of staghorn sumac, were abundant during the first week of July, and usually by mid-July only 1 or 2 were observed in the weekly samples. Adults were found in early August at higher elevations in western Pennsylvania.

Hemiptera-Homoptera.—In Pennsylvania, the cicadellid *Penthimia americana* Fitch was taken consistently on ninebark beginning with early-instar nymphs in late April. Third and fourth instars were collected in early to mid-May and fifth instars during mid- to late May. The host plants of this cercopid-like leafhopper (subfamily Gyponinae) have not been recorded. DeLong (1948) noted that it "seems to be associated with shrubs in wooded or cut-over areas"; Beirne (1956) stated that the hosts are "probably some woody plants."

Essig (1941) described the aphid *Utamphorophora humboldti* from *Viburnum ellipticum* Hook. in California but, as noted by Hille Ris Lambers (1966), Essig later "suspected that the aphids did not live on viburnum." Because Hille Ris Lambers collected this aphid on *Physocarpus* in California, it seems possible that Essig's "viburnum" was a species of ninebark. The secondary hosts are various

Table 2. Insects associated with inflorescences of *Physocarpus opulifolius* in New York and Pennsylvania.

Hemiptera-Heteroptera
Miridae
Metriorrhynchomiris dislocatus (Say)
M. fallax Reuter

Coleoptera
Staphylinidae
Acrotona sp.
Eusphalerum sp.

Helodidae
Cyphon variabilis (Thunberg)
Scirtes orbiculatus (F.)

Elateridae
Agriotes oblongicollis (Melsheimer)

Cantharidae
Chauliognathus marginatus F.

Dermestidae
Anthrenus fuscus Olivier

Nitidulidae
Carpophilus brachypterus (Say)

Melandryidae
Anaspis rufa Say

Mordellidae
Mordella marginata Melsheimer

Cerambycidae
Analeptura lineola (Say)
Brachyleptura circumdata (Olivier)
Clytus ruricola (Olivier)
Melorchus bimaculatus Say
Psenocerus supernotatus (Say)
Trachysida mutabilis (Newman)

Curculionidae
Centranaspis picumnus (Herbst)

Lepidoptera
Adelidae
Adela ridingsella Clemens

Nymphalidae
Phyciodes tharos (Drury)

Diptera
Tipulidae
Limonia canadensis (Westwood)

Chironomidae
Orthocladiinae

Bibionidae
Dilophus sp.

Scatopsidae
Anapausis n. sp.

Stratiomyidae
Stratiomys adelpha Steyskal

Tabanidae
Chrysops cincticornis Walker,[a] ♂
C. sackeni Hine,[a] ♂

Phoridae
Conicera dauci (Meigen)
Megaselia sp.

Syrphidae
Blera analis (Macquart)[a]
B. umbratilis (Williston)[a]
Brachyopa flavescens Shannon[a]
B. notata Osten Sacken[a]
B. perplexa Curran[a]
B. vacua Osten Sacken[a]
Cheilosia capillata Loew[a]
C. comosa Loew[a]
C. cynoprosopa Hull and Fluke[a]
C. leucoparea Loew[a]
C. orilliaensis Curran[a]
C. rita Curran[a]
C. n. sp.[a]
Chrysogaster nigripes Loew[a]
C. sp.[a]
Chrysotoxum pubescens Loew[a]
C. radiosum Shannon[a]
Copestylum vesicularium (Curran)[a]
Epistrophe xanthostoma (Williston)[a]
Eristalis arbustorum (L.)[b]
E. anthophorina (Fallen)[a]
E. saxorum Wiedemann[a]
E. tenax (L.)[a]
E. transversus Wiedemann[b]
Hiatomyia cyanescens Loew[a]
Lejops chrysostomus (Wiedemann)[a]
L. lineatus (F.)[a]
Mallota bautias (Walker)[a]
M. posticata (F.)[a,b]
Metasyrphus pomus (Curran)[a]
Myolepta nigra Loew[a]
M. varipes Loew[a]
Orthonevra sp.[a]
Parhelophilus laetus Loew[a]
Platycheirus n. sp.[a]
Somula decora Macquart[a]
Sphaerophoria contigua Macquart[b]
Sphecomyia vittata (Wiedemann)[a]
Sphegina brachygaster Hull[a]
S. campanulata Robertson[a]
S. flavimana Malloch[a,b]
S. lobata Loew[a]
S. lobulifera Malloch[a]

Table 2. Continued.

Spilomyia alcimus (Walker)[a]
Syritta pipiens (L.)[a]
Temnostoma alternans Loew[a]
T. barberi Shannon[a]
Toxomerus geminatus (Say)[b]
Tropidia quadrata (Say)[a]
Xylota quadrimaculata Loew[a]

Sepsidae
Unidentified sp.

Ephydridae
Ditrichophora exigua Cresson

Chloropidae
Chlorops certimus Adams
C. obscuricornis Loew
Malloewia nigripalpis (Malloch)
Olcella trigramma (Loew)
Rhopalopterum luteiceps (Sabrosky)
Tricimba melancholica (Becker)

Anthomyiidae
Hydrophoria sp.
Hylemya sp.

Muscidae
Graphomya maculata (Scopoli)

Calliphoridae
Lucilia illustris (Meigen)
Pollenia rudis (F.)

Tachinidae
Alophorella sp.
Archytas instabilis Curran
Epalpus signifer (Walker)
Gymnoclytia occidentalis (Walker)
Gymnosoma fuliginosum Robineau-Desvoidy
Hyalomyodes triangulifer (Loew)

Hymenoptera

Eucoilidae
Kleidostoma sp.

Formicidae
Camponotus nearcticus Emery
Formica schaufussi Mayr
F. subsericea Say
Lasius alienus (Foerster)
L. neoniger Emery

Halictidae
Dialictus cressonii (Robertson)
D. imitatus (Smith)
Sphecodes ? cressonii Robertson

Andrenidae
Andrena ceanothi Viereck
A. crataegi Robertson
A. hippotes Robertson
A. nivalis Smith
A. perplexa Smith
A. wilkella Kirby

Anthophoridae
Ceratina dupla Say or *calcarata* Robertson
Nomada lepida Cresson

Apidae
Apis mellifera L.

[a] Tabanidae and Syrphidae from records of F. D. Fee.
[b] Syrphidae from present study.

grasses. *Myzus physocarpi* Pepper, described from *P. opulifolius* in Pennsylvania, is a junior synonym of *U. humboldti* (Cook, 1984).

Eggs of this early-season colonizer of ninebark overwintered under bud scales or on stems just beneath leaf buds. The hatching of eggs coincided with the first flush of leaves. Newly hatched fundatrices were observed during the second week of April in 1980; the third week, in 1979. Aphids fed between veins on lower leaf surfaces, their colonies usually most abundant at shoot apices. Infested leaves appeared crinkled and distorted, and sometimes smaller than uninfested leaves. Alate aphids began to appear during mid-May after which populations soon declined. Aphids generally were not observed on the plants after late May or early June, when presumably they colonized a secondary host plant. In 1978, the only year in which late-season collections were made, alates returned to ninebark in mid-October; alatae and apterae were common in early November.

Aphis neilliae Oestlund, known from *Physocarpus opulifolius* in Pennsylvania (Pepper, 1965) and New York (Leonard, 1968), was another early-season colonizer, appearing on the plants by mid- to late April. This aphid formed dense colonies on new growth, typically on only a few plants or on several terminals of a single plant. Ants, *Lasius alienus* (Foerster) and *Tapinoma sessile* (Say), were present in most colonies. *Aphis neilliae* was not observed on ninebark after early or mid-May.

Coleoptera.—The chrysomelid *Calligrapha spiraeae* (Say), a specialist herbivore on ninebark, was the only coleopteran found to reproduce on the plant. A summary of its life history during 1977–78 (Wheeler and Hoebeke, 1979) and additional information obtained in 1979–84 are presented here.

Overwintered adults appeared on ninebark at leaf flush or shortly after (mid-April); they soon mated and deposited eggs, usually in small clusters (average of 5.9, n = 21), on the underside of leaves or on tips of dead twigs. A few first-instar larvae were observed in late May, but they did not become numerous until early to mid-June. Early-instar larvae chewed roundish holes in the interior of host foliage, whereas late instars fed on the edges of leaves, imparting a ragged appearance to the plants. Mature larvae dropped from ninebark and pupated in the soil beginning in mid-June, and adults of the first generation began to emerge in late June. A smaller second generation was produced during late July and August. In central Pennsylvania in 1977, larvae of the first generation defoliated an ornamental hedge (70 meters long). This chrysomelid was absent from the study sites in New York, and the only New York record is a single adult collected from ninebark at Aurora in June 1978 (Wheeler and Hoebeke, 1979).

Lepidoptera.—In New York and Pennsylvania, larvae of the thyatirid *Habrosyne gloriosa* (Guenée) were common on ninebark during late June through August. Although the larva was known to Forbes (1923), apparently no host plants have been recorded for this species.

Two geometrids known only from ninebark, *Eulithis molliculata* and *Itame abruptata* (McGuffin, 1977), were taken in our survey. As McGuffin noted, overwintering occurs in the egg stage, with egg hatch occurring in spring. McGuffin (1971) described the twig-mimicking larva of *E. molliculata* and (1972) the larva of *I. abruptata.* In Pennsylvania, early-instar larvae of these univoltine species usually appeared in the late April or early May samples, and mature larvae were collected during mid- to late May. In New York, a mid-July peak emergence of *E. molliculata* was indicated by blacklight collections made at the Ludlowville study site (J. E. Rawlins, pers. comm.). In New York, *E. molliculata* was collected more frequently than *I. abruptata.* A collection of the latter species at Taughannock Falls State Park in 1979 was a new state record (Hoebeke, 1980).

Another geometrid known from ninebark, *Lomographa semiclarata* (Walker) (McGuffin, 1981), was common in Pennsylvania. Eggs laid on upper leaf surfaces in mid- to late April hatched in late April or early May. Early-instar larvae collected in June probably represented a second generation.

The olethreutine tortricids *Olethreutes* sp., *O. permundana* (Clemens), and *Ancylis spiraeifoliana* (Clemens) were among the most common ninebark herbivores and were encountered in nearly all plant colonies sampled in New York and Pennsylvania. The following observations refer to *O. permundana,* a species known from *Physocarpus* (Forbes, 1923), and possibly also to an unidentified species of *Olethreutes.* Larvae were observed on ninebark at or just before bud break (mid-April). First-instar larvae bored into tightly closed leaf buds and tied expanding leaves. Larvae became numerous in early May, and mature larvae were collected by mid-May. First instars observed in late May and early June probably represented the beginning of a second brood; they often bored into flower buds. Larvae were present in samples until late June.

Ancylis spiraeifoliana was described from *Physocarpus opulifolius* (Clemens, 1861) and is also known from spirea (MacKay, 1959). Clemens noted that larvae fold leaves longitudinally and live on parenchyma within the fold. In 1982 we observed adults on ninebark in two plantings during late May; in 1979 first-instar larvae already were present by late May, although they were not found on host plants until early June in 1980. A pupa of the first generation was observed in early July (and mid-July in New York). The number of generations was not determined, but larvae were recorded in samples from July to early November.

A seed predator tentatively identified as a cochylid, *Aethes* sp., was common on ninebark in Pennsylvania but was rarely collected in New York. Larvae were not reared to the adult stage, but the moths that appeared on *Physocarpus* each season from late May to early June were believed to represent this species. First-instar larvae were dissected from developing seeds in mid-June, and late-stage larvae were found in seeds collected in late September. In early November, apparently mature larvae were observed in seeds that still remained on the plants. We believe this univoltine species overwinters as a larva (or perhaps pupa) in fallen seeds.

Diptera.—At least three types of cecidomyiid galls were observed on ninebark in Pennsylvania. Larvae from these galls belong to the genus *Contarinia* and, although generally similar, they are thought to represent distinct species (R. J. Gagné, in litt.). No adults were collected, but rearing would allow us to determine whether distinct species induce the gall types described below.

Galls of *Contarinia* sp. 1 appeared in early May on lateral veins of the lower surface of expanding leaves. They are bladderlike, about 2–5 mm long, and pinkish. Yellowish-green to red, pealike galls of *C.* sp. 2 were found in early June on or near the midrib of the upper surface. Whitish, globose inflorescence galls of *C.* sp. 3 appeared in late May to early June.

Hymenoptera.—Another seed predator, the torymid *Megastigmus gahani* Milliron, was present on ninebark in New York and Pennsylvania. Adults, like those of the lepidopteran seed predator, appeared on the plants when flower buds were still closed or just beginning to open (late May) and were present until late June or early July. *M. gahani* is known to infest seeds of ninebark and to co-exist with the related *M. physocarpi* Crosby (Milliron, 1949). In our survey a single adult of *M. physocarpi* was taken on ninebark at Ludlowville.

The fauna of *Physocarpus opulifolius* encompasses at least ten specialist herbivores (restricted to ninebark or feeding on other members of the Spiraeoideae), including the aphids *Utamphorophora humboldti* and *Aphis neilliae,* for which ninebark appears to be the primary host in the eastern U.S. When specific identifications and further biological data are obtained, five additional specialists, or at least species preferring ninebark, may be added: the cicadellid *Penthimia americana,* the buprestid *Dicerca pugionata,* the thyatirid *Habrosyne gloriosa,* an unidentified species of *Olethreutes,* and a cochylid seed predator identified as *Aethes* sp. The cecidomyiids whose feeding induced leaf and inflorescence galls also may represent host-restricted species.

Four oligophagous species associated with other rosaceous hosts were collected: the apple red bug, *Heterocordylus malinus* Slingerland, which has not been re-

Table 3. Predacious insects associated with *Physocarpus opulifolius* in New York and Pennsylvania.

Species	Stages Collected[a]	No. of Collections NY	PA	Prey Associations
Thysanoptera				
Phlaeothripidae				
Haplothrips faurei Hood	L, A	2[b]	1[b]	
Leptothrips mali (Fitch)	L, A	—	1[b]	
Hemiptera-Heteroptera				
Pentatomidae				
Podisus maculiventris (Say)	E, N, A	3	3	*Calligrapha spiraeae* larvae
P. placidus Uhler	N, A	1	—	
Stiretrus anchorago (F.)	N	—	1	*C. spiraeae* larva
Phymatidae				
Phymata sp.	A	—	1	
Reduviidae				
Pselliopus cinctus (F.)	A	—	1	*Cantharis rectus* adult
Zelus exsanguis (Stal)	N, A	1	6	
Anthocoridae				
Orius insidiosus (Say)	N	1	2	
Miridae				
Deraeocoris fasciolus Knight	A	—	1	
Coleoptera				
Coccinellidae				
Adalia bipunctata (L.)	E, L, P, A	1	10	*Aphis neilliae, Utamphorophora humboldti*
Anatis sp.	A	—	1	
Brachyacantha ursina F.	A	—	1	
Coccinella novempunctata Herbst	L	—	1	
C. septempunctata L.	A	—	1	
Coleomegilla maculata (DeGeer)	A	2	1	in colony of *U. humboldti*
Cycloneda munda (Say)	(?L), A	—	5	in colony of *U. humboldti*
Neuroptera				
Hemerobiidae				
Hemerobius humulinus L.	L, A	—	1	
Diptera				
Syrphidae				
Syrphus torvus Osten Sacken	L	—	1	*U. humboldti*

[a] Stages collected: E, eggs; L, larvae; N, nymphs; P, pupae; A, adults.

[b] Apparently common on *Physocarpus* but not always collected when observed and not all specimens collected were identified.

corded previously from ninebark; the tortricid *Olethreutes permundana*; and the geometrids *Lomographa semiclarata* and *L. vestaliata* (Guenée), which are known from *P. opulifolius* (Forbes, 1923; McGuffin, 1981). The aphid *Nearctaphis bakeri* (Cowan), whose primary hosts are various Rosaceae, has been recorded from *Physocarpus* in Pennsylvania (Pepper, 1965); we observed this species within

Table 4. Parasite species associated with *Physocarpus opulifolius* in New York and Pennsylvania.

Species	Host Associations/Stage Affected
Hymenoptera	
Braconidae	
Apanteles schizurae Ashmead	*Schizura unicornis*/larva
Macrocentrus iridescens French	*Choristoneura rosaceana*/larva
Meteorus leviventris (Wesmael)	*Eupsilia* sp./larva
Meteorus sp.	*Itame abruptata*/larva
Microplitis sp.	*Orthosia hibisci*/larva
Perilitus coccinellae (Schrank)	*Coleomegilla maculata*/adult
Aphidiidae	
Lysiphlebus testaceipes (Cresson)	*Aphis neilliae*/fundatrix
Ichneumonidae	
Ischnus inquisitorius atricollaris (Walsh)	*Choristoneura rosaceana*/larva
Itoplectis conquisitor (Say)	*Olethreutes permundana*/larva
Pteromalidae	
Dibrachys cavus (Walker)	*Choristoneura rosaceana*/larva
Erixestus winnemana Crawford	*Calligrapha spiraeae*/egg
Chalcididae	
Spilochalcis sp.	*Ancylis spiraeifoliana*/larva
Eulophidae	
Elachertus cacoeciae Howard	*Olethreutes permundana*/larva
Pediobius sp.	Host unknown; emerged from colln. of seeds
Tetrastichus sp.	Host unknown; emerged from colln. of seeds

ninebark inflorescences, the typical feeding site on this host in Pennsylvania (J. O. Pepper, pers. comm.).

Even though several specialist herbivores and oligophagous species are associated with *P. opulifolius,* woody plants, compared to native forbs, tend to have a less specialized fauna (Messina and Root, 1980). Of the herbivores observed to develop on ninebark and identified to species, nearly 80% were generalists. At least two of the polyphagous herbivores have been recorded from *Physocarpus*: the coreid *Acanthocephala terminalis* (Dallas) (Yonke and Medler, 1969) and the tortricid *Choristoneura rosaceana* (Harris) (Schuh and Mote, 1948).

We note also that larvae and adults of a mycophagous coccinellid, *Psyllobora vigintimaculata* (Say), not listed in Table 1, were abundant on inflorescences covered with powdery mildew, *Sphaerotheca macularis* Wall ex Frier, during June at a site near Harrisburg. Sometimes common on *P. opulifolius* at Ludlowville were adults of the presumed mycophagous coleopterans *Corylophodes marginicollis* (LeConte) (Corylophidae) and *Tomarus pulchellus* LeConte (Cryptophagidae).

The most abundant of the nine species that fed as adults on vegetative structures of ninebark was the chrysomelid *Nodonota puncticollis* (Say). This species fed on expanding foliage at shoot apices and also on petals; mating pairs often were observed on the plants. Inflorescences of ninebark attracted adults of numerous beetles and flies. Table 2 records a portion of the species that appeared to obtain nectar or pollen from *Physocarpus* flowers. In commenting on the attractiveness of ninebark inflorescences to insects, Stokes (1981) specifically mentioned the rose chafer, *Macrodactylus subspinosus* (F.), and cerambycids as flower visitors. Several species of andrenid bees are known to visit flowers of *P. opulifolius* (Laberge, 1973; Bouseman and Laberge, 1978; Hurd, 1979; Johnson, 1984). In Michigan, Waldbauer (1983) reported 14 syrphid species and (1984) 5 species of the syrphid genus *Temnostoma* from ninebark inflorescences.

The predacious insects occurring on ninebark and their associated prey are listed in Table 3. The aphid feeders *Adalia bipunctata* (L.) and *Cycloneda munda* (Say) generally were the most abundant predators encountered in sampling. Table 4 lists the parasitic species associated with insects collected on ninebark.

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LITERATURE CITED

Bailey, L. H. and E. Z. Bailey (and staff of the Liberty Hyde Bailey Hortorium). 1976. Hortus third: a concise dictionary of plants cultivated in the United States and Canada. MacMillan Publ. Co., New York. 1290 pp.

Beirne, B. P. 1956. Leafhoppers (Homoptera: Cicadellidae) of Canada and Alaska. Can. Entomol. 88, Suppl. 2. 180 pp.

Bouseman, J. K. and W. E. LaBerge. 1978. A revision of the bees of the genus *Andrena* of the Western Hemisphere. Part IX. Subgenus *Melandrena*. Trans. Am. Entomol. Soc. 104: 275–389.

Clemens, B. 1861. Contributions to American Lepidopterology.-No. 6. Proc. Acad. Nat. Sci. Philadelphia, 1860: 345–362.

Cook, E. F. 1984. *Glabromyzus* and *Utamphorophora* (Homoptera: Aphididae) species of North America. Ann. Entomol. Soc. Am. 77: 705–711.

Davis, J. J. 1910. A list of the Aphididae of Illinois, with notes on some of the species. J. Econ. Entomol. 3: 482–499.

DeLong, D. M. 1948. The leafhoppers, or Cicadellidae, of Illinois (Eurymelinae-Balcluthinae). Ill. Nat. Hist. Surv. Bull. 24(2): 97–376.

Essig, E. O. 1941. A new species of *Myzus* from Humboldt County, California (Homoptera, Aphididae). Pan-Pac. Entomol. 17: 182–184.

Everett, T. H. 1981. The New York Botanical Garden illustrated encyclopedia of horticulture. Vol. 8. Garland Publ., New York and London. pp. 2493–2862.

Forbes, W. T. M. 1923. The Lepidoptera of New York and neighboring states. Cornell Univ. Agric. Exp. Stn. Mem. 68. 729 pp.

Gleason, H. A. and A. Cronquist. 1963. Manual of vascular plants of northeastern United States and adjacent Canada. D. Van Nostrand Co., Princeton, N.J. 810 pp.

Henry, T. J. 1981. A new eastern United States *Psallus* Fieber (Heteroptera: Miridae) from *Physocarpus* (Rosaceae). Proc. Entomol. Soc. Wash. 83: 399–402.

Hille Ris Lambers, D. 1966. Notes on California aphids, with descriptions of new genera and new species (Homoptera: Aphididae). Hilgardia 37: 569–623.

Hoebeke, E. R. 1980. A record of *Itame abruptata* (Geometridae) from New York. J. Lepid. Soc. 34: 132.

Hurd, P. D., Jr. 1979. Superfamily Apoidea. Pp. 1741–2209. *In* K. V. Krombein et al., Catalog of Hymenoptera in America north of Mexico. Vol. 2. Apocrita (Aculeata). Smithsonian Inst. Press, Washington, D.C.

Johnson, M. D. 1984. The pollen preferences of *Andrena (Melandrena) dunningi* Cockerell (Hymenoptera: Andrenidae). J. Kans. Entomol. Soc. 57: 34–43.

Knight, H. H. 1923. Family Miridae (Capsidae). Pp. 422–658. *In* Britton, W. E., ed., Guide to the insects of Connecticut. Part IV. The Hemiptera or sucking insects of Connecticut. Conn. State Geol. Nat. Hist. Surv. Bull. 34.

Knull, J. N. 1925. The Buprestidae of Pennsylvania (Coleoptera). Ohio State Univ., Univ. Stud. 2(2): 1–71.

LaBerge, W. E. 1973. A revision of the bees of the genus *Andrena* of the Western Hemisphere. Part VI. Subgenus *Trachandrena*. Trans. Am. Entomol. Soc. 99: 235–371.

Leonard, M. D. 1968. A supplement to a list of the aphids of New York. Proc. Rochester Acad. Sci. 11: 257–372.

McGuffin, W. C. 1971. Descriptions of larvae of two eastern species of *Lygris* (Geometridae). J. Lepid. Soc. 25: 262–264.

———. 1972. Guide to the Geometridae of Canada (Lepidoptera) II. Subfamily Ennominae. 1. Mem. Entomol. Soc. Can. 86. 159 pp.

———. 1977. A study of the distributions of *Physocarpus opulifolius* and two geometrids feeding on it. J. Lepid. Soc. 31: 269–274.

———. 1981. Guide to the Geometridae of Canada (Lepidoptera) II. Subfamily Ennominae. 3. Mem. Entomol. Soc. Can. 117. 153 pp.

MacKay, M. R. 1959. Larvae of the North American Olethreutidae (Lepidoptera). Can. Entomol. 91, Suppl. 10. 338 pp.

Messina, F. J. and R. B. Root. 1980. Association between leaf beetles and meadow goldenrods (*Solidago* spp.) in central New York. Ann. Entomol. Soc. Am. 73: 641–646.

Milliron, H. E. 1949. Taxonomic and biological investigations in the genus *Megastigmus* with particular reference to the taxonomy of the Nearctic species (Hymenoptera: Chalcidoidea; Callimomidae). Am. Midl. Nat. 41: 257–420.

Pepper, J. O. 1965. A list of the Pennsylvania Aphididae and their host plants (Homoptera). Trans. Am. Entomol. Soc. 91: 181–231.

Say, T. 1826. Descriptions of new species of coleopterous insects of North America. J. Acad. Nat. Sci. Philadelphia 5: 293–304.

Schuh, J. and D. C. Mote. 1948. The oblique-banded leaf roller on red raspberries. Ore. Agric. Exp. Stn. Tech. Bull. 13. 43 pp.

Stokes, D. W. 1981. The natural history of wild shrubs and vines. Harper & Row Publ., New York. 246 pp.

Strausbaugh, P. D. and E. L. Core. 1978. Flora of West Virginia, 2nd ed. Seneca Books, Grantsville, WV. 1079 pp.

Takhtajan, A. 1969. Flowering plants: origin and dispersal (Transl. from Russian by C. Jeffrey). Smithsonian Inst. Press, Washington, D.C. 310 pp.

Waldbauer, G. P. 1983. Flower associations of mimetic Syrphidae (Diptera) in northern Michigan. Great Lakes Entomol. 16: 79–85.

———. 1984. Mating behavior at blossoms and the flower associates of mimetic *Temnostoma* spp. (Diptera: Syrphidae) in northern Michigan. Proc. Entomol. Soc. Wash. 86: 295–304.

Wheeler, A. G., Jr., T. J. Henry, and T. L. Mason, Jr. 1983. An annotated list of the Miridae of West Virginia (Hemiptera-Heteroptera). Trans. Am. Entomol. Soc. 109: 127–159.

Wheeler, A. G., Jr. and E. R. Hoebeke. 1979. Biology and seasonal history of *Calligrapha spiraeae* (Say) (Coleoptera: Chrysomelidae), with descriptions of the immature stages. Coleop. Bull. 33: 257–267.

Yonke, T. R. and J. T. Medler. 1969. Biology of the Coreidae in Wisconsin. Wisc. Acad. Sci., Arts Lett. 57: 163–188.

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A NEW SPECIES OF *BUCCULATRIX* ZELLER (LEPIDOPTERA: LYONETIIDAE) FROM TEXAS

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Abstract.—*Bucculatrix* ***kendalli*** is described from reared material obtained from *Colubrina texensis* (T. & G.) Gray (Rhamnaceae). Imago, last instar larva, cocoon, leaf mines, and male and female genitalia are figured.

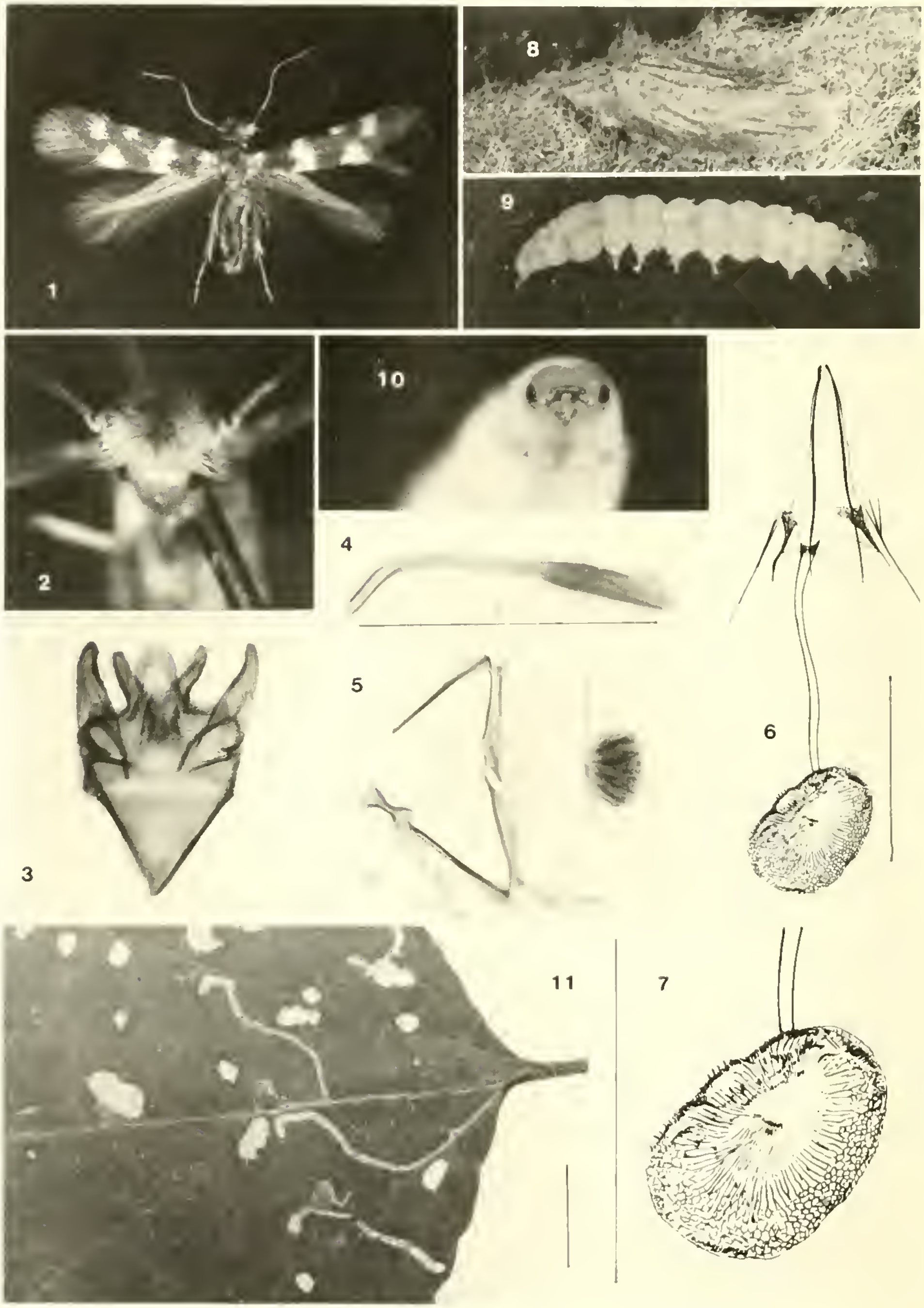
The genus *Bucculatrix* Zeller includes the majority of species included in the family Lyonetiidae, as it is represented in America north of Mexico. This genus was revised for this region by Annette F. Braun (1963), at which time 50 new species were described, representing half the total of included species. Until now, no other new North American species of *Bucculatrix* have been described, but as they are tiny, rather inconspicuous moths, it is likely that many more species remain undescribed. In the adult stage, *Bucculatrix* is most easily recognized by examination of the head under magnification. The long, tapering front, tiny palpi, short naked tongue, prominent scale tuft on the vertex, basal eye caps of the antennae, and notch in the first segment of the flagellum (in males) is a combination unique to this genus. On the other hand, the wing patterns and genitalia are quite diverse. The pupal stage is also easily recognized, by virtue of the ornate, ridged cocoon. Braun divided the genus into two main divisions based on larval habits and further subdivided these groups into eight sections based mainly on genitalic structure. The smaller division (including only section I), includes species that are gall formers or stem borers. The larger division (section II–VIII), includes species that begin life as leaf miners and, in most cases, leave the mine during the third instar and moult into an external feeding form. The species described below fits best into Braun's section II, based on genitalia, but the larval food plant is unusual for this group. The new species is known only from a single colony located in Bexar County, Texas and all examples were reared or collected by Roy O. Kendall.

***Bucculatrix kendalli*, A. Blanchard and E. Knudson, New Species**

Figs. 1–11

Head (Fig. 2).—Front light silvery grey; eye caps moderate, pale ochreous; tuft on vertex ochreous, shading to reddish brown centrally. Antennae fuscous, paler ventrally, male with deep notch at base of flagellum.

Thorax.—Patagia, tegulae, and mesonotum all dark brown; each edged posteriorly with a row of whitish scales. Legs brown with whitish annulations at joints of tibiae and tarsi.



Figs. 1–11. *Bucculatrix kendalli,* all from Bexar Co., Texas, Ebony Hill Research Station, Roy & C. A. Kendall collectors. 1, Holotype male. 2, Enlargement of the head of holotype, anterior view. 3, Male genitalia of paratype, ventral view, aedeagus removed, from slide ECK 991. 4, Aedeagus, same specimen. 5, Abdominal tergites, same specimen, showing scale sac between 2nd and 3rd tergites. 6, Female genitalia of paratype, drawn by senior author from slide ECK 990. 7, Enlargement of corpus bursae of same specimen. 8, Cocoon, dorsal view, on leaf of foodplant, from captive larva. 9, Last

Abdomen dark fuscous dorsally, whitish ventrally. Scale sac (Fig. 5) ovoid.

Forewings.—Both sexes alike. Ground color dark fuscous, slightly glossy, scales unicolorous, marked with pure white. Extreme base white; white fascia at basal ⅓, slightly widened toward dorsal margin; white costal spot at apical ⅓, followed by a slightly larger white costal spot, just before apex; white subtriangular spot on dorsal margin at tornus. Fringe shining dark fuscous, with a few white scales at subapical white spot.

Hindwings fuscous, fringe concolorous.

Length of forewing.—Males (N = 5), 2.6–2.9 mm, average 2.7 mm. Females (N = 6), 2.6–2.8 mm, average 2.7 mm.

Male genitalia (Figs. 3, 4, 5).—Valvae tapering bluntly at apex, moderately setose; uncus obsolete, socii large, diverging, sparsely setose; gnathos well developed, hood-like; vinculum large, triangular. Aedeagus (Fig. 4), elongate (exceeding length of capsule from vinculum to tip of gnathos), angulate distally, unarmed.

Female genitalia (Figs. 6, 7).—Papillae anales narrow, pointed, sparsely setose; apophyses posteriores three times the length of apophyses anteriores, both well sclerotized; ostium bursae narrowly cup shaped, sclerotized; ductus bursae membranous, nearly equal in length to apophyses posteriores; corpus bursae ovoid, signum consisting of very complicated arrangement of radiating ridges, emanating from a reticulation of hexagonal shapes. A few narrow specialized scales present at postero-lateral margins of 7th segment.

Larval foodplant.—*Colubrina texensis* (T. &. G.) Gray (Rhamnaceae). Early instars mine foliage, late instars are external feeders. Fig. 11 is a preserved leaf of the foodplant, showing several mines and shot-like holes, representing work of the external feeding stages.

Early stages (Figs. 8, 9, 10).—The last instar larva is represented in Figs 9 and 10. Head light yellow brown, with 5 stemmata closely grouped around black pigmented protuberances. Prothorax light yellow brown, with prominent black spot above spiracle. Mesothorax yellowish, shading to green; metathorax and abdominal segments grass green. Thoracic legs and abdominal prolegs yellowish. Cocoon (Fig. 8) gray brown, with 5 major ridges, some of which divide at the posterior end. In captivity, the cocoon is spun on any available surface, but in nature, only one cocoon has been found, spun on the undersurface of a stone, beneath the foodplant. There are at least two generations per year, with adults emerging late April to early June and mid August to late October. Some overwinter as pupae.

Holotype.—♂, Bexar Co., Texas, Ebony Hill Research Station, ex-larva, emerged 19-IX-84, Roy & C. A. Kendall collectors, deposited in the National Museum of Natural History.

Paratypes.—All, except one, reared from larvae collected by Roy & C. A. Kendall at Ebony Hill Research Station, Bexar Co., Texas. Larvae collected 2,3-XI-83 10 ♂, 14 ♀ emerged 19-IV-84 to 14-VIII-84. Larvae collected September 1984,

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instar larva, lateral view. 10, Frontal view of last instar larva. 11, Larval work on leaf of foodplant. Segments in 4, 6, and 7 represent 0.5 mm; 3, 4, and 5 are drawn to the same scale; segment in 11 represents 5 mm.

5 ♂, 3 ♀ emerged 12-IX-84 to 23-IX-94. Larvae collected October 1984, ♂, 5 ♀ emerged 18-X-84 to 24-X-84. Adult collected in mid afternoon, resting beneath leaf of foodplant, same locality, 9-X-84, 1 female.

Remarks.—This new *Bucculatrix* does not appear to be closely related to any previously described North American species. In forewing pattern, it is not unlike *B. fugitans* Braun, but the color of that species is different and the genitalia show no close relationship. The male genitalia, with the large triangular vinculum and hood-like structure ventral to the socii, which seems most likely to represent the gnathos, somewhat resembles *B. eupatoriella* Braun and *B. polymniae* Braun. The female genitalia are most distinctive, with modified papillae anales and well developed apophyses anteriores, the latter showing an unusual degree of development compared to other North American species. The life history, with both leaf mining and external feeding stages, follows that of the majority of North American species. The range of this new species may be found to include much of central and south Texas, but as yet, no attempts have been made to locate other colonies. The new species is named for Roy O. Kendall, who discovered it on the grounds of his home and laboratory, outside San Antonio.

ACKNOWLEDGMENTS

The authors wish to express gratitude to Roy O. Kendall for providing examples of this new species for their study and also for providing many important details of the life history. We are also grateful to Donald R. Davis of the National Museum of Natural History, Washington, D.C. for review of the manuscript.

LITERATURE CITED

Braun, A. F. 1963. The genus *Bucculatrix* in America north of Mexico (Microlepidoptera). Mem. Am. Entomol. Soc. 18: 1–207.

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87(2), 1985, pp. 375–380

A NEW PSILOPINE GENUS AND SPECIES FROM ISRAEL WITH A RECHARACTERIZATION OF THE TRIBE AND KEY TO OTHER PSILOPINE GENERA OF THE MIDDLE EAST (DIPTERA: EPHYDRIDAE)

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Abstract.—A new psilopine genus and species ***Eremomusca nussbaumi***, are described from specimens collected in Israel. The genus is apparently related to *Actocetor* Becker and *Trypetomima* de Meijere. The tribe Psilopini is recharacterized, and a key to genera of Psilopini occurring in the Middle East is presented.

Several years ago I received specimens of a curious psilopine fly from Israel that I did not immediately recognize at the generic or specific level. Eventually I restudied these specimens in connection with my revision of the shore flies of the Middle East. It is apparent now that the specimens represent both a new genus and species. The genus and species are uniquely characterized by several features, the mottled wing being the most notable and conspicuous. This species has now been collected from several localities, all in Israel, but its distribution will undoubtedly be found to range into other Middle Eastern countries as well. The purpose of this paper is to describe this fly and to discuss its relationships within the subfamily Psilopinae. I am also taking this opportunity to present a key to the psilopine genera of the Middle East.

The descriptive terminology follows that published in the recent Manual of Nearctic Diptera, Vol. 1 (McAlpine, 1981) with the exception noted in Mathis (1984).

Tribe Psilopini Cresson

Diagnosis.—Small to moderately small shore flies; usually vestiture mostly lacking, subshiny to shiny, black (amount of vestiture and coloration varying considerably, however).

Head: Ocellar bristles inserted behind alignment of anterior ocellus, sometimes very slightly so; reclinate fronto-orbital bristle inserted behind or directly laterad of proclinate fronto-orbital bristle; postocellar setae usually weakly developed and lateroclinate, sometimes more strongly developed, divergent, and slightly proclinate, length usually much less than ½ that of ocellar bristles; arista with 7–14 dorsally branching rays (*Scoliocephalus* is an exception with 1–3); conformation of face variable, usually mostly smooth, sometimes shallowly pitted or rugose; gena, including midportion, setulose, its posterior margin rounded.

Thorax: Supra-alar bristle usually lacking, if present, well developed, subequal to postalar bristle; arrangement of acrostichal setulae variable; prescutellar acrostichal bristles usually present, widely set apart, and inserted anterior of transverse alignment of posteriormost dorsocentral bristles; scutellar disc usually sparsely setulose; both anterior and posterior notopleural bristles inserted at about the same level near ventral margin.

KEY TO MIDDLE EASTERN GENERA OF PSILOPINI

1\. First flagellomere greatly elongate, about 4 times longer than wide; antennal length subequal to eye height; only proclinate fronto-orbital bristle present .... *Rhynchopsilopa* Hendel

– First flagellomere normally developed, length at most about twice its width; antenna much shorter than eye height; reclinate and proclinate fronto-orbital bristles present 2

2\. First flagellomere small, only slightly longer than wide, length subequal to 2nd antennal segment; postocellar setae well developed, with slightly divergent, posterodorsal orientation; facial series comprised of 4 setae; supra-alar bristle present, well developed; wing guttate, mostly dark with white spots .... *Actocetor* Becker

– First flagellomere conspicuously longer than wide and larger than 2nd antennal segment; postocellar setae weakly developed, lateroclinate; facial series at most with 2 prominent setae; supra-alar bristle lacking; wing either mostly hyaline or maculation pattern not as above 3

3\. Only inner vertical bristle present; fronto-orbital setae much reduced; prescutellar acrostichal setae lacing .... *Trimerina* Macquart

– Both inner and outer vertical bristles present; fronto-orbital setae well developed, conspicuous; prescutellar acrostichal setae present 4

4\. Arista at most with 3–4 dorsally branching rays; distance between reclinate and larger proclinate fronto-orbital bristles greater than between reclinate bristle and inner vertical bristle; bristles generally pale .... *Scoliocephalus* Becker

– Arista with at least 6 dorsally branching rays; reclinate and proclinate fronto-orbital bristles much closer together than reclinate bristle and vertical bristles; bristles generally dark 5

5\. Body generally with extensive areas bare to sparsely microtomentose, shiny; wing hyaline or darkened along crossveins or veins; vein R_{2+3} not bifurcate near apex; base of Rs vein bare of setulae .... *Psilopa* Fallén

– Body generally microtomentose, appearing dull, gray, with brown maculation; wing white with 2 irregular brown bands, one at midlength, the other apical; vein R_{2+3} bifurcate near apex; base of Rs vein with 3–5 setulae above .... *Eremomusca*, new genus

Eremomusca **Mathis, NEW GENUS**

Diagnosis.—Small to moderately small shore flies; body entirely microtomentose, cinereous to dark brown; setae mostly dark colored.

Head: In profile with antenna inserted at dorsal ⅓; frons conspicuously wider than long; both reclinate and proclinate fronto-orbital bristles well developed, distance between these about ½ that between reclinate bristle and inner vertical bristle; postocellar setae moderately well developed, divergent, and slightly reclinate; both inner and outer vertical bristles present, well developed; postocellar bristles weakly developed, lateroclinate; vertex moderately creased; posterior ocelli situated immediately before vertex. Antennal length slightly more than ½ eye height; 1st flagellomere short, subequal or slightly longer than length of 2nd segment; 1st segment not exerted; arista with 6–8 dorsally branching rays. Face densely invested with microtomentum but otherwise smooth, most prominent in profile just below its midheight; 2 strong facial setae, these inclinate, dorsal pair cruciate; proboscis normally developed, not elongate.

Thorax: Generally microtomentose, cinereous or brown; supra-alar bristle lacking; acrostichal setae arranged in 4–6 regular rows, setae of median rows larger and fewer, lateral rows better developed on anterior half; prescutellar acrostichal bristles present, well developed; scutellum only slightly wider than long, dorsum sparsely setulose; basal scutellar bristle over ½ length of apical bristle; anepisternum with 2 large bristles; halter white to yellowish, base brown. Wing conspicuously maculate, pattern irregular, about ½ dark; vein R_{2+3} short and bifurcate subapically with short posterior stump vein, merged with costal vein just apicad of level of crossvein dm-cu; R stem vein with 2–5 setulae dorsally. Legs with forebasitarsomeres concolorous with remaining tarsomeres.

Abdomen: Generally microtomentose, color and vestiture similar to mesonotum; tergum 4 lacking dorsal erect setae along posterior margin. For further details concerning the termialia, see the species diagnosis and figures.

Type-species: Eremomusca nussbaumi Mathis, by present designation.

Etymology.—*Eremomusca* (feminine) is of Greek derivation and is a combination of the nouns *eremia,* meaning solitude, desert, or wilderness, and *musca,* meaning fly.

Distribution.—Middle East. Israel.

Discussion.—Among psilopine genera, *Eremomusca* is very distinctive and is not likely to be confused with any of the others. Unique characters are the pattern of the mottled wing (Fig. 4), the extensive microtomentose vestiture, with its colorational pattern, and shape of the male terminalia. Its relationships with these genera, however, are not as clearly defined. *Eremomusca* appears to be closely related to *Actocetor* Becker (Old World) and *Trypetomima* de Meijere (Oriental and Oceanian), and of the two, a closer relationship with *Trypetomima* is suggested by more character evidence. All three genera have 2–4 setulae at the base of Rs on the dorsal surface, a reduced alula, and maculate wings. Furthermore, like *Trypetomima,* vein R_{2+3} of *Eremomusca* is short and subapically bears a stump vein. Both *Actocetor* and *Trypetomima* differ from *Eremomusca* in having larger postocellar bristles that are moderately divergent and have a slightly reclinate orientation. Moreover, *Actocetor,* unlike *Eremomusca* or *Trypetomima,* has a well-developed supra-alar bristle, high gena, and more facial bristles.

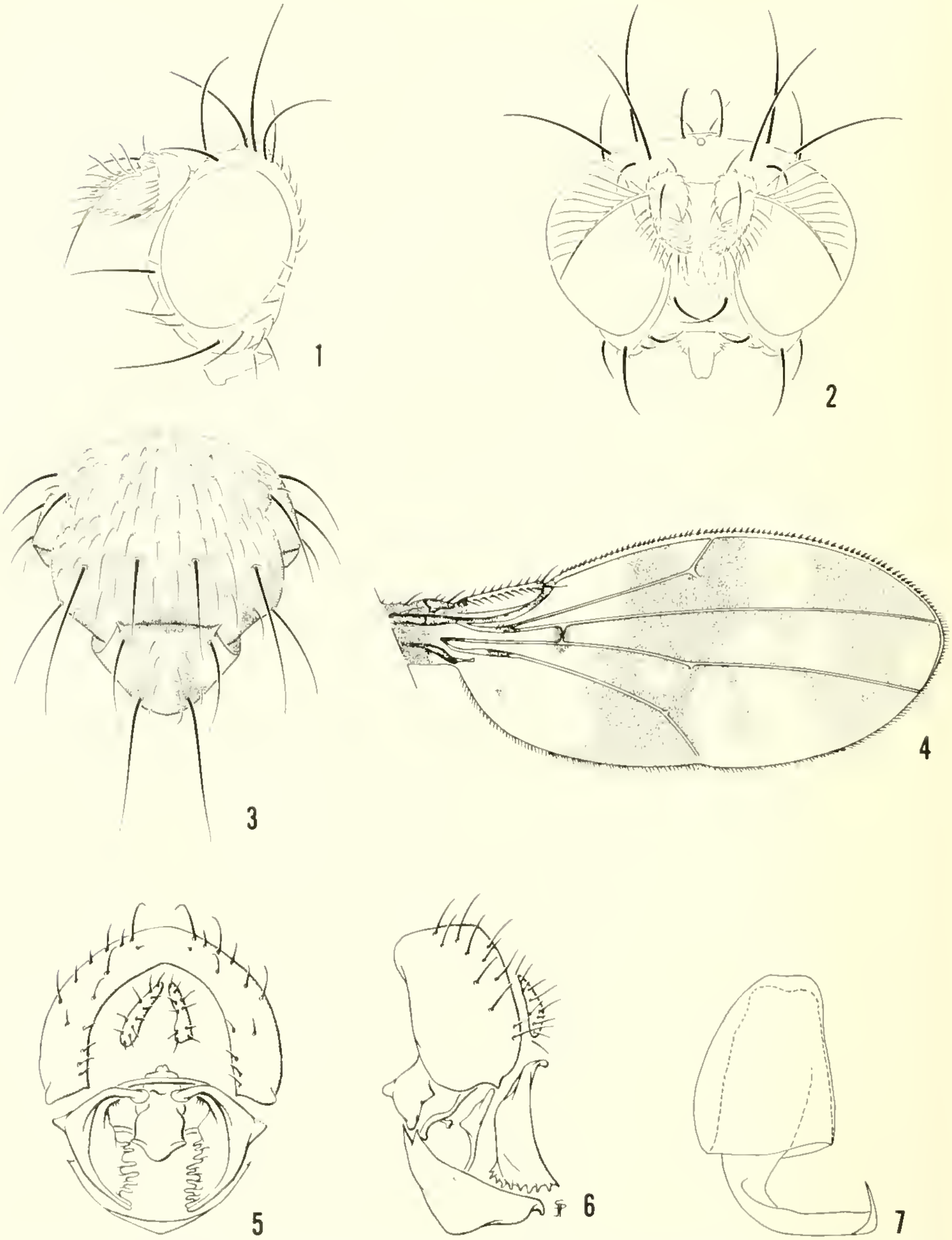
Although I have suggested here that *Eremomusca* is related to *Actocetor* and *Trypetomima* the character evidence has not been thoroughly tested against all other psilopine genera. Thus, the relationships are tentative and await further analysis of the entire tribe.

Eremomusca nussbaumi Mathis, New Species

Figs. 1–7

Diagnosis.—Small to moderately small shore flies, length 1.35 to 2.10 mm; body densely microtomentose, appearing dull, gray and brown.

Head (Figs. 1–2): Frons mostly gray, blackish brown immediately around in-



Figs. 1–7. *Eremomusca nussbaumi.* 1, Head, lateral view. 2, Head, anterior view. 3, Mesonotum, dorsal view. 4, Wing, dorsal view. 5, Male terminalia, posterior view. 6, Male terminalia, lateral view. 7, Female ventral receptacle, lateral view.

sertion of setae; mesofrons and parafrons similar in vestiture; postocellar setae moderately well developed, divergent. Antenna with 1st segment black; 2nd segment mostly yellow, venter black; 1st flagellomere black and slightly longer than 2nd segment; arista with 6–8 dorsally branching rays. Face yellow with whitish to grayish microtomentum; in profile slightly more prominent just above dorsal facial bristles, slightly recurved just before oral margin; facial bristles 2, dorsal pair much stronger, cruciate; clypeus brownish black; maxillary palpus yellowish. Eye conspicuously microsetulose, irregularly oval in lateral view, slightly higher than wide, eye ratio 0.86. Gena concolorous with face, very short, eye-to-cheek ratio 0.10; 1 large genal bristle.

Thorax (Fig. 3): Mesonotum (Fig. 3) mottled, with gray and brown coloration about equally divided, brown at base of most setulae and bristles, and more extensive posteriorly. Wing (Fig. 4) mottled, brown at extreme base, and with 2 irregular transverse brown bands, one at about basal ⅓, other at about apical ¼; stump vein near apex of R_1 about as long as apical section (from stump vein to apex) of R_1; costal vein ratio 1.25; M vein ratio 0.56. Legs with femora blackish brown except at femoral-tibial articulation; foretibia mostly yellowish, with faint postbasal brown annulus; mid- and hindtibia with 2 blackish brown annuli, postbasal one more or less twice width of preapical one; tarsomeres yellow except for brownish apical one.

Abdomen: Mostly brownish with somewhat symmetrical sparse grayish pattern. Male terminalia as figured (Figs. 5–6). Epandrium, in posterior view, broadly U-shaped, in lateral view subrectangular; cercus small, reniform to elliptical; surstylus gradually becoming wider ventrally in lateral view, in posterior view with dorsomedian processes that almost touch medially, anteroventral margin deeply edentate; aedeagal apodeme lunate in lateral view with median portion broadly developed; aedeagus irregularly ovate in lateral view; gonite slender, bandlike, with a dorsal process that is loosely attached above the aedeagus to its complement on the other side; hypandrium well sclerotized, shallowly bowl-shaped. Female ventral receptacle as figured (Fig. 7).

Type material.—Holotype ♂ is labeled "ISRAEL Mahanaim 5.v.1975 A. FREIDBERG/HOLOTYPE ♂ Eremomusca nussbaumi Mathis [red]." Allotype and 88 paratypes are labeled as follows: ISRAEL. Anti Patris, 9 May–1 Nov 1982–1983, I. Nussbaum (7 ♂, 20 ♀; Tau, USNM); Dan, 28 Sep 1983, I. Nussbaum (1 ♂, 3 ♀; TAU, USNM); Nahal Tut, 18 May 1982, A. Freidberg (1 ♂, 5 ♀; TAU, USNM); Rosh-Ha'ayin, 8–10 Apr–1 Nov 1976–1982, A. Freidberg, I. Nussbaum (21 ♂, 30 ♀; TAU, USNM). The holotype is double mounted (minute nadel in polyporus block), is in excellent condition, and will be deposited in the insect collection of the Tel-Aviv University, Tel-Aviv, Israel.

Natural history.—Adult flies were collected by sweeping vegetation along fresh or partly polluted streams. Sweeping was low, just above the mud or water. Prevailing plants were *Scirpus tuberosus* Desf. (Cyperaceae). *Nasturtium officinale* R. Br. (Cruciferae), *Mentha* sp. (Labiatae) and *Pulicaria dysenterica* (L.) Bernh. (Compositae).

Etymology.—The specific epithet, *nussbaumi*, is a Latinized genitive patronym to recognize Itzchak Nussbaum, who collected most of the paratypic series and furnished the information in the natural history section.

Remarks.—This is a very distinctive species, particularly the vestiture and coloration of the body and wing, and it is not likely to be confused with any other psilopine species.

ACKNOWLEDGMENTS

For reviewing a draft of this paper, I thank Amnon Freidberg and Norman E. Woodley. The illustrations were prepared by Molly Ryan and Stasia J. Penkoff, to whom I am likewise grateful.

Literature Cited

Mathis, W. N. 1984. A revision of the genus *Asmeringa* Becker (Diptera: Ephydridae). Israel J. Entomol. 17: 67–79.

McAlpine, J. F. 1981. Morphology and Terminology—Adults [chapter 2], pp. 9–63. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera. Vol. 1. Res. Branch Agric. Can. Mono. 27, 674 pp. Ottawa.

PROC. ENTOMOL. SOC. WASH.
87(2), 1985, p. 380

Zoological Nomenclature

The International Commission on Zoological Nomenclature requests comments on the following items.

Case No. 2115. Report on *Gyyphipteryx* Hübner, [1825] (Insecta, Lepidoptera).
Case No. 2318. *Aphodius rufus* Moll, 1782 and *Aegialia rufa* Fabricius, 1792 (Insecta, Coleoptera): proposed conservation under the plenary powers by suppression of *Aphodius scybalarius* Fabricius, 1792.

Comments also are solicited on Z.N.(S.)2474, a proposal by Gagné, Thompson, and Knutson (1984, Bull. Zool. Nom. 41: 149–150) concerning Article 51c. They propose to eliminate the use of parentheses around author names.

Send any comments on the above to: Secretary, International Commission on Zoological Nomenclature, % British Museum (Nat. Hist.), London SW7 5BD, United Kingdom.

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87(2), 1985, pp. 381–386

THE EPHEMEROPTERA OF ALASKA[1]

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Abstract.—A synopsis of the Ephemeroptera known from Alaska is provided. New collections from the north slope of the Brooks Range are reported and include new records of the genus *Heptagenia, Cinygmula subaequalis,* and *Ephemerella lacustris.* Mayfly data concur with the generalized pattern of Arctic fauna being represented by relatively few, widespread species, and having a strong circumpolar component. More species are expected to be Holarctic or at least have sister species in the Palearctic than can now be accounted for on the basis of present systematic knowledge. Zoogeography suggests that the fauna was present in a glacial refugium and is now composed of low-vagility species expressed by widely disjunct continental distributions and more easily dispersed species expressed by more continuous widespread distributions. Ephemeroptera known from Yukon drainage systems contiguous with Alaska are also treated and should eventually be found in Alaska.

The mayfly fauna of Alaska has been poorly known but of considerable recent interest because of the development and maintenance of a trans-Alaska pipeline corridor and its potential environmental impact. Freshwater ecological studies incorporating benthos (e.g., Watson et al., 1966; Nauman and Kernodle, 1974; Craig and McCart, 1975; Slack et al., 1977, 1979) have involved mainly the Brooks Range and Beaufort Sea drainage areas. Unfortunately, such studies have not provided much species-level information and therefore are of limited value for interpreting Alaskan mayfly faunistics.

Southern Alaskan distributions were indicated by range maps for nine Ephemeroptera genera by Allen and Brusca (1973). Edmunds et al. (1976) listed eight nominal species and at least seven other unidentified species among 12 genera reported from Alaska. Slack et al. (1977) added two genera to this in their study of the Dietrich River. Lehmkuhl (1979) reported one more nominal species and genus, and Harper and Harper (1981) reported an additional five nominal species and one genus from Umiat. Table 1 provides a taxonomic listing of the presently known mayfly fauna of Alaska and is based in part on the above references, beginning with Edmunds et al. (1976).

A list of species that are very likely to be eventually found in Alaska can be generated on the basis of records from the adjacent Yukon Territory of Canada, particularly the Yukon River System-Pacific Drainage Basin, which is shared by Alaska and the Yukon. Records for this area are provided generally by Harper

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[1] Purdue Experiment Station Journal No. 9905.

and Harper (1981) and for the Porcupine River drainage subsystem by Wiens et al. (1975). Table 1 incorporates these records; however, taxa presently known to occur in the Yukon but as yet unreported from Alaska are bracketed.

New Collections

Recent collections from the north slope of the Brooks Range were provided to me by T. L. Harris of Athens, Georgia. New Alaskan records for one genus and two species were represented in these collections. Female adults of *Rhithrogena* sp., male and female adults and subimagos of *Ephemerella lacustris,* and larvae of *Serratella tibialis* were taken at the Kuparuk River, 5 miles northeast of Toolik Lake, on August 6, 1979. Male adults of *Cinygma lyriforme* and *Cinygmula subaequalis,* and female adults of *Heptagenia* sp. were taken at Bonanza Creek, 12 miles north of Old Man Camp, on August 4, 1979. These taxa are treated below and included in Table 1.

Rhithrogena futilis is well known from western North America and was reported from Umiat, Alaska, and the Yukon Territory by Harper and Harper (1981). The females of *Rhithrogena* I have could possibly be *R. futilis* since they agree in color with males of that species. Other workers have seen *Rhithrogena* from Alaska (Table 1) but have been unable to identify them to species.

Ephemerella lacustris has been known previously only from Yellowstone Lake, Wyoming, where larvae develop in up to 2 feet of water (Allen and Edmunds, 1965). Even though the fact that adults were taken at the Kuparuk River strongly suggests a lotic habitat for *E. lacustris* larvae in Alaska, lentic habitats within flight range of this site cannot be entirely ruled out. Alaskan congeners, *E. aurivilii* and *E. inermis,* have wider ranges in western North America but with continuous rather than disjunct distribution patterns.

Serratella tibialis is a common boreal western North American species known from British Columbia and Alberta in Canada (Allen and Edmunds, 1963) but not from the Northwest or Yukon Territories (Cobb and Flannagan, 1980; Harper and Harper, 1981). Edmunds et al. (1976) listed it as occurring in Alaska but gave no specifics. The mature larvae I have are not typical of *S. tibialis.* Instead they lack any indication of a median longitudinal stripe on the head, thoracic nota, or abdominal terga, and they are brown with only a few pale markings on the dorsal abdomen and head. Several of them have 8 or 9 claw denticles rather than the 5–7 reported for the species. Their abdominal armature is typical of *S. tibialis,* however, and the Alaskan larvae are therefore presumed to represent a population variant of the species.

Cinygma lyriforme was first reported from Alaska (near Fairbanks, July 4, 1968) by Lehmkuhl (1979). Except for this and the more northern location in Alaska reported herein, the species is known only from Oregon and Alberta. The larval stage remains unknown and may prove difficult to place to genus because of our lack of knowledge of *Cinygma* with respect to its exact affinities with some Palearctic species classified in other heptageniid genera.

Cinygmula subaequalis was known previously only from eastern North America. My male adults from Alaska have both genitalia and color patterns typical of this distinctive species, and I therefore have no reason to describe them as a new species at this time. The apparent vicariant distribution of this species is most probably a result of glaciation.

Heptagenia pulla and *H.* sp. have been reported from the Yukon by Harper

Table 1. Families, genera, and species of Ephemeroptera reported from Alaska and adjacent areas of the Yukon Territory. Taxa reported only from the Yukon are in brackets. Generic names followed by sp. indicate one or more species (based on unidentifiable stages, sexes, or conditions) that may or may not be conspecific with listed nominal species. Notes: 1, Alaskan records from Edmunds et al. (1976); 2, Yukon records from Wiens et al. (1975); 3, Alaskan records from Slack et al. (1977); 4, Alaskan and/or Yukon records from Harper and Harper (1981); 5, Possibly misidentified *B. insignificans* McDunnough; 6, Alaskan record from Lehmkuhl (1979); 7, Alaskan records reported herein.

Siphlonuridae	
Ameletus validus McDunnough[1]	[*Siphlonurus alternatus* (Say)][4]
Ameletus sp.[2,3]	[*Siphlonurus occidentalis* Eaton][4]
Parameletus chelifer Bengtsson[4]	*Siphlonurus* sp.[1,2]
Parameletus sp.[1,4]	
[Metretopodidae]	
[*Metretopus borealis* Eaton][2,4]	[*Siphloplecton* sp.][2]
Baetidae	
Acentrella lapponica Bengtsson[4]	*Callibaetis* sp.[1,2]
Baetis macani Kimmins[4]	*Centroptilum* sp.[1,2]
[*Baetis propinquus* (Walsh)][2,5]	[*Cloeon* sp.][2,4]
Baetis sp.[2,3]	*Pseudocloeon* sp.[2,3]
[*Callibaetis* cf *coloradensis* Banks][4]	
Heptageniidae	
Cinygma lyriforme (McDunnough)[6,7]	[*Epeorus* sp.][2,3]
Cinygmula par (Eaton)[4]	[*Heptagenia pulla* (Clemens)][4]
Cinygmula subaequalis (Banks)[7]	*Heptagenia* sp.[2,7]
Cinygmula sp.[1,2,3]	*Rhithrogena futilis* McDunnough[4]
Epeorus longimanus (Eaton)[1]	*Rhithrogena* sp.[1,2,4,7]
Leptophlebiidae	
[*Leptophlebia nebulosa* (Walker)][4]	[*Paraleptophlebia moerens* (McDunnough)][4]
[*Leptophlebia* sp.][4]	*Paraleptophlebia* sp.[1]
Ephemerellidae	
Drunella coloradensis (Dodds)[1]	*Ephemerella lacustris* Allen & Edmunds[7]
Drunella doddsi (Needham)[1]	[*Ephemerella mucronata* (Bengtsson)][4]
Drunella grandis (McDunnough)[1]	[*Ephemerella* sp.][2]
Ephemerella aurivilii (Bengtsson)[1]	*Serratella tibialis* (McDunnough)[1,7]
Ephemerella inermis Eaton[1]	*Serratella* sp.[3]
[Caenidae]	
[*Caenis* sp.][2]	

and Harper (1981) and Wiens et al. (1975), respectively. The genus (sensu Edmunds et al., 1976), however, has not been known previously from Alaska. Wiens et al. (1975) also reported several other species of *Heptagenia* from the Mackenzie River Watershed, Northwest Territories. These are eastern and south-central North American species with either northwestern disjunctions or continuous patterns via Manitoba (Flannagan and Flannagan, 1982).

DISCUSSION

It is generally accepted that Arctic fauna comprises relatively few, widely distributed species (Downes, 1962). Studies of benthic macroinvertebrates (e.g., Brunskill et al., 1973; Slack et al., 1979) indicate that this segment of the Alaskan fauna concurs with this generalization. The mayfly fauna of Alaska, particularly in regard to those of the Arctic Seaboard as reported here and by Harper and Harper (1981), would also support this generalization. Species in Table 1, even if more than doubled with possible future records, represent only a small fraction of the approximately 700 North American species of Ephemeroptera (McCafferty, 1981). All known Alaskan species have widespread distributional patterns that can be categorized as having either a) relatively continuous distributions in western, northwestern, or north-central North America, b) widespread eastern U.S. distributions with a northern range continuing through Canada to Alaska, or c) largely disjunct patterns between Alaska and either southwestern U.S. or eastern U.S. and southeastern Canada. No endemic mayfly species are known from Alaska.

Much of Alaska and the Yukon was not glaciated and may have been a glacial refugium, whereas the remainder of Canada, except for a few scattered small refugia, was glaciated during maximum Wisconsin glaciation (Matthews, 1979). This may account for the observed disjunctions, and also for the mayfly fauna of this unglaciated area being richer than those at comparable northern latitudes in other regions (Cobb and Flannagan, 1980). The theory that aerial colonization of aquatic insects is limited to highly developed flying species (Edmunds, 1972; Cobb and Flannagan, 1980) and that other, low-vagility species are restricted to aquatic dispersal and thus relatively limited by present-day watersheds (Ide, 1955; Ross et al., 1967; Scudder, 1979; Flannagan and Flannagan, 1982) would possibly explain the faunal mix of continuously distributed and disjunct elements of Alaskan Ephemeroptera.

Downes (1962) noted that most Arctic insect species may be found in both North America and Eurasia, and Munroe (1956) indicated that circumpolar species outnumber all others in the Arctic area. It remains difficult to determine how well the Alaskan mayfly fauna supports these contentions because ephemeropterists generally have not brought together Nearctic and Palearctic materials for comparative studies. Preliminary knowledge, however, indicates a considerable Holarctic fauna in Alaska.

Alaskan species that are presently known to occur in Eurasia include *Parameletus chelifer, Acentrella lapponica* (see Müller-Liebenau, 1981), *Baetis macani* (see Morihara and McCafferty, 1979), and *Ephemerella aurivilii.* Lehmkuhl (1979) indicated that *Ecdyonurus peterseni* Lestage from the Arctic Urals is strikingly similar in detail to *Cinygma lyriforme.* It may be that these Palearctic and Nearctic mayflies are conspecific. When Yukon species in Table 1 are also considered, *Siphlonurus alternatus, Metretopus borealis* and *Ephemerella mucronata* can be included with the Holarctic Alaskan species. All of the above Holarctic species have Eurasian distributions mainly in Scandinavia and Siberia. I expect more Holarctic species will be found in Alaska, and many other Alaskan species to have sister-species cognates in Eurasia.

This short synopsis and zoogeographic analysis should serve as a base for further developing knowledge of this fauna, and I would suggest that particular emphasis be given to comparing upper boreal Eurasian species with the possibility of resolving intercontinental systematic and zoogeographic relationships in the Ephemeroptera. Several other genera and species may be predicted as possible components of the Alaskan fauna simply on the basis of common zoogeographic patterns and geological history expressed herein. For example, given the Arcto-Tertiary distribution of *Litobrancha* (McCafferty, 1983), ephemeroid mayflies may be represented in Alaska by this genus.

LITERATURE CITED

Allen, R. K. and R. C. Brusca. 1973. The known geographic distribution of the Mexican mayfly genera in North America (Insecta: Ephemeroptera). Proc. 1st Int. Conf. Ephem. 1970: 49–63.

Allen, R. K. and G. F. Edmunds, Jr. 1963. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VI. The subgenus *Serratella* in North America. Ann. Entomol. Soc. Am. 56: 583–600.

———. 1965. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VIII. The subgenus *Ephemerella* in North America. Misc. Publ. Entomol. Soc. Am. 4: 243–282.

Brunskill, G. J., D. M. Rosenberg, N. B. Snow, G. L. Vascotto, and R. Wagemann. 1973. Ecological studies of aquatic systems in the Mackenzie-Porcupine Drainages in relation to proposed pipeline and highway developments. Task Force North. Oil Devel., Rep. 73-40: 131 pp.

Cobb, D. G. and J. F. Flannagan. 1980. The distribution of Ephemeroptera in northern Canada, pp. 155–166. *In* Flannagan, J. F. and K. E. Marshall, eds., Advances in Ephemeroptera biology. Plenum, New York.

Craig, P. C. and P. J. McCart. 1975. Classification of stream types in Beaufort Sea drainages between Prudhoe Bay and Mackenzie Delta, N.W.T., Canada. Arctic Alpine Res. 7: 183–198.

Downes, J. A. 1962. What is an Arctic insect? Can. Entomol. 94: 143–162.

Edmunds, G. F., Jr. 1972. Biogeography and evolution of Ephemeroptera. Ann. Rev. Entomol. 17: 21–42.

Edmunds, G. F., Jr., S. L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. Univ. Minn. Press, Minneapolis. 330 pp.

Flannagan, P. M. and J. F. Flannagan. 1982. Present distribution and post-glacial origin of the Ephemeroptera, Plecoptera, and Trichoptera of Manitoba. Manitoba Dept. Nat. Res. Fish. Tech. Rep. 82-1: 79 pp.

Harper, F. and P. P. Harper. 1981. Northern Canadian mayflies (Insecta: Ephemeroptera), records and descriptions. Can. J. Zool. 59: 1784–1789.

Ide, F. 1955. Two species of mayflies representing southern groups occurring at Winnipeg, Manitoba (Ephemeroptera). Ann. Entomol. Soc. Am. 48: 15–16.

Lehmkuhl, D. M. 1979. The North American species of *Cinygma* (Ephemeroptera: Heptageniidae). Can. Entomol. 111: 675–680.

Matthews, J. V., Jr. 1979. Tertiary and Quaternary environments: Historical background for an analysis of the Canadian insect fauna, pp. 31–86. *In* Danks, H. V., ed., Canada and its insect fauna. Mem. Entomol. Soc. Can. 108.

McCafferty, W. P. 1981. Aquatic entomology. Sci. Books Intern., Boston. 448 pp.

———. 1983. *Litobrancha* from the Oligocene in eastern Asia (Ephemeroptera: Ephemeridae). Ann. Entomol. Soc. Am. 76: 205–208.

Morihara, D. K. and W. P. McCafferty. 1979. Subspecies of the trans-atlantic species, *Baetis macani* (Ephemeroptera: Baetidae). Proc. Entomol. Soc. Wash. 81: 34–37.

Müller-Liebenau, I. 1981. Review of the original material of the baetid genera *Baetis* and *Pseudocloeon* from the Sunda Islands and the Philippines described by G. Ulmer, with some general remarks (Insecta: Ephemeroptera). Mitt. Hamb. Zool. Mus. Inst. 78: 197–208.

Munroe, E. 1956. Canada as an environment for insect life. Can. Entomol. 88: 372–476.

Nauman, J. W. and D. R. Kernodle. 1974. Aquatic organisms from collected sites along the proposed trans-Alaska pipeline corridor September 1970 to September 1972. U.S. Geol. Surv. Open File Rep. 23 pp.

Ross, H. H., G. L. Rotramel, J. E. H. Martin, and J. F. McAlpine. 1967. Postglacial colonization of Canada by its subboreal winter stoneflies of the genus *Allocapnia*. Can. Entomol. 99: 703–712.

Scudder, G. G. E. 1979. Present patterns in the fauna and flora of Canada, pp. 87–179. *In* Danks, H. V., ed. Canada and its insect fauna. Mem. Entomol. Soc. Can. 108: 1–573.

Slack, K. V., J. W. Nauman, and L. J. Tilley. 1977. Benthic invertebrates in an Arctic mountain stream, Brooks Range, Alaska. J. Res. U.S. Geol. Surv. 5: 519–527.

———. 1979. Benthic invertebrates in a north-flowing stream and a south-flowing stream, Brooks Range, Alaska. Wat. Res. Bull. 15: 108–135.

Watson, D. J., W. C. Hanson, J. J. Davis, and C. E. Cushing. 1966. Limnology of tundra ponds and Ogoturuk Creek, pp. 415–435. *In* Wilimovsky, N. J. and J. N. Wolfe, eds., Environment of the Cape Thompson Region, Alaska. U.S. Atom. Energ. Comm. PNE-481.

Wiens, A. P., D. M. Rosenberg, and N. W. Snow. 1975. Species list of aquatic plants and animals collected from the Mackenzie and Porcupine River watersheds from 1971–1973. Can. Fish. Mar. Serv. Tech. Rep. 557: 39 pp.

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TWO NEW SPECIES OF *CERATOCAPSUS* FROM NORTH AMERICA (HETEROPTERA: MIRIDAE)

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Abstract.—Two new species of the plant bug genus *Ceratocapsus* (Heteroptera) are recognized from North America. *Ceratocapsus* ***cunealis*** is described from British Columbia and Idaho and *C.* ***keltoni*** from Ohio and Ontario. Male genitalia are illustrated and diagnoses are provided to help separate the new taxa from known related species.

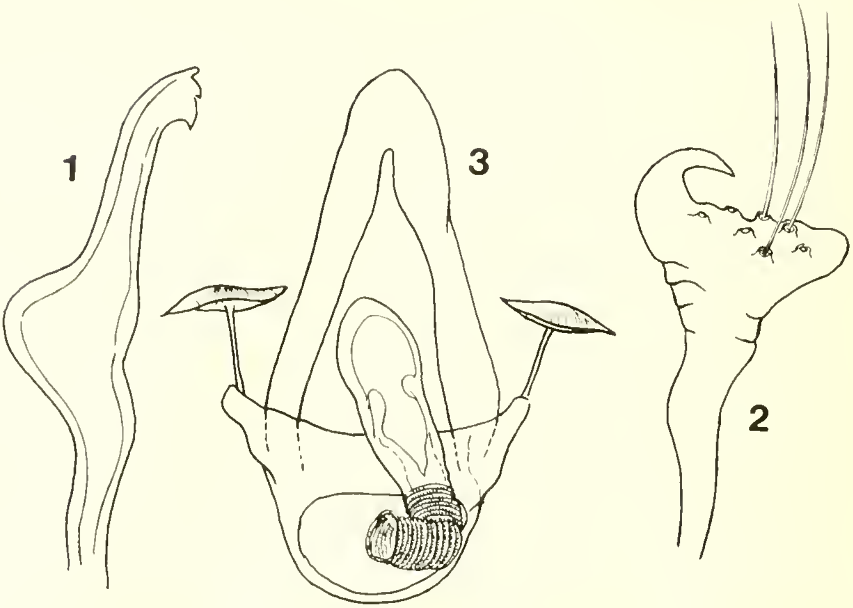
The two new species of *Ceratocapsus* presented in this paper are described ahead of a forthcoming revision of the genus to provide names needed for two identification manuals on the Miridae of Canada now being prepared by Leonard A. Kelton of the Biosystematic Research Institute, Agriculture Canada, Ottawa, Ontario. Type-specimens are deposited in the Canadian National Collection (CNC) at the Biosystematic Research Institute and the U.S. National Museum of Natural History (USNM), Washington, D.C.

The genus *Ceratocapsus* is a large New World group, with more than 60 species listed in the Carvalho Catalog (1958). More recently, Henry (1979) described seven new species from the Eastern United States, and Carvalho et al. (1983) described 45 new species from South America. Although little is known of the habits of members of this genus, Wheeler and Henry (1979) observed that *C. modestus* (Uhler) preyed on eggs of grape phylloxera, *Daktulosphaira vitifoliae* (Fitch), and Carvalho et al. (1983) reported that *C. dispersus* Carvalho and Fontes has been taken preying on pink bollworm, *Heliothis virescens* (F.) in Peru. Henry (in Carvalho et al.) noted that immatures of most eastern United States species of *Ceratocapsus* require some animal food to complete development in the laboratory, indicating that, although most species are host-plant specific, they probably are largely predaceous on co-existing arthropod eggs and immatures.

Ceratocapsus cunealis **Henry, NEW SPECIES**

Figs. 1–3

Description.—*Male:* Length 2.92–3.24 mm, width 1.16–1.24 mm, general coloration brown. *Head:* Width 0.66–0.68 mm, vertex 0.20–0.24 mm; chestnut brown, frons transversely striated, basal carina distinct; set with relatively long, simple setae, especially on vertex. *Rostrum:* Length 0.98–1.04 mm, extending to bases of metacoxae. *Antenna:* Yellowish brown, segment IV and apex of III brownish to reddish brown in some specimens; segments II–IV uniformly slender,



Figs. 1–3. Male genitalia of *Ceratocapsus cunealis.* 1, Left paramere. 2, Right paramere. 3, Aedeagus.

segment I slightly thicker; segment I, length 0.24–0.26 mm, II, 0.88–1.04 mm, III, 0.54–0.60 mm, IV, 0.40–0.42 mm. *Pronotum:* Length 0.48–0.50 mm, basal width 0.94–1.00 mm; chestnut brown, evenly and finely dark punctured, including calli, set with long, pale, semierect setae, intermixed with short, appressed, silvery, sericeous pubescence, each anterior angle with a single, erect, pilose seta; scutellum colored and punctate as pronotum, with long, erect, simple setae. *Hemelytra:* Pale brown, set with long, erect, simple setae, evenly punctate as on pronotum, each puncture having a single, appressed, sericeous seta; cuneus red, with lateral margin and paracuneus brown; membrane and veins smoky brown. *Venter:* Reddish to chestnut brown, abdomen darker shiny brown on some specimens; ostiolar evaporative area pale, tinged with red. *Legs:* Uniformly pale, yellowish brown, apex of hindfemur and base of hindtibia pale reddish to brown. *Male genitalia:* Left paramere (Fig. 1); right paramere (Fig. 2); aedeagus (Fig. 3).

Female: Length 2.92–3.08 mm, width 1.16–1.25 mm. *Head:* Width 0.64–0.66 mm, vertex 0.30–0.32 mm. *Rostrum:* Length 1.08–1.10 mm. *Antenna:* Segment I, length 0.24–0.26 mm; II, 0.84–0.90 mm; III, 0.48–0.54 mm; IV, 0.34–0.40 mm. *Pronotum:* Length 0.50–0.52 mm, basal width 1.00–1.02 mm.

Very similar to male in color and pubescence, differing mainly in the slightly broader form and proportionately wider vertex.

Type-data.—*Holotype:* ♂, Oliver, British Columbia, 15 Sept. 1953, J. E. H. Martin (CNC). *Paratypes:* 1 ♂, same data as for holotype (CNC); 1 ♀, Richter Pass, Osoyoos, British Columbia, 28 June 1959, L. A. Kelton, on greasewood [*Sarcobatus vermaculatus* (Hook.)Torr.] (CNC); 2 ♂, 1 ♀, Summerland, British Columbia, 2–11 Jul. 1974, L. A. Kelton, on *Clematis* sp. (1 ♂ [CNC]; 1 ♂, 1 ♀ [USNM]); 1 ♂, Vaseaux L., Oliver, British Columbia, 10 Jul. 1959, L. A. Kelton (CNC); 1

♀, Idaho, Owyhee Co., nr. Grand View, 21 June 1982, T. J. Henry, taken beating. *Artemesia* sp. and *Sarcobatus* sp. (USNM).

Etymology.—The name *cunealis* is given to this species to denote the red area of the cuneus that contrasts with the overall reddish-brown coloration of the dorsum.

Remarks.—*Ceratocapsus cunealis* belongs to a group of species that probably is not congeneric with *C. lutescens* Reuter, the type-species of *Ceratocapsus*. Henry (1979) defined *Ceratocapsus*, in part, as having a large male genital capsule opening or pygophore that is broadly expanded to accommodate the typically large, and often bizarrely shaped, parameres. *Ceratocapsus cunealis* and a large number of mostly southern and western species form a group that has the pygophore and parameres reduced in size. As indicated in the introduction, a full revision of the genus to study the relationships of all taxa now included in *Ceratocapsus* is in preparation.

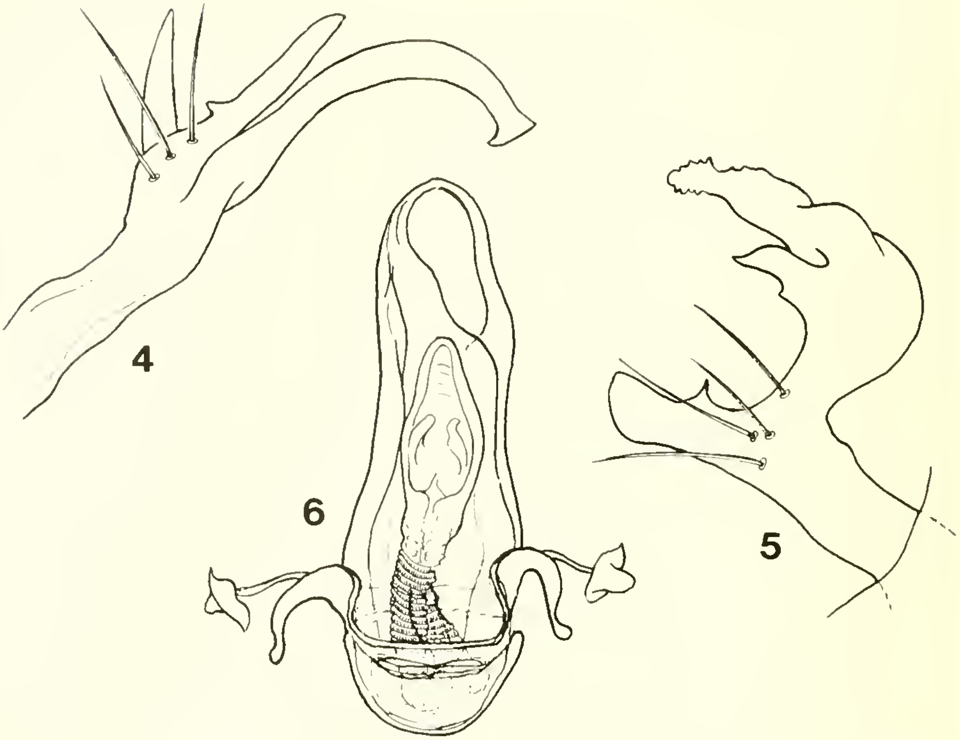
This species will run to the genus *Ceratocapsus* using Knight's Miridae of Illinois (1941) or The Miridae of the Nevada Test Site (1968). At the species level, *cunealis* is the only *Ceratocapsus* known to me from British Columbia and the Northwestern United States that is uniformly reddish to chestnut brown, with the cuneus red centrally and has the pronotum, including the calli, evenly punctate and the pygophore reduced, with the parameres simplified or unbranched as in Figs. 1 and 2.

Ceratocapsus keltoni **Henry, New Species**

Figs. 4–6

Description.—*Male:* Length 4.04–4.40 mm, width 1.68–1.84 mm, general coloration dark brown to fuscous, with paler brown along wing margins and basal area of pronotum. *Head:* Width 0.74–0.80 mm, vertex 0.30–0.34 mm, fuscous, jugum and lorum paler brown, finely alutaceous, meson weakly grooved, eyes sparsely set with short erect setae. *Rostrum:* Length 1.38–1.42 mm, brown, segments I and II darker brown, extending to bases of metacoxae. *Antenna:* Uniformly brown to fuscous; segment I, length 0.36–0.38 mm, II, 1.26–1.32 mm, III, 0.64–0.70 mm, IV, 0.42–0.52 mm. *Pronotum:* Length 0.70–0.74 mm, basal width 1.40–1.42 mm, fuscous, basal margin paler on dark specimens, entire disc pale brown on others, disc punctate, calli impunctate and alutaceous; clothed with suberect, golden setae; scutellum fuscous, apex paler brown, impunctate, transversely rugose. *Hemelytra:* Reddish brown to fuscous, on darkest specimens embolium, corium on base and outer part of apical region, and clavus along commissure paler brown or testaceous; uniformly punctate except on embolium; clothed with recumbent and semierect pale-brown pubescence, intermixed with a few recumbent, silvery, sericeous setae; membrane smoky or fumate, paler near border of cuneus, veins brownish. *Venter:* Fuscous to reddish brown, ostiolar evaporative area reddish brown; abdomen set with semierect, rather long, setae, especially on genital segment. *Legs:* Coxae and femora testaceous, metafemora becoming darker or reddish brown apically, some specimens with a subapical, fuscous blotch on posterior surface; tibiae, tarsi, and claws slightly darker brown. *Male genitalia:* Left paramere (Fig. 4); right paramere (Fig. 5); aedeagus (Fig. 6).

Female: Very similar to male in general form, pubescence, and coloration. Length 4.08 mm, width 1.80 mm. *Head:* Width 0.72 mm, vertex 0.32 mm.



Figs. 4–6. Male genitalia of *Ceratocapsus keltoni*. 4, Left paramere. 5, Right paramere. 6, Aedeagus.

Rostrum: Length 1.28 mm. *Antenna:* Segment I, length 0.30 mm; II, 1.10 mm; III, 0.58 mm; IV, 0.44 mm. *Pronotum:* Length 0.72 mm, basal width 1.34 mm.

Type-data.—*Holotype:* ♂, Ohio, Clark Co., 25 miles west of Columbus, along Interstate 70, 4 Jul. 1979, T. J. Henry, taken on *Salix* sp. (USNM type No. 76358). *Paratypes:* 1 ♂, 1 ♀, same data as for holotype (USNM); 1 ♂, Ontario, Tillsonburg, 20 June 1962, L. A. Kelton and G. Thorpe, on *Salix* (CNC); 1 ♂, Ontario, Kemble, 1 Jul. 1962, G. Thorpe, on willow (CNC).

Etymology.—This species is named in honor of Leonard Kelton (CNC) for his excellent work on the Canadian Miridae and for collecting the first known specimen of this species.

Remarks.—*Ceratocapsus keltoni* belongs in the *pumilus* group of *Ceratocapsus* and is most similar externally to *fuscinus* Knight, *incisus* Knight, and *pumilus* (Uhler). In Knight's (1941) key to the genus it will run to couplet 17 to *incisus*, a species also known to occur on *Salix* spp. *Ceratocapsus keltoni* can be separated from *incisus* by the darker brown antennae and the apically reddish-brown to fuscous femora (rather than uniformly pale-yellow antennae and legs). The basal process (Fig. 5) of the right paramere is thick and blunt, similar to that of *quadrispiculus* Knight, but has a needlelike spine extending perpendicular from near the base; the middle and distal processes of the right paramere compare most closely to *uniformis* Knight. The 3-pronged left paramere (Fig. 4) is distinct from all other species with a strongly down-curved main stem and a blunt nodule at the base of the middle prong. The aedeagus (Fig. 6) is typical for the *pumilus* group.

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LITERATURE CITED

Carvalho, J. C. M. 1958. Catalogue of the Miridae of the World. Part III. Orthotylinae. Arq. Mus. Nac. 47: 1–161.

Carvalho, J. C. M., A. V. Fontes, and T. J. Henry. 1983. Taxonomy of the South American species of *Ceratocapsus,* with descriptions of 45 new species (Hemiptera: Miridae). U.S. Dept. Agric. Tech. Bull. No. 1676. 58 pp.

Henry, T. J. 1979. Review of the *Ceratocapsus lutescens* group, with descriptions of seven new species from the Eastern United States (Hemiptera: Miridae). Proc. Entomol. Soc. Wash. 81: 401–423.

Knight, H. H. 1941. The plant bugs, or Miridae, of Illinois. Ill. Nat. Hist. Surv. Bull. 22: 1–234.

———. 1968. Taxonomic review: Miridae of the Nevada Test Site and the Western United States. Brigham Young Univ. Sci. Bull. 9(3): 1–282.

Wheeler, A. G., Jr. and T. J. Henry. 1979. *Ceratocapsus modestus* (Hemiptera: Miridae), a predator of grape phylloxera: Seasonal history and description of fifth instar. Melsheimer Entomol. Ser. 25: 6–10.

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NEW RECORDS FOR *STIGMATOMYCES VERRUCULOSUS* THAXTER (ASCOMYCETES: LABOULBENIACEAE), A FUNGAL PARASITE OF ADULT TEPHRITIDAE (DIPTERA) IN SOUTHERN CALIFORNIA

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Abstract.—Males of *Paroxyna americana* Hering, *Tephritis araneosa* (Coquillett), and *T. californica* Doane are reported for the first time as hosts of the laboulbeniaceous fungus, *Stigmatomyces verruculosus*. The known geographic range of this fungus is extended to and across North America from the Caribbean. The locations of the thalli of this fungus on infected flies are described.

This paper reports new collection records from California for, and observations on, Tephritini adults (Diptera: Tephritidae) infested with the minute, nearly microscopic, ectoparasitic fungus, *Stigmatomyces verruculosus* Thaxter (Ascomycetes: Laboulbeniaceae). The few-celled body or "thallus" of this fungus, like that of most Laboulbeniales, is attached by a blackened holdfast or "foot" to the exoskeleton of the host (Thaxter, 1896).

On October 1, 1981, RDG swept a male of *Tephritis californica* Doane from flowering *Baccharis pilularis* de Candolle (Asteraceae), a male of *T. araneosa* (Coquillett) from flowering *Artemesia californica* Lessing (Asteraceae), and a male of *Paroxyna americana* Hering from flower heads of *Heterotheca grandiflora* Nuttal (Asteraceae) in Cervada Canyon on Santa Cruz Island, Santa Barbara Co., off the coast of southern California. All three flies were infected with *S. verruculosus* subsequently identified by RKB. On October 13, 1983, RDG swept three males of *T. araneosa* infected with *S. verruculosus* from flowering *A. californica* 1 to 2 m above sea level at Willows Anchorage on Santa Cruz Island. Four females of *T. araneosa* subsequently were reared from a quantity of flower heads of *A. californica* collected on the same date from the plants swept at Willows Anchorage.

On September 9, 1982, RDG swept five males of *P. americana* from flower heads of *Haplopappus pinifolius* Gray (Asteraceae) at ca. 1500 m elevation near Paradise Valley in the San Bernardino National Forest, Riverside Co. All five flies were infected with *S. verruculosus*, which, at least on the two specimens examined microscopically by RKB, were found to be only about half mature. None bore perithecia containing mature ascospores.

Three each, dry, point-mounted specimens of the above *P. americana* and *T. araneosa*, not dissected in saline for mycological examination by RKB, were examined 100× with a Wild steromicroscope and the following placement of thalli of *S. verruculosus* recorded (nomenclature after Bessey (1950) and McAlpine (1981)): for *P. americana,* (1) small group of thalli on left meron; (2) small row of thalli along ventral margin of left gena, group of three thalli from between hind coxae, and a thallus at base of arista of right antenna; (3) several thalli on upper surface of left wing along proximal part of costal vein and on subcostal vein; for *T. araneosa,* (1) thalli arising from ventral surfaces of coxa of midleg and its juncture with midfemur, from left and right katepisternum, from ventral base of left forefemur and its ventral juncture with left forecoxa, and from ventral base of right forefemur; (2) thalli arising from ventral surfaces at base of left hindfemur and left hindcoxa, from ventral surface at base of left midfemur, from ventral surface at base and middle of right forefemur, from right postgena and left margin of frontoclypeal membrane; (3) thalli arising from middle of sternites 3, 4, and 5 and from ventral side of abdominal terminalia; from ventral surfaces of left and right hind coxae, and from middle of ventral surface of left hindtibia.

Discussion.—The genus *Stigmatomyces* commonly occurs on various Diptera. Four species of *Stigmatomyces* on Tephritidae (as Trypetidae) are: *S. aciurae* Thaxter (1917) on *Aciurina* (as *Aciura*) sp. and *Ensina* sp. from Jamaica; *S. dacinus* Thaxter (1918) on *Dacus* sp. from Borneo; *S. ensinae* Thaxter (1917) on *Ensina* sp. from Jamaica; and *S. verruculosus* Thaxter (1917) on *Ensina* sp. from Jamaica and Grenada. Recently, Balazuc (1982) described *S. autriquei* Balazuc from *Dioxyna sororcula* (Wiedemann) from Burundi in Africa.

Ours are the first records from North America for *S. verruculosus,* and the first tephritid host records from *Paroxyna* and *Tephritis* for *Stigmatomyces. Paroxyna americana, T. araneosa,* and *T. californica* were initially reported herein from Santa Cruz Island (Foote and Blanc, 1963; Novak, 1974; Miller and Menke, 1981); and *P. americana,* initially from Riverside Co. (Foote and Blanc, 1963). The new rearing of *T. araneosa* from *A. californica* and known utilization of *B. pilularis* and *H. grandiflora* flower heads by *T. californica* and *P. americana,* respectively (Wasbauer, 1972), indicate that seasonal synchronization with tephritid adult and flowering host plant, is involved in the life cycle of *S. verruculosus.*

Inter- and intraspecific variation was recorded in the locations of thalli of *S. verruculosus* on the few tephritids examined. Thalli on the three *T. araneosa* males showed a distinct tendency to cluster on the thoracic and abdominal venters. A position specificity of thalli ventrally on males and dorsally on females related to their copulatory postures has been reported for both Coleoptera and Diptera (Benjamin and Shanor, 1952; Whisler, 1968). Grooming movements in tephritids normally involve brushing the legs over the antennae, head, and wings and may have been the activity responsible for the secondary transfer of ascospores that resulted in the infection of the frontoclypeal membrane in *T. araneosa.* However, the immature thalli found on head and wing of *P. americana* suggested that these were locations of primary, not secondary infections.

LITERATURE CITED

Balazuc, J. 1982. Description de trois Laboulbeniales nouvelles (Ascomycetes). Int. J. Myc. Lich. 1(1): 39–48.

Benjamin, R. K. and L. Shanor. 1952. Sex of host specificity and position specificity of certain species of *Laboulbenia* on *Bembidion picipes.* Am. J. Bot. 39: 125–131.

Bessey, E. A. 1950. Morphology and Taxonomy of Fungi. Hafner Publ. Co., New York, 791 pp.

Foote, R. H. and F. L. Blanc. 1963. The fruit flies or Tephritidae of California. Bull. Calif. Insect Surv. 7, 115 pp.

McAlpine, J. F. 1981. Morphology and terminology—adults, pp. 9–63. *In* McAlpine, J. F., B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood (Coordinators). Manual of Nearctic Diptera, Vol. 1. Research Branch, Agric. Can. Mono. 27, 674 pp.

Miller, S. E. and A. S. Menke. 1981. Entomological bibliography of the California Islands. Santa Barbara Mus. Nat. Hist. Occas. Pap. 11, 78 pp.

Novak, J. A. 1974. A taxonomic revision of *Dioxyna* and *Paroxyna* (Diptera: Tephritidae) for America north of Mexico. Melandria 16, 53 pp.

Thaxter, R. 1896. Contribution towards a monograph of the Laboulbeniaceae. Mem. Am. Acad. Arts Sci. 12: 187–429, Pls. I–XXVI.

———. 1917. New Laboulbeniales, chiefly dipterophilous American species. Proc. Am. Acad. Arts Sci. 52: 647–721.

———. 1918. Extra-American dipterophilous Laboulbeniales. Proc. Am. Acad. Arts Sci. 53: 695–749.

Wasbauer, M. W. 1972. An annotated host catalog of the fruit flies of America north of Mexico (Diptera: Tephritidae). Calif. Dep. Agric. Bur. Entomol. Occas. Pap. 19, 172 pp.

Whisler, H. C. 1968. Experimental studies with a new species of *Stigmatomyces* (Laboulbeniales). Mycologia 60: 65–75.

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THE IDENTITY OF *QUADRACEPS CRASSIPEDALIS* (HARRISON) AND TWO NEW SPECIES OF *QUADRACEPS* (MALLOPHAGA: PHILOPTERIDAE)

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Abstract.—The identity of *Quadraceps crassipedalis* (Harrison) is clarified by a redescription and illustrations from specimens taken off the type-host *Thinocorus rumicivorus.* Two new species are described and illustrated: *Quadraceps ruficollis* off *Oreopholus ruficollis* in Argentina and Chile and *Q. rubricollis* off *Charadrius rubricollis* in Tasmania, Australia.

Species of the mallophagan genus *Quadraceps* Clay and Meinertzhagen are found mostly on hosts of the avian order Charadriiformes (Plovers, Sandpipers, Snipes, Gulls, Terns, etc.) where they live on the wing feathers. The Charadriiformes presently contains over 300 species, of which it is estimated that 240 are likely to be hosts to species of *Quadraceps* sensu stricto; at the present time about 100 species and subspecies of *Quadraceps* have been recorded on 147 species of hosts. Herewith, we clarify the status of one species which has been in doubt for a century and we describe and illustrate two new species.

All measurements are in millimeters. Scientific names of the hosts are from Peters (1934). Paratypes of the new species will be distributed, as quantities permit, to the collections of the authors, the National Museum of Natural History, Washington, D.C., and the British Museum (Natural History), London.

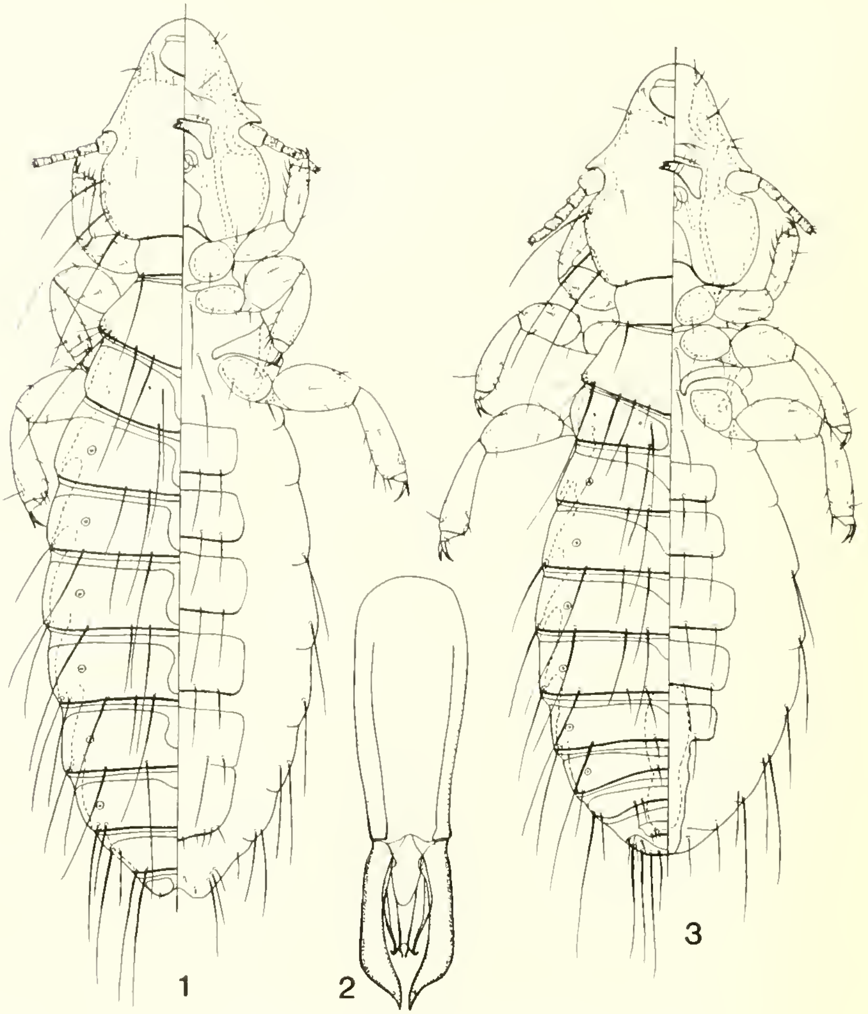
***Quadraceps crassipedalis* (Harrison)**

Figs. 1–3

Nirmus crassipes Piaget, 1885: 30 (*nec* Denny, 1852: 21). Type-host: *Thinocorus rumicivorus* Eschscholtz, the Lesser Seedsnipe.

Degeeriella crassipedalis Harrison, 1916: 111. *Nomen novum* for *Nirmus crassipes* Piaget, 1885 (*nec* Denny, 1852).

Male.—External morphology and chaetotaxy as in Fig. 3. Head broadest across temples, with preantennal region tapered and evenly rounded; dorsal anterior plate with flattened anterior margin; temple with 3 very long marginal setae on each side; antennae essentially filiform, but with somewhat enlarged basal segment; temple width, 0.38; head length, 0.46. Pronotum with 1 long seta at each lateroposterior corner; each side of pteronotum with 7 short to very long marginal setae; pronotum width, 0.23; pteronotum width, 0.38. Abdomen with tergite II (= first apparent tergite) completely divided at midline, tergites III–VII deeply indented medioanteriorly, VIII more gently narrowed medially, and IX evenly narrowed.



Figs. 1–3. *Quadraceps crassipedalis.* 1, Female. 2, Male genitalia. 3, Male.

Marginal tergal setae: II–III, 4; IV–VI, 8; VII, 6; VIII, 4; IX, 8; posterior margin of abdomen with row of very long setae. Quadrangular sternal plates on III–VI, each with 4 marginal setae; subgenital plate extending from VII to end of abdomen. Abdomen width, 0.58; total body length, 1.67. Genitalia (Fig. 2) with basal plate about twice length of parameres; parameres stout, tapered to point posteriorly, with subapical very short seta; mesosomal structures as shown; genitalia length, 0.33; genitalia width, 0.07.

Female.—External morphology and chaetotaxy as in Fig. 1. Much as for male, except as follows. Temple width, 0.44; head length, 0.52; pronotum width, 0.29; pteronotum width, 0.46. Abdomen with tergites II–VII very deeply indented medioanteriorly, II not completely divided; VIII longer, with slight medioanterior indentation; IX evenly longer. Marginal tergal setae: II, 2; VI, 10; VIII, 4, but with 2 at each lateroposterior corner; IX, 8, but 2 at each lateroposterior corner and 2 at each lateroanterior corner. Subgenital plate of fused sternites VII–VIII, with posterior margin having series of 10 short setae. Abdomen width, 0.68; total body length, 2.14.

Discussion.—Hopkins and Clay (1952) placed *Q. crassipedalis* in the genus *Brueelia* Kéler with the notation "Referred here doubtfully." When Carriker (1949) described his new species *Quadraceps titicacae,* he compared it with the description and illustration of *Nirmus crassipes* Piaget, 1885. Apparently Hopkins and Clay were unaware of Carriker's referral of this species to the genus *Quadraceps.*

We recently received a series of *Q. crassipedalis* off the type-host, these likely representing the first specimens of this species seen by any mallophagan taxonomist since Piaget. A comparison of these specimens with the illustration by Piaget indicates that they represent the species he described. Apparently Hopkins and Clay based their decision on the fact that the preantennal region of the head is more tapered than other previously known species of *Quadraceps.* To end the confusion concerning the generic status of this species, we have illustrated both sexes and provided descriptive details and measurements which clearly place the species in the genus *Quadraceps.* The details of the male genitalia (Fig. 2), the medially indented abdominal tergal plates, and the shape of the abdominal terminal sternal plates are unique.

Material examined.—1 ♂ and 1 ♀ from *Thinocorus rumicivorus* collected September 26, 1981, at Los Salinas, El Convento, Santiago, Chile, by M. A. Marin.

Quadraceps ruficollis **Emerson and Price, New Species**

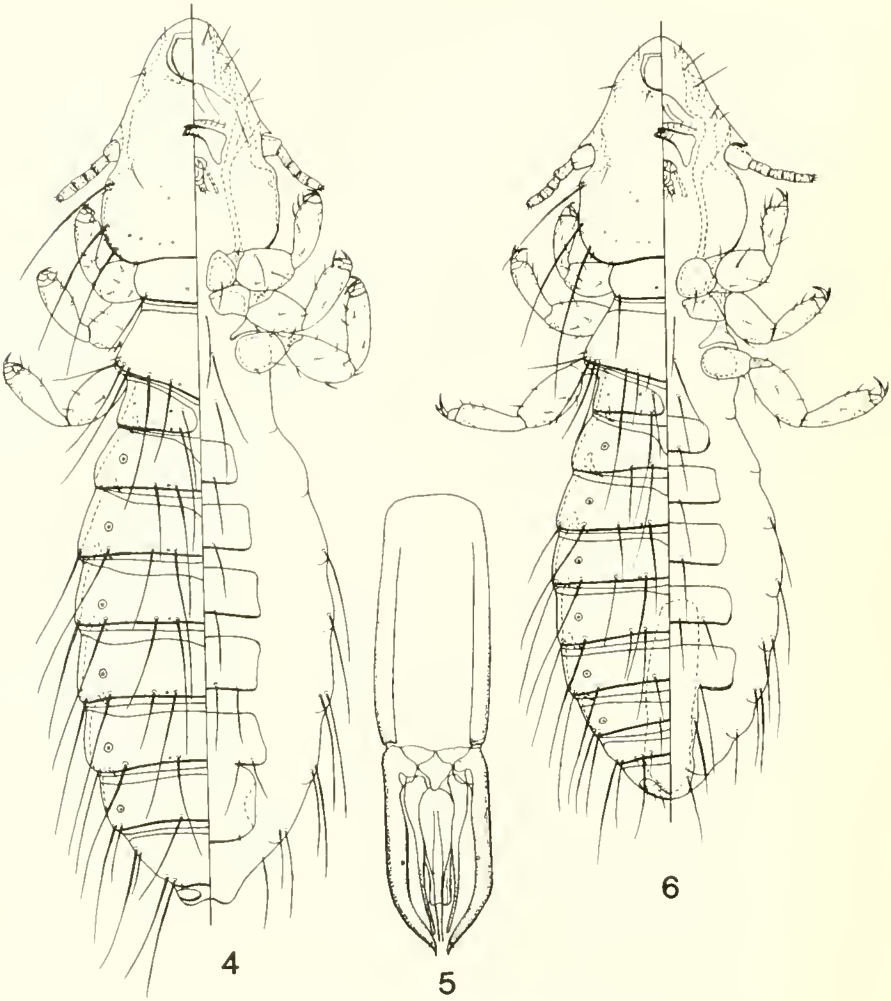
Figs. 4–6

Type-host: *Oreopholus ruficollis* (Wagler), the Tawny-throated Dotterel.

Male.—External morphology and chaetotaxy as in Fig. 6. Much as for *Q. crassipedalis,* except as follows. Dorsal anterior head plate of slightly different shape and size. Temple width, 0.29–0.32; head length, 0.38–0.41. Each side of pteronotum with 6–8 setae. Pronotum width, 0.19–0.20; pteronotum width, 0.27–0.31. Only abdominal tergites III–V with obvious medioanterior indentation. Tergite II with only 2 marginal setae, VIII with 6, and IX with 10, with lengths as shown; without series of very long setae at posterior margin of abdomen. Sternites III–V each with only 2 marginal setae. Subgenital plate with row of lateral setae. Abdomen width, 0.38–0.44; total body length, 1.33–1.43. Genitalia (Fig. 5) with longer, more slender, and more gently curved parameres, and conspicuously different mesosomal structural details; genitalia length, 0.31–0.33; genitalia width, 0.08.

Female.—External morphology and chaetotaxy as in Fig. 4. Likewise, much as for *Q. crassipedalis,* except differing as for male above and as follows. Temple width, 0.34–0.36; head length, 0.44–0.46. Pronotum width, 0.20–0.22; pteronotum width, 0.32–0.35. Only abdominal tergites III–IV with obvious medioanterior indentation. Subgenital plate lacking series of short setae on posterior margin. Abdomen width, 0.46–0.53; total body length, 1.64–1.69.

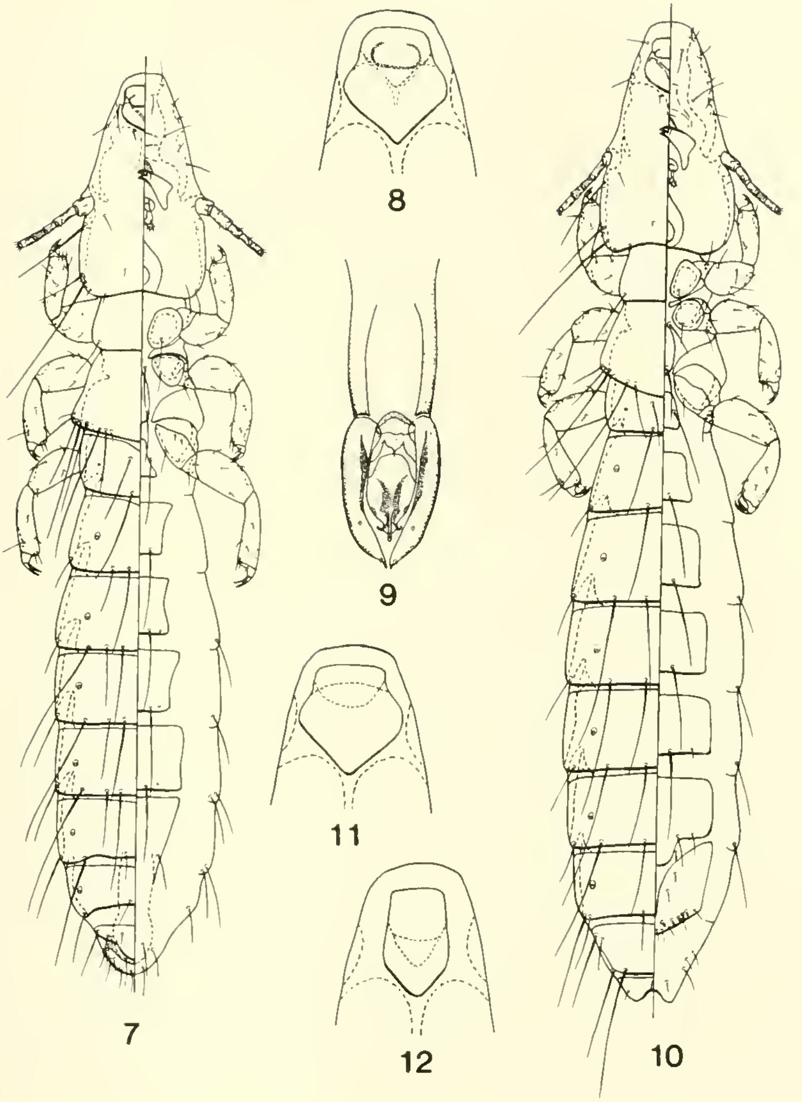
Discussion.—While the head and thorax structures are somewhat similar between *Q. crassipedalis* and this new species, the latter is easily differentiated by being consistently smaller in size and having considerably different abdominal chaetotaxy, degree of indentation of abdominal tergites, and details of the ter-



Figs. 4–6. *Quadraceps ruficollis.* 4, Female. 5, Male genitalia. 6, Male.

minalia and male genitalia. *Q. ruficollis* is also close to *Q. charadrii* (Linnaeus) found on *Pluvialis apricaria* (Linnaeus), the Eurasian Golden Plover. The chaetotaxy, except for terminal abdominal segments, is similar in these two species. The head and abdomen of *Q. ruficollis* in both sexes are wider and not as long as for *Q. charadrii.* The most noticeable differences between these two species are the shape of the dorsal anterior head plate and the details of the male genitalia. The dorsal head plate of *Q. charadrii* has a convex anterior margin, whereas that of *Q. ruficollis* (Figs. 4, 6) is flattened. The male genitalia of *Q. charadrii* are only 0.23 long with stout parameres and a short basal plate, while for *Q. ruficollis* the male genitalia (Fig. 5) are over 0.30 long and have long slender parameres and a longer basal plate.

Material examined.—Holotype ♂ from *Oreopholus ruficollis* collected July 3, 1981, at Punitaqui, Coquimbo, Chile, by M. A. Marin; in the U.S. National



Figs. 7–12. 7–10, *Quadraceps rubricollis*. 7, Male. 8, Male dorsal anterior head plate. 9, Male genitalia. 10, Female. 11, 12, Male dorsal anterior head plate. 11, *Q. boephilus*. 12, *Q. hiaticulae*.

Museum of Natural History. Paratypes: 45 ♂, 64 ♀, same data as holotype; 34 ♂, 21 ♀ from *O. ruficollis* collected on May 1973 at Camino a Punta Blanca Pd. Magdalena, Buenos Aires, Argentina, by A. C. Cicchino.

Quadraceps rubricollis **Emerson and Price, New Species**

Figs. 7–10

Type-host: *Charadrius rubricollis* Gmelin, the Australian Plover.

Male.—External morphology and chaetotaxy as in Fig. 7. Head elongate, narrowed, with slightly flattened anterior margin; dorsal anterior plate heart-shaped, as in Fig. 8; temple with 1 very long and 2 shorter marginal setae on each side; antennae filiform, with basal segment slightly enlarged; temple width, 0.28–0.29; head length, 0.46–0.47. Pronotum with 1 long seta at each lateroposterior corner; each side of pteronotum with 5–8 short to very long marginal setae; pronotum width, 0.19–0.21; pteronotum width, 0.28–0.30. Abdomen with tergites II–VII of approximately similar size, with II–III slightly indented medioanteriorly; VIII smaller; terminal tergites as shown. Marginal tergal setae: II, 2; III, 6; IV–VI, 8; VII, 6; VIII, 4. Sternal plates on II–VI each with 2 setae. Abdomen width, 0.35–0.37; total body length, 1.88–1.95. Genitalia (Fig. 9) with stout parameres, gently inwardly curved; mesosomal structures as shown; genitalia length, 0.27–0.28; genitalia width, 0.07–0.08.

Female.—External morphology and chaetotaxy as in Fig. 10. Much as for male, except as follows. Temple width, 0.29–0.30; head length, 0.47–0.48. Pronotum width, 0.20–0.22; pteronotum width, 0.29–0.30. Abdominal tergite VIII of much same size as I–VII, with IX only slightly shorter. Marginal tergal setae: III, 4; IV–VIII, 6. Sternal plate on IV with 4 setae; subgenital plate with VII separated from VIII, chaetotaxy as shown. Abdomen width, 0.38–0.40; total body length, 2.03–2.14.

Discussion.—The long slender species of *Quadraceps* found on Plovers of the genus *Charadrius* are in the *hiaticulae* species group. In addition to *Q. rubricollis* described here, the species group includes *Q. hiaticulae* (O. Fabricius) found on *Charadrius hiaticula* Linnaeus and *Q. boephilus* (Kellogg) found on *C. vociferus* Linnaeus. These three species are easily separated by the shape of the anterior dorsal head plate (Figs. 8, 11, 12). The parameres and the entire male genitalia of *Q. rubricollis* are shorter than those of the other two species. The chaetotaxy and shape of the terminal abdominal segments also differ in each of the three species. *Q. rubricollis* and *Q. hiaticulae* have darkened lateral margins on abdominal segments II–VII, whereas *Q. boephilus* has median darkened hour-glass shaped areas on abdominal tergites II–VII. Timmermann (1955) described *Q. cucullatus*, the shorter species of *Quadraceps*, from the same type-host as for *Q. rubricollis*, but the differences in size and structure are readily apparent.

Material examined.—Holotype ♂ from *Charadrius rubricollis* collected March 24, 1981, at Ordnance Point, Tasmania, by R. H. Green; in the Queen Victoria Museum, Launceston, Tasmania, Australia. Paratypes: 13 ♂, 8 ♀, same data as holotype.

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LITERATURE CITED

Carriker, M. A., Jr. 1949. Neotropical Mallophaga miscellany. V. New genera and species. Rev. Brasil. Biol. 9: 297–313.

Denny, H. 1852. Anoplura or parasitic insects. *In* Gray, J. E., ed., List of specimens of British animals in the collection of the British Museum, Pt. II: 1–51.

Harrison, L. 1916. The genera and species of Mallophaga. Parasitology 9: 1–155.

Hopkins, G. H. E. and T. Clay. 1952. A check list of the genera & species of Mallophaga. Brit. Mus. (Nat. Hist.), London. 362 pp.

Peters, J. E. 1934. Check-list of birds of the world. Vol. II. Harvard Univ. Press, Cambridge. 401 pp.

Piaget, E. 1885. Les Pediculines. Essai monographique. Supplement. E. J. Brill, Leide. xvi + 200 pp.

Timmermann, G. 1955. Studien über Mallophagen aus den Sammlungen des Britischen Museums (Nat. Hist.), London. Ann. Mag. Nat. Hist. (Ser. 12) 8: 513–534.

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A DESCRIPTION OF THE ADULT AND IMMATURE STAGES OF *ECTECEPHALA CAPILLATA* (COQUILLETT) (DIPTERA: CHLOROPIDAE)

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Abstract.—*Ectecephala capillata* is redescribed from adults of both sexes, larva and puparium from material collected in and reared from shoots of the grass *Paspalum fasciculatum* from Trinidad, the larval description being the first for a species of this genus. The larva is compared with those of species of *Pachylophus.*

During 1981 F. D. Bennett observed heavy shoot fly damage to *Paspalum fasciculatum* Willd. ex Fluegge (Poaceae) sward at Curepe, St. George Co., Trinidad. From the grass shoots showing "deadheart" he reared a number of species of acalyptrate Diptera, most prevalent amongst which was *Sepsisoma erythrocephalum* (Schiner) (Richardiidae). The immature stages of this species are to be described by the identifier, Mr. G. Steyskal. Four species of Chloropidae were reared, being *Trigonomma albipes* (Wiedemann), *Elachiptera* sp., an unidentified species of Oscinellinae and *Ectecephala capillata* (Coquillett). It has not been possible to determine whether any of these Chloropids causes primary damage to the grass or whether any had predaceous larvae. As no information on hostplants and no larval description exists for any species of *Ectecephala* Macquart, a description of *E. capillata* is worthwhile.

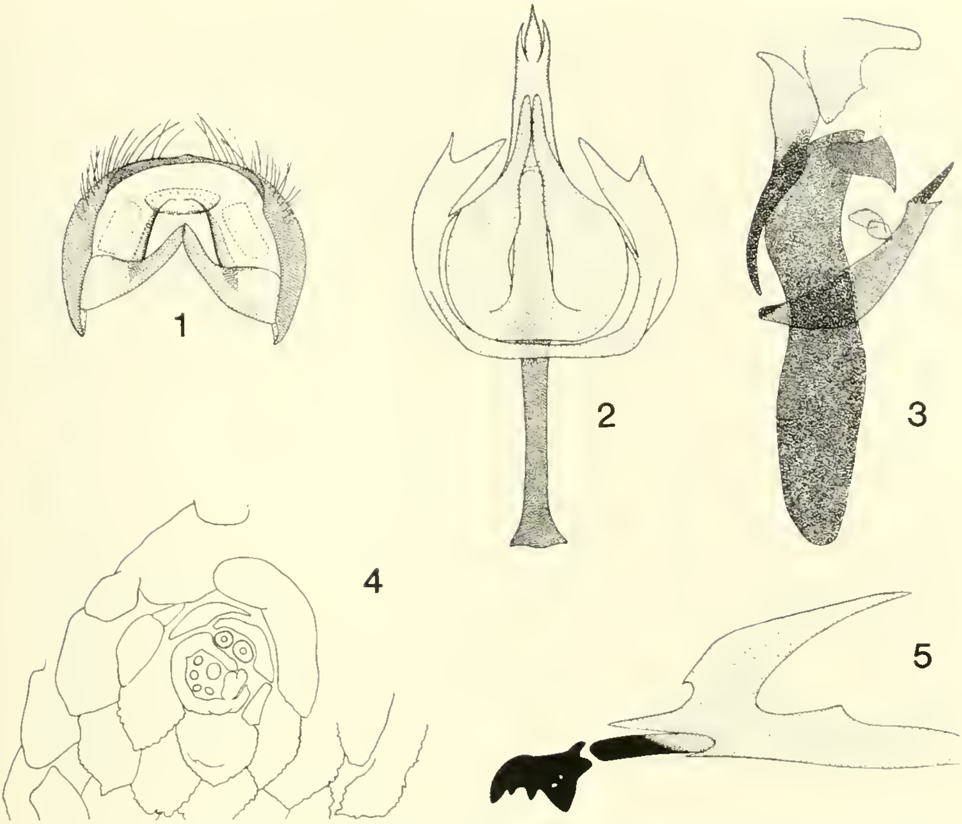
Stereoscan micrographs were made from a single larva, which was originally preserved in alcohol and was prepared by critical point drying in a Samdri-780 prior to electron microscopy at the National Museum of Wales.

***Ectecephala capillata* (Coquillett)**

Figs. 1–12

The type series of *Chlorops capillata* consists of the type female from Granada, Nicaragua and two further specimens from Georgia and North Carolina, U.S.A. Sabrosky recognized the two U.S.A. specimens to belong to *Chlorops unicolor* Loew and transferred that species (1965: 791) to *Ectecephala* Macquart. Seemingly without having seen the type of *capillata,* the species was placed in new combination by Becker (1912: 151) as *Ectecephala capillata* (Coquillett). In that paper Becker cited a wide distribution within the Americas. Sabrosky & Paganelli (1984: 36) restrict this distribution to Central America and Mexico.

Through the great kindness and help of C. W. Sabrosky and C. H. Paganelli I have been able to arrive at an identification for the Trinidad material. Dr. Sabrosky has furnished me with a male from the collections of the National Museum of



Figs. 1–5. *Ectecephala capillata* (Coquillett) from Trinidad. 1, Male, epandrium and surstyli, ventral. 2, Male phallic complex and hypandrium, ventral. 3, Male phallic complex and hypandrium in profile. 4, Third instar larva, frontal papilla and surrounding rami. 5, Third instar larva, cephalopharyngeal skeleton.

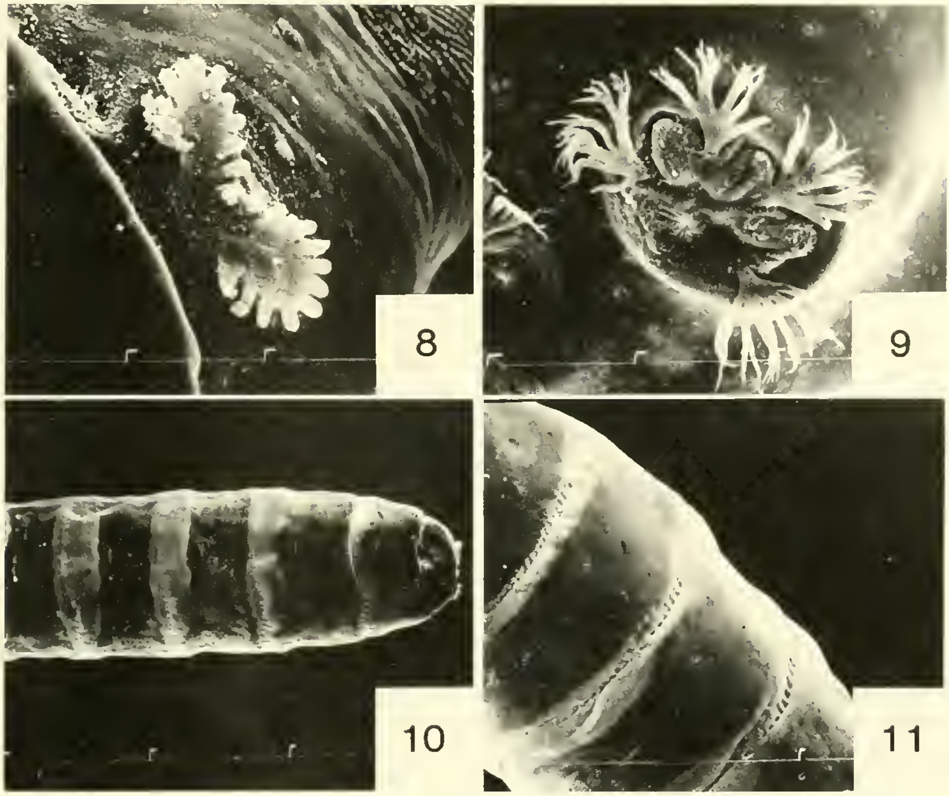
Natural History in Washington, D.C. labelled "Higuito, San Mateo, CR (Costa Rica), Pablo Schild Coll., *Ectecephala capillata* Coq. det. Sabrosky" and Miss Paganelli has availed me of one of the genitalia figures she has made from a Mexican male (Chiapas, 9 mi. sw Teopisca Hwy.), which specimen she had compared with the type of *E. capillata.* Both the Higuito male (Fig. 12) and Miss Paganelli's figures of the Chiapas male show the postgonites in profile to be apically more strongly recurved and of a "vulture-headed" shape. In all other respects, however, the Trinidad specimens agree with these other specimens and I do not consider that such a single minor difference merits the erection of a separate taxon.

Diagnosis.—A predominantly yellow species with mesopleuron totally devoid of hairs, broad frontal triangle, the antenna not strikingly elongate with a large sensory pit on outer surface of third segment, the notopleural bristles long and much longer and stronger than the humeral, the preapical scutellar marginal bristle more than half as long as the apical, characterized by the structure of the male genitalia.

Male.—Head in ratio of width: length: height 27:20:18, yellow, very faintly

Figs. 6–7. *Ectecephala capillata* (Coquillett) third instar larva from Trinidad. 6, Facial mask, ventral. 7, Head and first thoracic segment, anterior.

brownish laterally and anteriorly on frontal triangle with ocellar prominence black and sides of frons anteriorly golden and of a silken texture; frons at narrowest point 0.7 × width of head, projecting in front of eye for a distance equal to ¼ head length; frontal and upper occipital chaetotaxy black, that of the gena yellow; frontal triangle reaching front of frons as a point, posteriorly weakly concave sided, anteriorly more strongly convex sided, with 2–3 rows of proclinate hairs laterally situated extending forward from level of anterior ocellus, the ocellar and postvertical bristles proclinate, only slightly longer than these and much shorter than the subequal vertical bristles; vibrissa distinct; gena weakly haired on mouth margin and in a line extending from the postocular hairs, at narrowest part 0.22 × vertical height of the obliquely oval eye, the height of which is 0.75 × that of the head; mouth margin laterally raised, devoid of the fine pale dusting present elsewhere on face, gena and occiput; vibrissal angle rounded, forming an angle of 122° between face and mouth margin; occiput convex with a distinct vertical ridge on either side abutting the humerus; palpus simple, yellow; antenna slightly less than ½ length of head, somewhat hooded by the frons, the second segment 0.73 × length of third, brownish with hairs black dorsally and yellow ventrally; third segment with dorsal edge in length only 1.1 × its greatest depth, apically roundedly angulate but appearing more strongly so due to the convergence of pile, yellow with dorsal edge and apex black, more extensively black on outer surface than inner, on outer surface with a deep round sensory pit which in area is equal to 4 eye facets; arista white with swollen base yellow. Thorax slightly narrower than head, yellow, vaguely reddish on three raised mesonotal lines, the median of which extends backwards only as far as wing base, on humerus, a large triangular mark on katepisternum, on lower half of meron, more strongly darkened on notopleural ridge and a round spot at anterior spiracle; pleura dusted only posterior to wing base; notopleuron covered in short dense pale pilosity; scutum shining, dorsally covered in short fine hairs which are longer than the intervals between them, their bases situated on slight elevations, giving a rugose appearance; slope of scutum in front of scutellum densely yellow pilose, chaetotaxy black, the single dorsocentral bristle short, shorter than the single postalar and the 1 + 2 notopleurals, but stronger than the weak humeral; scutellum rounded, finely pilose,



Figs. 8–11. *Ectecephala capillata* (Coquillett) third instar larva from Trinidad. 8, Left anterior spiracle. 9, Left posterior spiracle. 10, Ventral surface of posterior half. 11, Lateral surface of mid abdominal segments.

devoid of setulae on a semicircular basal patch, elsewhere dorsally with hairs slightly longer and more widely spaced than on scutum, the strong apical bristles separated by a distance equal to ⅓ length of scutellum, these much longer and stronger than the 2 pairs of lateral bristles; metanotum dusted. Legs yellow, with foretarsus and apical 2 segments of other tarsi black, pale dusted and predominantly dark haired with coxae pale haired, the apical ventral bristle of midtibia black; forefemur with a row of close set minute studs anteroventrally on apical ⅗ of length, hindtibia lacking a sensory area. Wing faintly brown fumose with dark brown veins; ratio of length of second: third: fourth costal sectors 45:30:16 and of lengths of penultimate sections of R^{4+5}:M 13:21; posterior crossvein somewhat oblique; squama grey with dark margin and fringe; haltere yellow. Abdomen yellow with indistinct darker areas especially on ventrally facing edges of tergites, subshining through weak pale dust, with tergites dark haired and sternites pale haired; epandrium and surstyli (Fig. 1); phallic complex (Figs. 2–3). Length about 3.5 mm, of wing 2.9 mm.

Female.—Resembling male except in abdominal structure. Sternite 1 short, straplike; sternite 2 droplet shaped, but with basal margin straight, tapering backwards to a fine point; sternites 3–5 narrow oval; sternite 6 roundedly trapezoidal, 12

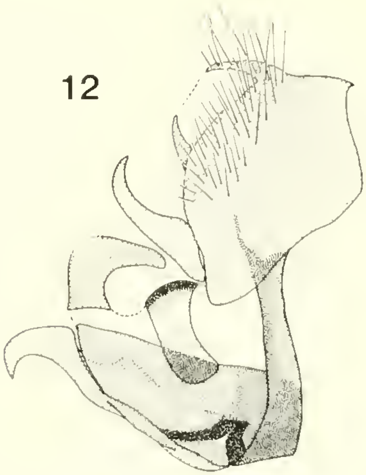


Fig. 12. *Ectecephala capillata* (Coquillett) from Costa Rica, External male genitalia in profile.

with apical margin twice length of basal; sternite 7 hardly sclerotized, indicated only by a transverse line of 4 hairs between the spiracles; sternite 8 much more heavily sclerotized and darkened than any other, medially divided into a pair of roundedly triangular plates which basally are widely and apically narrowly separated, subanal sclerite black; hairs on sternites 2–4 moderate, yellow, on 5 moderate, yellow and black, on 6 and 7 moderate, black, and on 8 minute, black; cercus simple.

Third instar larva.—5.8 mm in length, 1.1 mm in greatest width, yellowish white; anterior spiracle (Fig. 8) of transverse rosette shape, bearing 21–24 digitations; posterior spiracles (Fig. 9) separated by about one half their individual widths, very little raised above surrounding cuticle, with rimlike edges and each with 4 scales resembling kelp fronds and 3 spiracular openings; facial mask (Fig. 6) with frontal rami formed by overlapping plates, some of which are serrate; maxillary ring (Figs. 4, 7) broken, with the usual arrangement of papillae; cephalopharyngeal skeleton (Fig. 5) with mandibular sclerite and anterior half of hypostomal sclerite black, posterior half of the latter brown and pharyngeal sclerite dirty yellow; first thoracic segment (Figs. 6, 7) ringed by 12–14 rows of course spicules, the more anterior rows of which are shorter, more curved and broken, this the only spicular zone present on integument; abdomen (Figs. 10, 11) with 9 rings, incomplete ventrally and doubled laterally, of quadrate indentations, all but the last of which have a single lateral pore behind; anal plate (obscured by dirt in specimen) narrow oval.

Puparium brown, shining, resembling larva in general shape but more dorsoventrally flattened, intensively finely transverse ridged; posterior spiracles lacking rim, abdominal pores strikingly evident, with cuticular thickening and darkening marking their immediate positions.

Material examined.—6 ♂, 3 ♀, 2 pharate adult ♀ TRINIDAD: St. George Co., Curepe, ex shoots *Paspalum fasciculatum* Willd. ex Fluegge (Poaceae), reared vi, viii, xi.1981, iii.1982, (F. D. Bennett). All the above with individual puparia. One third instar larva (same locality and hostplant) mounted on EM stub. All the above deposited in National Museum of Wales, Cardiff.

This species most resembles *Ectecephala brasiliensis* Becker from Santa Catarina, Brazil which has a striking black spot under the anterior spiracle and a leaf-shaped black spot on lower mesopleuron, the surstylus with distinct hairs and the apices of the postgonites in profile deeply U-shaped emarginate, in ventral view broader and not coming into contact with one another. A full description of *E. brasiliensis* is to published by Miss Paganelli in her revision of Neotropical chloropine genera.

The larva of *Ectecephala capillata* most resembles those of *Pachylophus beckeri* Curran and *P. lugens* Loew (described by Deeming, 1973: 155 and 1977: 327) in having the anterior spiracle of a transverse rosette shape and spicular zones restricted to the first 2 (*beckeri*) or first only (*lugens*) thoracic segments. Furthermore, a puparium of *P. pellucidus* Becker from Kenya shows, though difficult to discern, the lateral row of abdominal pores described for *capillata*. However, both these described larvae lack the rings of quadrate abdominal indentations and have very different facial rami.

ACKNOWLEDGMENTS

My sincere thanks are due to F. D. Bennett, Commonwealth Institute of Biological Control, Curepe for entrusting me with the study of this interesting material, to Celuta Paganelli, Museu de Zoologia da Universidade de São Paulo for kindly supplying me for purposes of comparison with descriptive notes and figures of the male genitalia of *Ectecephala capillata* (Coquillett) and *brasiliensis* Becker, and to Curtis W. Sabrosky, Washington, D.C. for specimen loan and for his critical scrutiny of the manuscript of this paper.

LITERATURE CITED

Becker, T. 1912. Chloropidae. Eine monographische Studie V. Teil. Neotropische Region. Ann. Hist. Nat. Magyar Nemzeti Muz. 10: 121–122.

Coquillett, D. M. 1904. New Diptera from Central America. Proc. Entomol. Soc. Wash. 6: 90–98.

Deeming, J. C. 1973. Notes on immature stages of *Pachylophus beckeri* Curran (Dipt., Chloropidae). Entomol. Mon. Mag. 109: 155–157 (1974).

———. 1977. The immature stages of *Elachiptereicus abessynicus* Becker and *Pachylophus lugens* Loew (Diptera: Chloropidae). Bull. Entomol. Res. 67: 325–328.

Sabrosky, C. W. 1965. Chloropidae, pp. 773–793. *In* Stone, A. et al, eds., A Catalog of the Diptera of America north of Mexico. Agr. Handbook 276. Washington, D.C. iv + 1696 pp.

Sabrosky, C. W. and C. H. Paganelli. 1984. 81. Family Chloropidae, 63 pp. *In* A Catalogue of the Diptera of the Americas South of the United States. Univ. São Paulo, Brazil.

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NEARCTIC *OLETHREUTES*: FIVE NEW SYNONYMIES, TWO REVISED STATUSES, AND NOTES (LEPIDOPTERA: TORTRICIDAE)[1]

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Abstract.—Seven nearctic or holarctic species are treated primarily, and two palaearctic species secondarily. The following are new synonymies: *Olethreutes coruscana* (Clemens) (= *O. puncticostana* (Walker) and *O. constellatana* (Zeller)); *O. metallicana* (Hübner) (= *O. murina* (Packard) and *O. major* (Walsingham)); *O. obsoletana* (Zetterstedt) (= *O. kennethana* McDunnough). The latter two species are thus holarctic. *Olethreutes glaciana* (Möschler) and *O. agilana* (Clemens) are shown to differ structurally from the palaearctic *O. bipunctana* (Fabricius) and *O. fuligana* (Hübner), respectively; the second is removed from the synonymy of the fourth. *Olethreutes ferrolineana* (Walker), currently misidentified, is removed from the synonymy of *O. coruscana*. The female currently associated with the male *O. troglodana* (McDunnough) is implausible, and a plausible female is identified.

More than 80 species of *Olethreutes* are known in North America where the genus appears to attain its greatest diversity (Powell, 1983). The known larvae feed on leaves and other soft tissues of perennial plants. The most recent generic treatment of nearctic species (Heinrich, 1926) is out of date. The nearctic species are plagued with taxonomic confusion due to interspecific similarity, intraspecific variability, and inadequate type study. The problems addressed here are similar to ones dealt with earlier (Miller, 1979). They became apparent during attempts to identify upper midwest species. Seven nearctic or holarctic species are treated here primarily, and two palaearctic species secondarily. All are illustrated to aid identification of both sexes.

Only original descriptions and revisions are cited in the nomenclatural summaries. Purely palaearctic synonymies are omitted. Spelling of names follows Powell (1983). The letter n refers to the number of specimens underlying a particular statement or conclusion, and ± denotes standard error. Forewing length is used as a size index; its validity for this purpose is documented elsewhere (Miller, 1977).

Museum abbreviations are: AM, American Museum of Natural History, New York; AP, Academy of Natural Sciences of Philadelphia; BM, British Museum (Natural History), London; CN, Canadian National Collection, Ottawa; HU, Zoo-

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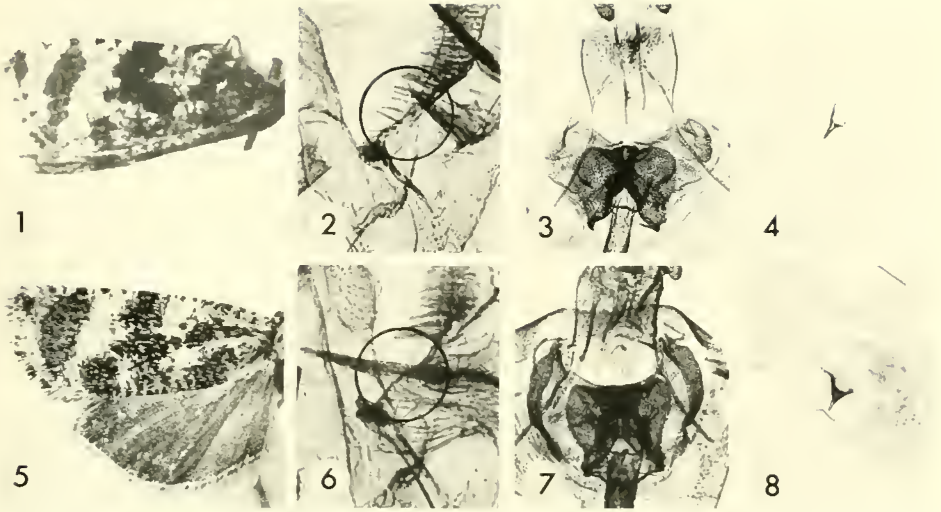


Figs. 1–8. *Olethreutes coruscana* and *O. ferrolineana.* 1, Wings of *O. puncticostana* lectotype male. 2, Part of male genitalia of preceding with valval arch circled. 3, Sterigma and associated structures of female *O. coruscana* from Detroit, Mich. (prep. BJT 61). 4, Corpus bursae and signum of preceding. 5, Wings of *O. ferrolineana* female from Livingston Co., Mich. 6, Part of male genitalia of *O. ferrolineana* lectotype with valval arch circled. 7, Sterigma and associated structures of preceding *O. ferrolineana* female (prep. MMD 63). 8, Corpus bursae and signum of preceding.

logisches Museum, Humboldt-Universität, Berlin; IS, Illinois Natural History Survey, Urbana; LCM, Natural History Museum of Los Angeles County, Los Angeles, California; MS, Michigan State University Entomology Museum, East Lansing; MZ, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; NM, National Museum of Natural History, Washington, D.C.; UL, University of Lund, Sweden; UMI, University of Michigan Museum of Zoology, Ann Arbor; UMN, University of Minnesota, St. Paul; and UW, University of Wisconsin, Madison.

Olethreutes coruscana (Clemens)

Figs. 1–4

Antithesia coruscana Clemens (1860: 346) (lectotype designated and illustrated by Miller, 1973a: male, North America, no date, forewing 9.0 mm long, in AP).

Sciaphila puncticostana Walker (1863: 339) (lectotype selected by N. S. Obraztsov, designated and illustrated here in Fig. 1–2: male, "Type . . . ; N. Scotia, Redman; . . . genit. slide No. 11624," no date, forewing 9.5 mm long, in BM, photos in AM). New Synonomy.

Sericoris constellatana Zeller (1876: 279) (lectotype selected by N. S. Obraztsov, designated here: male, ". . . Ohio, Schl. . . . ; Type; . . . genit. slide No. 11622," no date, forewing 9.5 mm long, in BM, photos in AM). New Synonymy.

Olethreutes constellatana; Heinrich (1926: 174).

Discussion.—This species has been most recently known as *O. constellatana.* The new synonymies are unmistakable. Male valval arches of all type specimens have setae nearly throughout; as pointed out by Heinrich (1926), this is a sure character state (Fig. 2) separating this species from its most similar relative, *O. ferrolineana,* the male valval arch of which lacks such setae (Fig. 6).

The digitus bearing the cluster of setae at the base of the male valval cucullus usually projects outward in genital preparations, as in Heinrich (1926: fig. 429) and Miller (1973a: fig. 9b). The digitus is folded inward in the *O. puncticostana* lectotype slide, however (Fig. 2).

This species accounts for the fourth of at least six long-standing misidentifications of Clemens olethreutine types (Miller, 1973a); previous ones are discussed elsewhere (Miller, 1973b, 1974, 1979).

The larval host is unknown.

Olethreutes ferrolineana (Walker), Revised Status

Figs. 5–8

Carpocapsa ferrolineana Walker (1863: 395) (lectotype selected by N. S. Obraztsov, designated and illustrated here in Fig. 6: male, "Type . . . N. America, Carter . . . genit. slide No. 11621," no date, forewing 7.0 mm long, in BM, photos in AM).

Olethreutes ferrolineana; Heinrich (1926: 175).

Olethreutes coruscana (not Clemens 1860: 346); Heinrich (1926: 175).

Sericoris argyroelana Zeller (1876: 277) (lectotype selected by N. S. Obraztsov, designated here: female, "N. York, Speyer . . . Type . . . genit. slide No. 11650," no date, forewing 7.5 mm long, abdomen glued, in BM, photos in AM).

Discussion.—This species has been most recently known as *O. coruscana.* It is the one alluded to in the foregoing discussion with much of the male valval arch lacking setae (Fig. 6). Heinrich (1926) correctly identified it, but placed it as a synonym of *O. coruscana.*

Zeller's (1876) description of *O. argyroelana* mentions only males, but the glued abdomen of the lectotype is female. Structural details are not clearly discernible in the preparation, but the genitalia seem more like those of *O. coruscana* than *O. ferrolineana.* Hence there is doubt whether the glued abdomen is the correct one. The darker hues and more distinct patterning of lectotype forewings match *O. ferrolineana,* however.

Unlike most genital preparations of *O. ferrolineana,* that of the lectotype male has the setal bearing digitus at the base of the cucullus folded inward (Fig. 6).

The larval host is unknown.

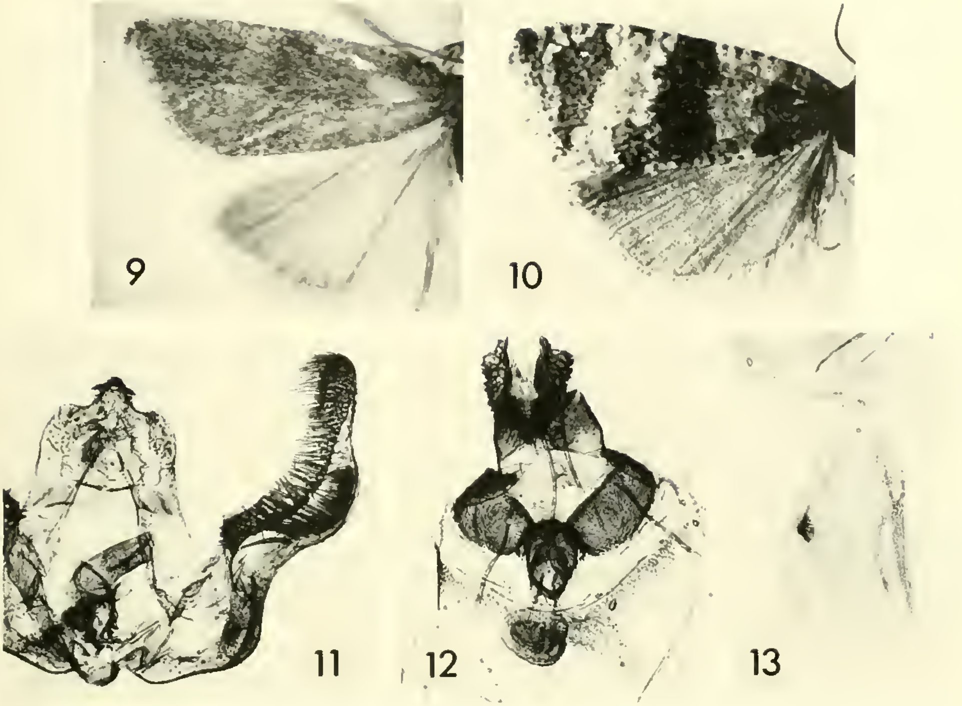
Olethreutes metallicana (Hübner)

Figs. 9–13

Tortrix metallicana Hübner (1796–99: pl. 11, fig. 68) (type unknown).

Penthina murina Packard (1867: 60) (lectotype designated and illustrated here in Fig. 9, 11: male, ". . . Type 14307 . . . C(aribou) Is., Labrador . . . *Penthina murina* Pack. lectotype des. W. E. Miller," genit. prep. JCL 1026831, no collection date, forewing 9.0 mm long, in MZ). New Synonymy.

Penthina major Walsingham (1895: 502) (lectotype selected by N. S. Obraztsov, designated and illustrated here in Fig. 10: male, "Type . . . Loveland, Colorado . . . VII.1891, Smith . . . genit. slide No. 11623," forewing 11.0 mm long, in BM, photos in AM). New Synonymy.



Figs. 9–13. *Olethreutes metallicana.* 9, Wings of *O. murina* lectotype male. 10, Wings of *O. major* lectotype male. 11, Male genitalia of *O. murina* lectotype. 12, Sterigma and associated structures of female from St. Paul, Minn. (prep. DH 915804). 13, Corpus bursae and signum of preceding.

Olethreutes puncticostana (not Walker 1863: 339); Heinrich (1926: 176).
Olethreutes puncticostana major; Heinrich (1926: 177).

Discussion.—This species has been most recently known in the nearctic as *O. puncticostana.* Heinrich (1926) misidentified both *O. murina* and *O. puncticostana,* placing the former as a synonym of the latter. He also suggested that *O. major* is different from *O. metallicana* but offered no supporting evidence.

In maculation (Figs. 9–10) and male genitalia (Fig. 11), I found no differences between examples from the nearctic (20 n) and palaearctic (16 n). Distinctness of forewing pattern varies similarly in the palaearctic (Bradley et al., 1979). In female genital structure (Fig. 12), no differences in shape were apparent. However, female genitalia of the palaearctic sample (3 n) seemed more heavily sclerotized than nearctic counterparts (6 n). Such a difference could be spurious considering the small sample sizes; if real, it is not of signal importance. Genitalia of palaearctic examples are illustrated by Bentinck and Diakonoff (1968), Pierce and Metcalfe (1922), and others.

In forewing length, males, which were represented in larger numbers than females, averaged 8.6 ± 0.2 mm for eastern nearctic specimens (12 n), and 8.2 ± 0.1 mm for palaearctic specimens (12 n). The difference is not significant statistically. Nearctic examples originating west of the 100th meridian were excluded in the foregoing comparison because size in western nearctic populations is greater than in eastern (Heinrich, 1926).

Nearctic examples originated in Alberta, British Columbia, Colorado, Labrador, Manitoba, Michigan, Minnesota, New York, Ontario, and Quebec (AM, CN, IS, MS, MZ, UW); palaearctic examples, in England and Germany (AM, NM).

The larval host in the palaearctic is *Vaccinium* spp. (Bradley et al., 1979, and others); the larval host is unknown in the nearctic. Nearctic capture dates range from 24 June to 27 July (15 n).

Olethreutes glaciana **(Möschler)**

Figs. 14–17, 18, 20

Sericoris glaciana Möschler (1860: 380) (presumed holotype: male, Labrador, Hoffthl., . . . , no date, Coll. Möschler, genit. prep. WEM 68841, forewing 7.5 mm long, in HU).

Penthina dealbana Walker (1863: 374) (lectotype selected by N. S. Obraztsov, designated and illustrated here in Fig. 15: male, "Type . . . N. Scotia, Redman . . . genit. slide No. 11629," no date, forewing 7.0 mm long, in BM, photos in AM).

Sericoris fuscalbana Zeller (1876: 284) (lectotype selected by N. S. Obraztsov, designated here: male, "Ohio, Schl.; Type; . . . genit. slide No. 11627," no date, abdomen glued, in BM, photos in AM).

Argyroploce castorana McDunnough (1922: 45) (holotype: male, Nordegg, Alta., July 7, J. McDunnough, in CN).

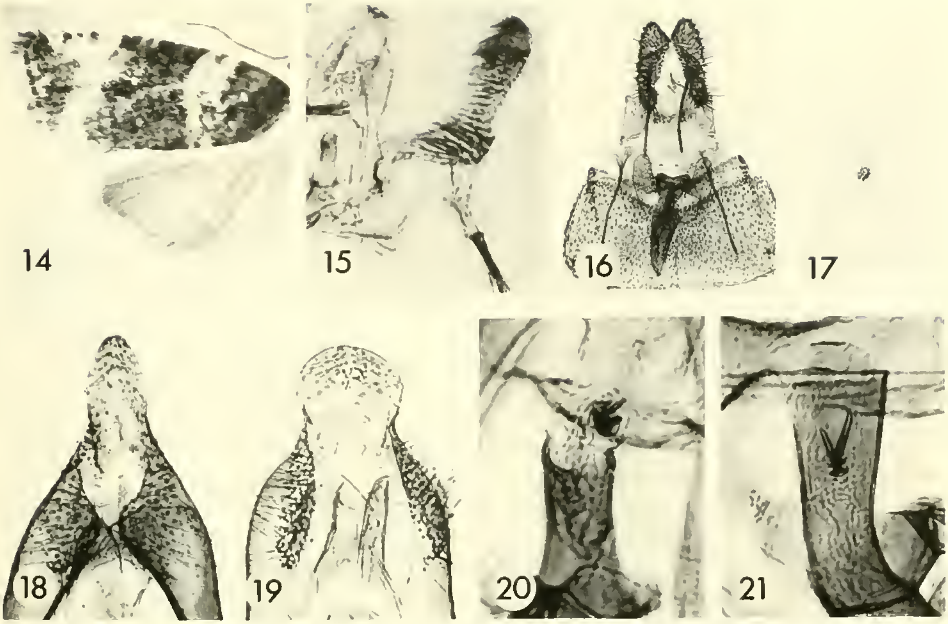
Olethreutes glaciana; Heinrich (1926: 182).

Discussion.—Prompted by Benander's (1940) suggestion that *O. glaciana* might be a synonym of the palaearctic *O. bipunctana* (Fabricius), and Diakonoff's (1973) opposing statement that they differ in details of valval shape, I compared examples that included the presumed holotype of *O. glaciana*. The *O. glaciana* examples were collected in Labrador, Michigan, New Hampshire, New York, North Carolina, Ontario, Washington, West Virginia, and Wisconsin (AM, HU, LCM, MS, NM, UMI, UW); the *O. bipunctana*, in Czechoslovakia, Germany, and Italy (AM, NM). I found more differences that seem to refute conspecificity; the most pronounced are summarized below.

For males of *O. glaciana* and *O. bipunctana*, respectively, forewing length was 7.2 ± 0.1 (18 n), and 8.6 ± 0.2 (9 n); the uncus was twice as long as wide (Fig. 18) (21 n), and equally as long as wide (Fig. 19) (5 n); and cornuti originated from a sclerotized plate (Fig. 20) (3 n), and from a membrane (Fig. 21) (6 n). For females of *O. glaciana* and *O. bipunctana*, respectively, forewing length was 6.3 ± 0.2 (12 n), and 7.6 ± 0.1 (9 n); and posterior apophyses were shorter or no longer than anterior apophyses (8 n), and longer than anterior apophyses (5 n). Forewing length of each sex averaged significantly less in *O. glaciana* than in *O. bipunctana* ($P_t < .001$). The above states of *O. bipunctana* genital characters are also visible in published illustrations (Diakonoff, 1973; Hannemann, 1961; Kuznetsov, 1978; and others).

In most slide preparations, the uncus of *O. glaciana* curves caudally, and its length may thereby be obscured (Fig. 15); viewing it in a flattened position brings out its true dimensions (Fig. 18). Also, the sclerotized plate with cornuti (Fig. 20) is easily lost during preparation unless care is taken to retain it.

The *O. glaciana* larva feeds in rolled leaves of *Betula, Populus, Acer,* and others



Figs. 14–21. *Olethreutes glaciana* and *O. bipunctana*. 14, Wings of *O. glaciana* female from Blackwater Falls St. Park, W. Va. 15, Male genitalia of *O. dealbana* lectotype. 16, Sterigma and associated structures of female *O. glaciana* from Delta Co., Mich. (prep. KL 71). 17, Corpus bursae and signum of preceding. 18, Uncus of male *O. glaciana* from Forest Co., Wis. (prep. PB 5). 19, Uncus of male *O. bipunctana* from Torfhaus, Germany (prep. DH 601813). 20, Aedeagus and cornuti of male *O. glaciana* from Schoolcraft Co., Mich. (prep. DH 610813). 21, Aedeagus and cornuti of preceding *O. bipunctana* male.

(Prentice, 1965). The *O. bipunctana* larva feeds on *Vaccinium, Pyrola,* and *Rhododendron* (Bentinck and Diakonoff, 1968; Swatschek, 1958).

Olethreutes agilana **(Clemens), Revised Status**

Figs. 22–24

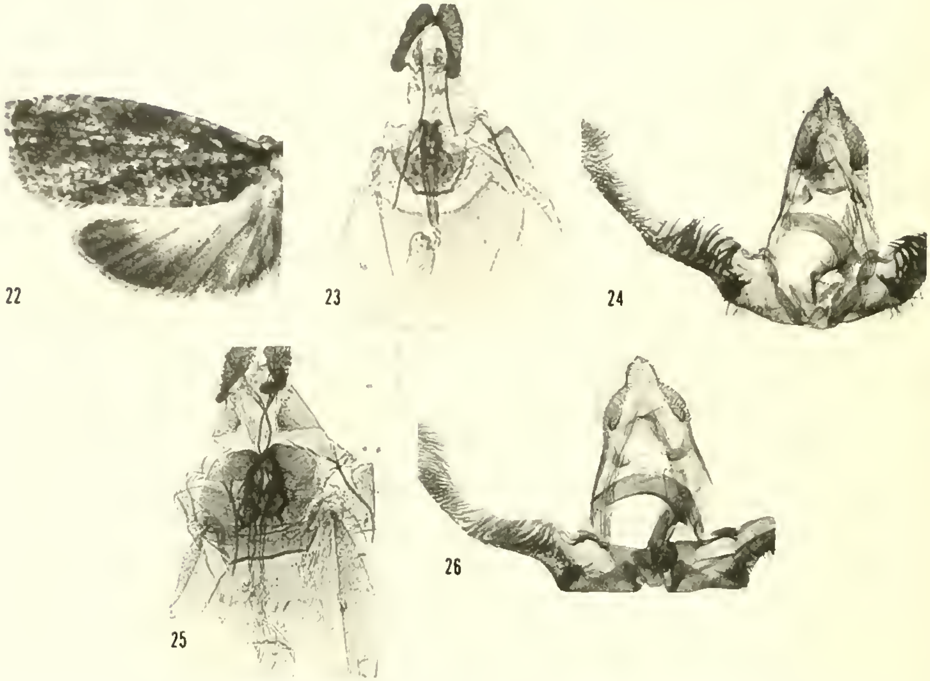
Endopiza agilana Clemens (1860: 359) (lectotype designated by Darlington, 1947, illustrated by Miller, 1973a: male, North America, no date, forewing 5.5 mm long, in AP).

Olethreutes agilana; Heinrich (1926: 171).

Pristerognatha fuligana (not Hübner, 1796–99); Oku (1979: 617).

Discussion.—In synonymizing *O. agilana* under *O.* (= *Pristerognatha*) *fuligana,* Oku (1979) cited overall similarity in genitalia illustrations and larval hosts (Bentinck and Diakonoff, 1968; Heinrich, 1926; Kuznetsov, 1978). He did not mention comparing actual specimens.

In maculation, specimens of *O. agilana* (Fig. 22) and *O. fuligana* are scarcely separable. Genitally, they differ in both sexes, however. In females, the main difference is in sterigmata. That of *O. agilana* (Fig. 23) is small in outline with irregular margins, while that in *O. fuligana* (Fig. 25) is large with smooth margins (3 n and 1 n, respectively). Neither have signa. In males, differences include longer socii and a larger angle between the sacculus and valval neck in *O. agilana* than in *O. fuligana*; and the uncus area of *O. agilana* has an anal slit that is lacking



Figs. 22–26. *Olethreutes agilana* and *O. fuligana*. 22, Wings of *O. agilana* male from Essex Co., N. J. 23, Sterigma and associated structures of female *O. agilana* from "Penn." (prep. WEM 78844). 24, Male genitalia of *O. agilana* from Cincinnati, O. (prep. WEM 78842). 25, Sterigma and associated structures of female *O. fuligana* from Germany (prep. WEM 68842). 26, Male genitalia of *O. fuligana* presumably from Germany (prep. 1-Obr. 1960).

in *O. fuligana* (Figs. 24, 26) (4 n and 1 n, respectively). These differences cannot be dismissed as due to an anomalous, small sample of *O. fuligana*, a rare species in collections; the pertinent character states can also be seen in illustrations of Bentinck and Diakonoff (1968) and Kuznetsov (1978). Forms so readily separable by structural characters cannot be considered conspecific.

The *O. agilana* larva feeds in stems of *Impatiens* (Heinrich, 1926). Forewing length ranges from 5.0 to 6.5 mm (18 n), and adult capture dates from 30 May to 8 July (14 n).

Examples of *O. agilana* originated in Maryland, New Jersey, Ohio, and Pennsylvania (18 n) (NM, AM, LCM); *O. fuligana*, in Germany (2 n) (HU).

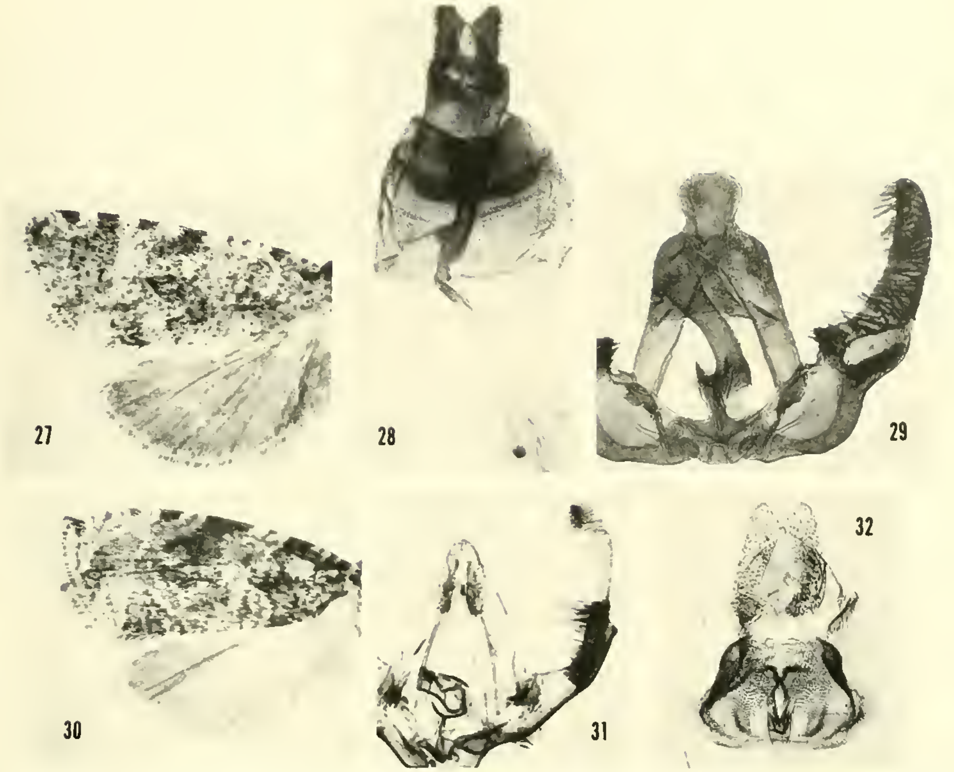
***Olethreutes obsoletana* (Zetterstedt)**

Figs. 27–29

Tortrix obsoletana Zetterstedt (1840: 980) (lectotype designated by Benander, 1940: male, Lapland, Raschstind, no date, in UL).

Olethreutes kennethana McDunnough (1941: 99) (holotype: Edmonton, Alberta, 1 August 1940, K. Bowman, No. 5213, in CN). New Synonymy.

Discussion.—I found no differences between nearctic and palaearctic examples in maculation (Fig. 27) (24 n and 10 n, respectively), female genitalia (Fig. 28) (3 n each), or male genitalia (Fig. 29) (5 n and 3 n, respectively). Both nearctic and



Figs. 27–32. *Olethreutes obsoletana* and *O. troglodana.* 27, Wings of *O. obsoletana* female from Great Bear Lake, Canada. 28, Sterigma and associated structures of female *O. obsoletana* from preceding locality (prep. WEM 37842). 29, Male genitalia of *O. obsoletana* from Dietrich R., Alaska (prep. WEM 107841). 30, Wings of *O. troglodana* male from Oneida Co., Wis. 31, Male genitalia of *O. troglodana* from Putnam Co., Ill. (prep. MOG 355). 32, Sterigma and associated structures of female *O. troglodana* from Jockuale, Ont. (prep. MAM 24791).

palaearctic samples showed only part of the range of variation in maculation illustrated by Bradley et al. (1979). Genitalia of palaearctic examples are illustrated by Pierce and Metcalfe (1922), Kuznetsov (1978), and others. The nearctic sample originated in Alaska, Alberta, and the Northwest Territories (Great Bear Lake), and included four *O. kennethana* paratypes (24 n) (AM, CN, UMN); the palaearctic sample, in Germany, Lapland, Scotland, and the USSR (Murmansk) (10 n) (BM, NM).

Forewing length of nearctic examples ranges from 7.0 to 8.0 mm (10 n), and capture dates from 29 June to 1 August (24 n). The larval host is unknown.

***Olethreutes troglodana* (McDunnough)**

Figs. 30–32

Exartema troglodanum McDunnough (1922: 37) (holotype: male, Meach Lake, Que., June 17, C. H. Young, in CN).
Exartema troglodanum (part); Heinrich (1926: 159).
Olethreutes troglodanum; Diakonoff (1973: 484).

Discussion.—The maculation of *O. troglodana* (Fig. 30) is like that of several other species of *Olethreutes*. Such similarities increase chances of taxonomic confusion. In the original description, only the distinctive male valva is shown (McDunnough, 1922). The female genitalia supplied later by Heinrich (1926: fig. 219) are implausible given the divergent male genitalia (Fig. 31). Also, they represent an undocumented association of sexes. Females whose genitalia are depicted here (Fig. 32) (2 n) are associated with authentic males. The association is based on same localities of capture in Ontario (CN) and Illinois (IS), and proximate capture dates (24–28 June, 6–16 June). The scobinate female signum is not shown here; it is rudimentary and barely visible.

The larval host is unknown.

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LITERATURE CITED

Benander, P. 1940. Revision von Zetterstedts lappländischen Microlepidoptera. Opusc. Entomol. 5: 49–65.

Bentinck, G. A., Graaf, and A. Diakonoff. 1968. De Nederlandse Bladrollers (Tortricidae). Monogr. Ned. Entomol. Ver. 3, 201 pp.

Bradley, J. D., W. G. Tremewan, and A. Smith. 1979. British tortricoid moths. Tortricidae: Olethreutinae. The Ray Society, London. 336 pp.

Clemens, B. 1860. Contributions to American lepidopterology. No. 6. Proc. Acad. Nat. Sci. Phila. 1860: 345–362.

Darlington, E. P. 1947. Notes on certain types of Lepidoptera described by Brackenridge Clemens. Trans. Am. Entomol. Soc. (Phila.) 73: 85–104.

Diakonoff, A. 1973. The south Asiatic Olethreutini. Rijksmus. Nat. Hist. Zool. Monogr. 1, 699 pp.

Hannemann, H. J. 1961. Die Tierwelt Deutschlands und der angrenzenden Meersteile 48, Kleinschmetterlinge oder Microlepidoptera I, Die Wickler (s. str.) (Tortricidae). Veb. Gustav Fischer Verlag, Jena. 233 pp.

Heinrich, C. 1926. Revision of the North American moths of the subfamilies Laspeyresiinae and Olethreutinae. U.S. Nat. Mus. Bull. No. 132, 216 pp.

Hübner, J. (1796–99). Sammlung europäischer Schmetterlinge. 7. Tortrices, Wickler. Augsburg.

Kuznetsov, V. I. 1978. Family Tortricidae, pp. 193–680. *In* A taxonomic key to insects of the European USSR. Vol. 4, Lepidoptera. Part 1. (Russian).

McDunnough, J. 1922. Undescribed Lepidoptera in the Canadian National Collection. Can. Entomol. 54: 34–47.

———. 1941. A new Albertan olethreutid. Can. Entomol. 73: 98–99.

Miller, W. E. 1973a. Clemens types of Olethreutinae (Lepidoptera, Tortricidae). Trans. Am. Entomol. Soc. (Phila.) 99: 205–234.

———. 1973b. Two previously unrecognized scientific names for the strawberry leafroller. Ann. Entomol. Soc. Am. 66: 553–554.

———. 1974. Identities of taxonomically confused moths of the *Eucosma agricolana* group and description of a new species (Lepidoptera, Tortricidae). Ann. Entomol. Soc. Am. 67: 601–604.

———. 1977. Wing measure as a size index in Lepidoptera: The family Olethreutidae. Ann. Entomol. Soc. Am. 70: 253–256.

———. 1979. The genus *Olethreutes*: Identity corrections and description of a new species (Lepidoptera: Tortricidae: Olethreutinae). Ann. Entomol. Soc. Am. 72: 232–236.

Möschler, H. B. 1860. Beiträge zur Lepidopteren-Fauna von Labrador. Wien. Entomol. Monatschr. 4: 369–381.

Oku, T. 1979. Notes on a tortricid moth, *Pristerognatha fuligana* (Hübner). Kontyû 47: 616–617.

Packard, A. S. 1867. View of the lepidopterous fauna of Labrador. Proc. Boston Soc. Nat. Hist. 11: 32–62.

Pierce, F. N. and J. W. Metcalfe. 1922. The genitalia of the group Tortricidae of the Lepidoptera of the British Islands. Oundle, Northants. 101 pp.

Powell, J. A. 1983. Tortricidae, pp. 31–41. *In* R. W. Hodges, ed., Check list of the Lepidoptera of America north of Mexico. London. 284 pp.

Prentice, R. M., ed. 1965. Forest Lepidoptera of Canada recorded by the Forest Insect Survey, vol. 4. Can. Dept. For. Publ. 1142: 543–840.

Swatschek, B. 1958. Die Larvalsystematik der Wickler (Tortricidae und Carposinidae). Akademie-Verlag, Berlin. 269 pp.

Walker, F. 1863. List of the specimens of lepidopterous insects in the collection of the British Museum. Part 28. Tortricites and Tineites.

Walsingham, T. de Grey, Sixth Earl. 1895. New species of North American Tortricidae. Trans. Entomol. Soc. London 1895: 495–518.

Zeller, P. C. 1876. Beiträge zur Kenntniss der nordamericanischen Nachtfalter, besonders der Microlepidopteren. Verh. Zool.-bot. Ges. Wien 25: 205–360.

Zetterstedt, J. W. 1840. Insecta Lapponica. 1140 pp.

PROC. ENTOMOL. SOC. WASH.
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THE LARVA OF *TVETENIA VITRACIES* (SAETHER) (DIPTERA: CHIRONOMIDAE)

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Abstract.—The fourth instar larva of *Tvetenia vitracies* (Saether) is described and important taxonomic characters are illustrated. This larva belongs to the *Tvetenia discoloripes* species group as defined by Bode (1983) based on the single median mental tooth and the prominent ventromental plates. Potential diagnostic species characters include the three long serrations on the inner mandibular margin, postoccipital margin entirely dark brown, and head capsule yellow with light brown gular region.

Saether (1969) described the male and female imagines and the pupa of *Eukiefferiella vitracies.* This species was later placed in *Tvetenia* by Saether and Halvorsen (1981) who considered it a senior synonym of *Eukiefferiella.* Cranston et al. (1983) provided a description and illustrations of the larva of *Tvetenia.* In a recent study of the Chironomidae of the Saskatchewan River (Mason, 1983), several imagines and pupae were reared from fourth instar larvae collected from mud, sand and gravel substrates in shallow (0.5–1.0 m), slow-flowing water.

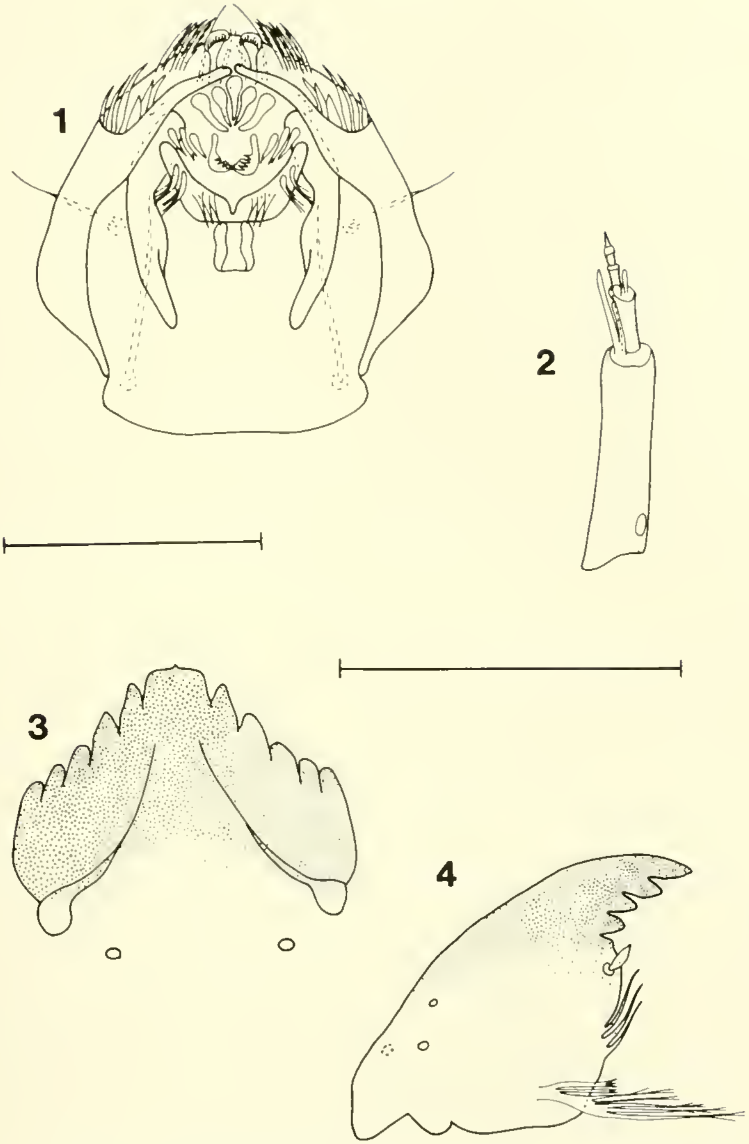
The larva belongs to the *discoloripes* species group of *Tvetenia* as defined by Bode (1983), possessing a single median mental tooth, posterolaterally pointed ventromental plates, and longer serrations on the inner mandibular margin. Saether (1969) stated that the male imago of *vitracies* belonged to the *bavarica* species group while the pupa showed characters of both the *bavarica* and *discoloripes* species groups. Bode (1983) interpreted that Saether (1969) placed *vitracies* as part of the *bavarica* group. Since the new information presented here indicates that the larva of *vitracies* unquestionably belongs to the *discoloripes* group, a reevaluation of the species groups may be necessary.

Bode (1983) was not able to find suitable diagnostic characters for larvae of the species of the *discoloripes* group. Potentially useful characters that may separate the larva of *vitracies* from other species of *Tvetenia* include the three long serrations on the inner mandibular margin, the entirely dark brown postoccipital margin and the yellow head capsule with a light brown gular region.

The Saskatchewan River records represent a north and westward range extension for *T. vitracies.* Universal Transverse Mercator Grid coordinates are presented in brackets following each locality.

FOURTH INSTAR LARVA OF *EUKIEFFERIELLA VITRACIES* SAETHER
Figs. 1–4

Description (n = 10, except when otherwise indicated).—Head capsule yellow, with dark brown apex of mandible, dark brown mentum and postoccipital margin,



Figs. 1–4. *Tvetenia vitracies* (Saether). 1, Epipharynx. 2, Antenna. 3, Mentum and ventromental plates. 4, Mandible. Scales, 100 μm.

and light brown gular region. Body blackish. Head capsule 280 μm (n = 1) wide; ventral head length 225 (205–260) μm. Antenna (Fig. 2) 100 (95–109) (n = 8) μm long; individual segments I–V 66 (63–70): 18 (15–20): 7 (6–8): 5 (4–5): 5 (5–6) (n = 8) μm long; antennal ratio 1.92 (1.76–2.09) (n = 8); ring organ on basal 0.19 (0.16–0.21) (n = 8) of first segment; antennal blade 33 (29–37) (n = 5) μm long; accessory blade 18 (14–20) (n = 3) μm long; lauterborn organs apically on segment II, 8 (6–10) (n = 5) μm long; antennal style preapically on segment II, 8 (6–10) (n = 6) μm long. Epipharynx (Fig. 1). Labrum with SI plumose, with 8 lobes, 16

(15–19) (n = 6) μm long; SII simple, 16 (10–18) (n = 4) μm long. Premandible simple, 68 (65–70) (n = 5) μm long. Mandible (Fig. 4) 127 (119–137) μm long; basal width 76 (68–94) μm; with three long serrations, each 20 (15–22) μm long, anteriormost reaching base of seta subdentalis; ratio of mandible length to basal width 1.67 (1.32–1.94); seta subdentalis 10 (9–11) μm long; seta interna with 7 serrated branches arising from single trunk. Mentum (Fig. 3) 104 (101–111) (n = 7) μm wide, with 11 teeth; single median tooth peaked, 9 (7–11) (n = 6) μm long and 23 (20–27) (n = 6) μm wide at base; median tooth height/basal width 0.44 (0.30–0.55) (n = 6); median tooth 2.40 (2.00–2.88) (n = 6) times as wide as first lateral tooth. Ventromental plates prominent. Maxillary palp with first segment 1.68 (1.18–2.00) (n = 7) times as long as basal width. Each body segment with simple setae. Anterior parapod claws weakly pectinate. Posterior parapods with 14–15 simple claws. Each procercus 1.62 (1.30–1.84) (n = 9) times as long as basal width, with 6 apical and 1 lateral setae.

Material examined.—SASKATCHEWAN: 2 pupae, reared from larvae, Saskatchewan River, 6.4 km upstream from Nipawin (13UEK6208), 19/V/79, P. G. Mason; ♂, 2 ♀, reared, 7 pupae, reared from larvae, Saskatchewan River, 18 km downstream from Squaw Rapids Powerhouse (13UFK2455), 13/VIII/79, P. G. Mason.

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LITERATURE CITED

Bode, R. W. 1983. Larvae of North American *Eukiefferiella* and *Tvetenia* (Diptera: Chironomidae). N.Y. State Mus. Bull. 452. 40 pp.

Cranston, P. S., D. R. Oliver, and O. A. Saether. 1983: 9. The larvae of Orthocladiinae (Diptera: Chironomidae) of the Holarctic region—Keys and diagnoses. Entomol. Scand. Suppl. 19: 149–291.

Mason, P. G. 1983. Systematics and ecology of Chironomidae (Diptera) associated with Tobin Lake Reservoir and the Saskatchewan River. Ph.D. Thesis, Univ. Sask., Saskatoon. 771 pp.

Saether, O. A. 1969. Some Nearctic Podonominae, Diamesinae, and Orthocladiinae (Diptera: Chironomidae). Bull. Fish. Res. Board Can. 170. 154 pp.

Saether, O. A. and G. A. Halvorsen. 1981. Diagnoses of *Tvetenia* Kieff. emend., *Dratnalia* n. gen., and *Eukiefferiella* Thien. emend., with a phylogeny of the *Cardiocladius*-group (Diptera: Chironomidae). Entomol. Scand. Suppl. 15: 269–285.

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NEW SPINY CRAWLERS FROM HEADWATERS OF THE SAVANNAH RIVER (EPHEMEROPTERA: EPHEMERELLIDAE)[1]

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Abstract.—A highly distinctive new species of ephemerellid mayfly, *Ephemerella* ***floripara*** n. sp., is described from larvae from headwater tributaries in the upper Savannah River Basin of Georgia and South Carolina. The new species was taken as mature larvae from four localities in mid-winter, and it possesses a diagnostic and unusual dorsal color pattern along with other diagnostic structural traits. A highly unusual larval specimen of *Drunella* is also characterized, but because of the lack of an adequate series is not named at this time.

Extensive collections of larval mayflies from several lotic sampling stations in the Savannah River Basin of Georgia, North Carolina, and South Carolina, made by J. Bruce Wallace and his students in 1969, were given to me for analysis. The so-called spiny crawlers, or family Ephemerellidae, constitute one of the few groups of mayflies that can presently be studied comprehensively at the species level in the larval stage. Twenty-two species were taken that had at one time or another been reported from the Savannah Drainage Area (Berner, 1977). Additionally, two previously undescribed forms were taken from headwater tributaries of the Savannah River. One is described here as *Ephemerella floripara* sp. n., and the other is referred to only as *Drunella* sp. because it is known only from an inadequate series of specimens.

The new species of *Ephemerella* is very distinctive, and the only explanation I have for it not having been discovered previously in a historically heavily collected area of Georgia and South Carolina is that it atypically exists as mature larvae in mid-winter. Most known spiny crawlers are collected as mature larvae in warmer months when sampling is more common. Adults possibly emerge in very early spring and thus have also gone unnoticed.

Ephemerella floripara, NEW SPECIES
Figs. 1–4

Larva.—Body up to 7.5 mm, dorsum generally light to medium brown with various pale markings, with most conspicuous broad median longitudinal stripe extending length of thorax and abdomen; dense covering of minute, mostly clear spicules rendering somewhat irridescent quality to entire head and body. Head pale on vertex, somewhat mottled posteriorly, with very weakly developed pair of suboccipital tubercles; pair of pale round spots on frons at base of clypeus. No

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tubercles evident on thoracic nota, only weak sculpturing on pronotum; pro- and mesonotum usually with very distinct median pale stripe; venter of thorax entirely pale. Fore legs patterned as in Fig. 1, with medial tarsal, distal tibial, and subbasal tibial pale bands; patterning not as distinct in some individuals; scattered blunt spines weakly developed mostly in distal half of dorsal face of fore femora; tarsal claws with 6–10 denticles. Dorsal abdomen somewhat darker brown laterally than thorax, with broad longitudinal median pale stripe very distinctive in nearly all individuals, and with tips of posterolateral projections pale; gill plates pale bordered, each with median brown pattern resembling fleur-de-lis design, sometimes also with a pale spot in center of pattern; ventral abdomen generally pale and lacking distinctive markings, with lateral areas of sterna 4–9 (except for tips of posterolateral projections) and distal portion of 9 and sometimes 8 darkening to light to medium brown; posterolateral projections well-developed on segments 5–9, weakly developed on 4; paired dorsal submedian tubercles weakly developed on segments 5–8, most developed on segments 6 and 7, with some slight indication of prominences on segment 4 of some individuals; some spicules darkly pigmented in corresponding dark lateral areas of abdominal terga. Caudal filaments light brown, unicolorous with whorls of spines at segmental margins in basal half, and with fine setae, weaker spines, and some pale banding in distal half.

Material examined.—Holotype larva: Georgia, Rabun Co., Chattooga River at U.S. Rt. 76, J. B. Wallace et al., I-25-1969, deposited in the Purdue Entomological Research Collection, Purdue University, West Lafayette, Ind. Three larval paratypes: same data and deposition as holotype. One larval paratype: Georgia, Rabun Co., Talullah River, 2 miles north of Talullah Falls, J. B. Wallace et al., I-26-1969, same deposition as holotype. Four larval paratypes: Georgia, Stephens Co., Panther Creek 1 mile north of Yonah Dam, J. B. Wallace et al., 1-26-69; two larvae deposited with the United States National Museum; two larvae deposited with holotype. Nine larval paratypes: Georgia (Rabun Co.)-South Carolina (Oconee Co.) border, Chattooga River at St. Rd. 28, J. B. Wallace et al., I-18-1969; two larvae deposited in the Florida A&M University Insect Collection, Tallahassee; seven larvae deposited with holotype.

Etymology.—Floriparus, Latin, meaning flower bearing, an allusion to the fleur-de-lis patterns occurring on the gills.

Remarks.—*Ephemerella floripara* is so distinctive that it is difficult to discern its affinities within the genus. The maxillary palpi of *E. floripara* are very small but retain three segments. This small palpal size is more typical of the genus *Serratella* (Allen and Edmunds, 1963); however, the caudal filaments become setaceous distally and are thus typical of *Ephemerella* (Allen and Edmunds, 1965). *Ephemerella needhami* McDunnough is another eastern spiny crawler that possesses a broad pale median dorsal stripe for the length of the body. This stripe of *E. needhami* usually contains a dark median line or is modified into two pale submedian lines. The median dorsal stripe of *E. floripara* is not modified as such or subdivided, and the dorsal armature of the two species are fundamentally different, being much more developed in *E. needhami*.

Ephemerella floripara, on the basis of the weakly developed armature and general spiculate condition, may be closely related to *Ephemerella crenula* Allen and Edmunds and *Ephemerella simila* Allen and Edmunds. Paired submedian tubercles occur on abdominal terga 3–8 and 2–8 respectively for the latter two

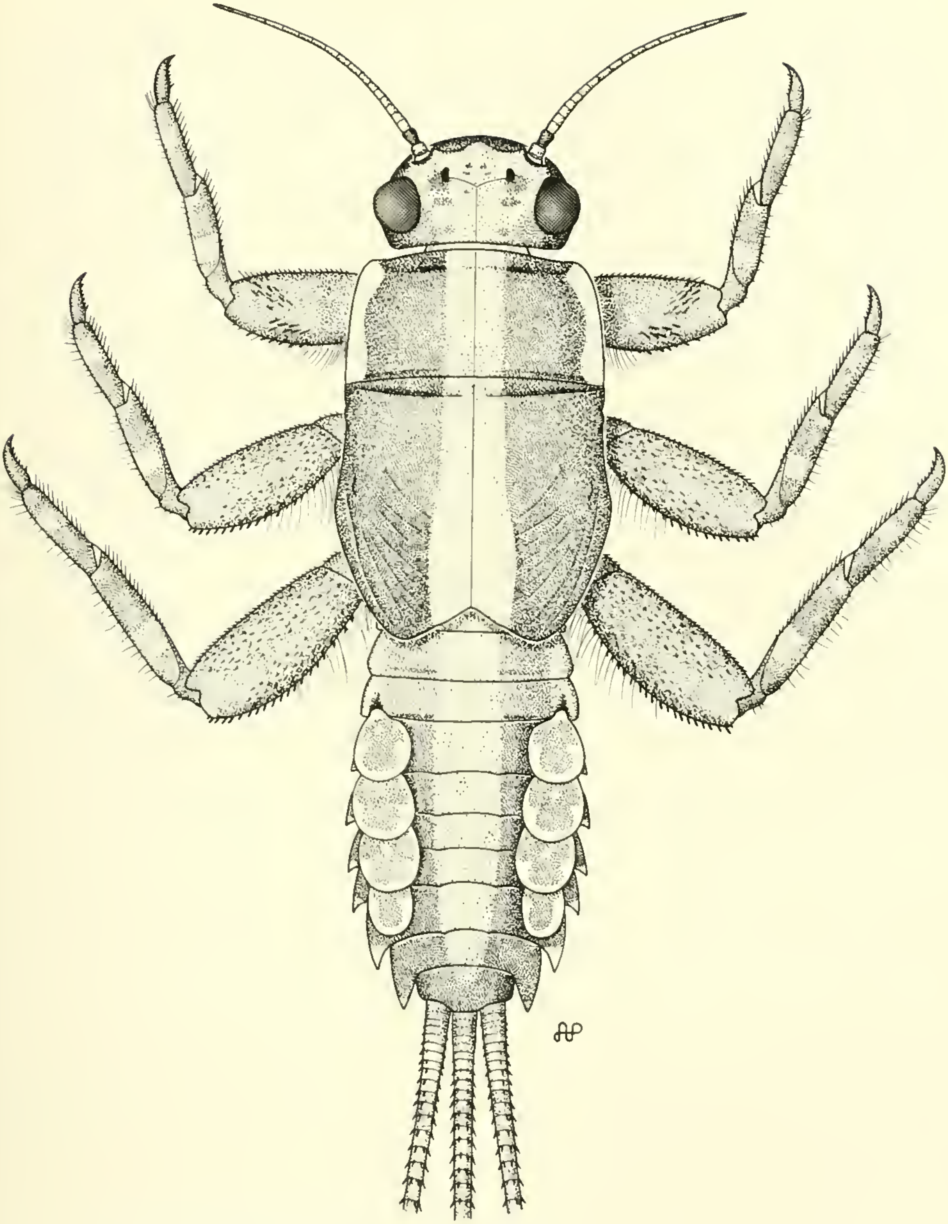
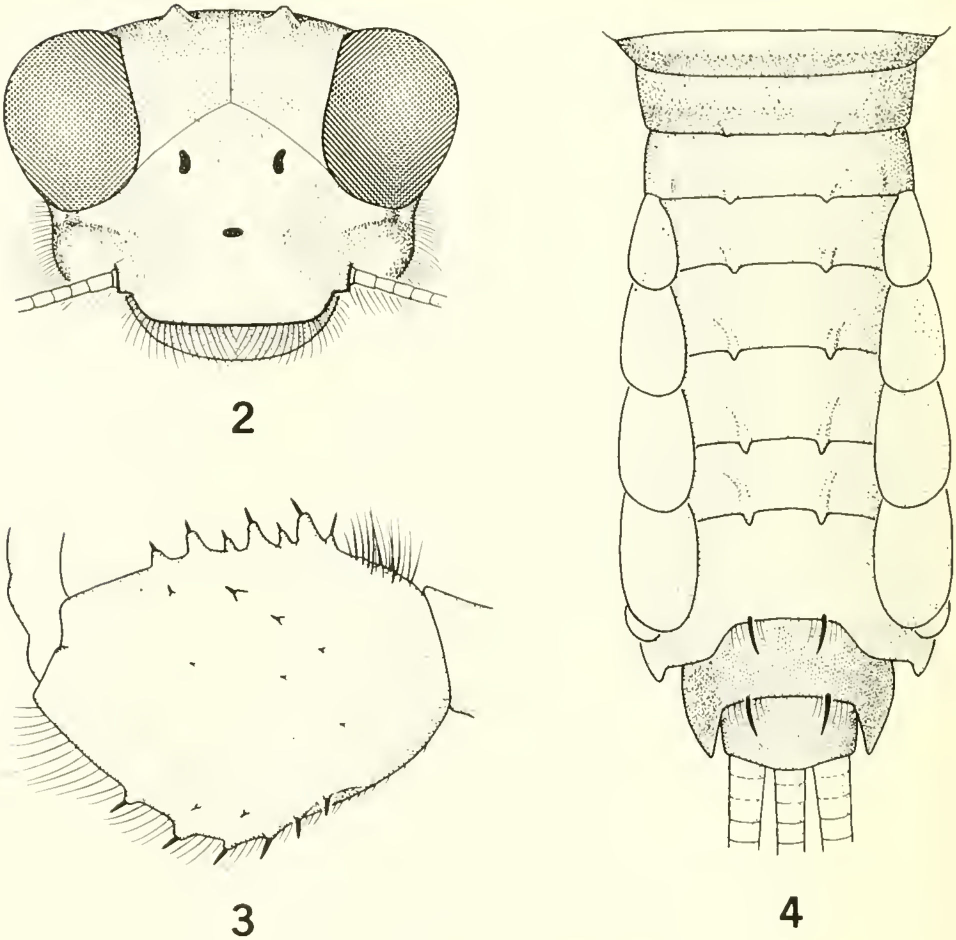


Fig. 1. *Ephemerella floripara* n. sp., dorsal whole larva.

species, whereas *E. floripara* has these tubercles only on terga 5–8 or possibly 4–8. Paired suboccipital tubercles are present in *E. simila*, absent in *E. crenula*, and very weakly developed in *E. floripara*. Both *E. simila* and *E. crenula* possess paired submedian tubercles on the prothorax, but these are absent in *E. floripara*. The color patterns of *E. crenula* and *E. simila* (and all other *Ephemerella* species) are very different than the striking pattern of *E. floripara* (the pattern of *E. needhami* is only superficially similar as discussed above).



Figs. 2–4. *Drunella* sp., larva. 2, Head, frontal view. 3, Fore femur. 4, Dorsal abdomen.

Based on the four sites where *E. floripara* was collected, the species occurs in Piedmont or lower mountain headwater tributaries of the Savannah River between 200 and 800 m elevation. The streams were between 10 and 90 m in width, and all had a mixture of either stones and sand or bedrock and sand substrates with moderate to swift currents. It is not known whether *E. floripara* was taken in pools or riffles at these sites.

Drunella sp.

Figs. 2–4

Larva.—General color very light brown, with head, thoracic nota, and abdominal terga 1, 2, 9, and 10 darker brown. Head (Fig. 2) with pair of small bluntly pointed occipital tubercles and small, somewhat indistinct median ocellar tubercle; frontal shelf well developed with more-or-less truncate margin; frontoclypeal projections small, not acute, and not reaching margin of frontal shelf; genae produced into largely rounded anterolateral projections. Thoracic nota without distinct tubercles; metathoracic nota with pair of small posterior sublateral maculae. Fore femoral armature as in Fig. 3. All femora with sparse row of black spines along posterior (dorsal) carina, with hind femoral row of spines terminating distally with one or two blunt, black, bristlelike spines. Abdominal terga 1 and 2 with darker posterior margins; entire terga 9 and 10 darker than middle abdominal terga; paired dorsal submedian tubercles (Fig. 4) present on segments 2–7, weakly developed on 2 and becoming progressively more developed on more posterior segments; abdominal terga 8 and 9 with paired submedian, long, dark, and well-developed bristlelike setae rather than tubercles (Fig. 4); posterior margin of tergum 8 deeply emarginate; gills on terga 3–6 becoming progressively larger posteriorly on each segment. Caudal filaments entirely pale.

Material examined.—One larva: Georgia, Rabun Co., Branch to Chattooga River on Georgia Rt. 28, 2.8 miles north of Georgia-South Carolina line, J. B. Wallace et al., VI-11-1969, deposited in the Purdue Entomological Research Collection, Purdue University, West Lafayette, IN.

Remarks.—This single specimen is unusual and unique for the genus *Drunella*, but I am reluctant to apply a new species name to it until it can be authenticated by a series. I have studied the larvae of most other *Drunella* species from eastern and western North America and have not seen any or read of others treated by Allen and Edmunds (1962) that possess the dorsal abdominal armature of this specimen. The bristlelike setae of segments 8 and 9 are particularly diagnostic. The posterior spination of the femora may also be unique. *Drunella* sp. described here possesses a head somewhat similar (with respect to tubercles, frontal shelf, frontoclypeal projections, and genae) to *Drunella conestee* (Traver) and *Drunella wayah* (Traver). Also, *Drunella walkeri* (Eaton), *D. wayah*, and *D. conestee* lack tubercles on terga 8 and 9 as does the species described here. These former species instead possess a row of fine hairs at the posterior margin of these terga, but lack the bristles.

Drunella sp. was collected in a mountain tributary of the Chattooga River at 640 m elevation. The stream was 1 to 3 m wide with some large pools. Riffle areas were swift with mixed stone substrate. No other spiny crawlers were collected with it.

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LITERATURE CITED

Allen, R. K. and G. F. Edmunds, Jr. 1962. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) V. The subgenus *Drunella* in North America. Misc. Publ. Entomol. Soc. Am. 3: 147–179.

———. 1963. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VI. The subgenus *Serratella* in North America. Ann. Entomol. Soc. Am. 56: 583–600.

———. 1965. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae) VIII. The subgenus *Ephemerella* in North America. Misc. Publ. Entomol. Soc. Am. 4: 243–282.

Berner, L. 1977. Distributional patterns of southeastern mayflies (Ephemeroptera). Bull. Fla. St. Mus., Biol. Sci. 22: 1–55.

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PSYCHONOCTUA MASONI (SCHAUS), NEW COMBINATION (LEPIDOPTERA: COSSIDAE: ZEUZERINAE), REDESCRIPTION AND FIRST RECORDS FROM TEXAS AND USA

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Abstract.—*Psychonoctua* **masoni** (Schaus), a new combination, is redescribed and reported for the first time from Texas and USA. Males, wing venation, and genitalia are figured.

Although this interesting cossid was first collected in Texas as early as 1961, it first came to the attention of the senior author when he collected it in extreme south Texas in 1965 and 1974. It was initially thought to represent a new species of *Xyleutes* Hübner, closely related to *Xyleutes masoni* (Schaus). Through the kind assistance of Ronald W. Hodges, Agricultural Research Service, USDA and Chen W. Young at the Carnegie Museum of Natural History, a series of specimens of *masoni* was obtained for comparison. It was evident from examination of the specimens that all represent *masoni*, a species that is quite variable in size and pattern. This species was originally described as *Zeuzera masoni* (Schaus, 1894), from an unspecified number of males from Jalapa, Mexico. The Schaus and Barnes Collection in the USNMNH and CMNH, contains a series of 19 males from Quirigua and Cayuga, Guatemala. This species was first collected in the USA by R. L. Wescott in 1961, from extreme south Texas. The senior author later collected 14 males and the junior author 13 males, all from extreme south Texas. The female remains unknown. Dyar and Schaus (1937) places *masoni* in *Xyleutes*, where it has remained until the present.

In his unpublished manuscript revision of the New World Zeuzerinae, the late Harry K. Clench reassigned *masoni* to *Psychonoctua* Grote. Julian P. Donahue (1980), based on part of Clench's manuscript, resurrected the genus *Morpheis* Hübner from synonymy under *Xyleutes* (strictly an Old World genus) and described a new species from Arizona. In that paper Donahue noted that "Several American species formerly placed in *Xyleutes* . . . are not referable to *Morpheis*, but belong in *Psychonoctua* Grote (1866) or an undescribed genus." Anticipating Donahue (in press) we here transfer *masoni* to *Psychonoctua*.

Grote (1866: 249) proposed the genus *Psychonoctua* (in the Psychidae), with one included species, *P. personalis* Grote (1866: 251), from Cuba. The generic description agrees well with *masoni* in regard to venation, but there is little else to distinguish it from other Zeuzerinae. According to J. P. Donahue (pers. comm.), the key distinguishing feature of *Psychonoctua* from other New World Zeuzerinae is the presence of an arolium between the tarsal claws. This structure is present in *masoni* and 12 other nominal species placed in *Psychonoctua* by Donahue (in press). Although *masoni* is somewhat similar in pattern to the species of *Morpheis* illustrated by Donahue (1980), *Morpheis* lacks an arolium and also differs in forewing venation and male genitalia.

***Psychonoctua masoni* (Schaus), New Combination**

Figs. 1–16

Zeuzera masoni Schaus, 1894: 235.
Xyleutes masoni; Dyar & Schaus, 1937: 1266, pl. 167e.

Head.—Front and vertex grayish brown. Labial palpi light brown, ascending, closely appressed to front. Antennae whitish, bipectinate from base to about ½ total length, shortly uniserrate beyond.

Thorax.—Vestiture fine, closely appressed. Patagia light gray margined outwardly with a fine blackish line. Mesonotum light gray with a central black triangle, apex directed cranially, sometimes filled with light gray. Posteriorly, there is a small black dorsal scale tuft flanked by black spots at the lower angles of the mesonotal triangle. Ventrally rough scaled, light gray. Legs light gray, tarsi with 4 or 5 black bands.

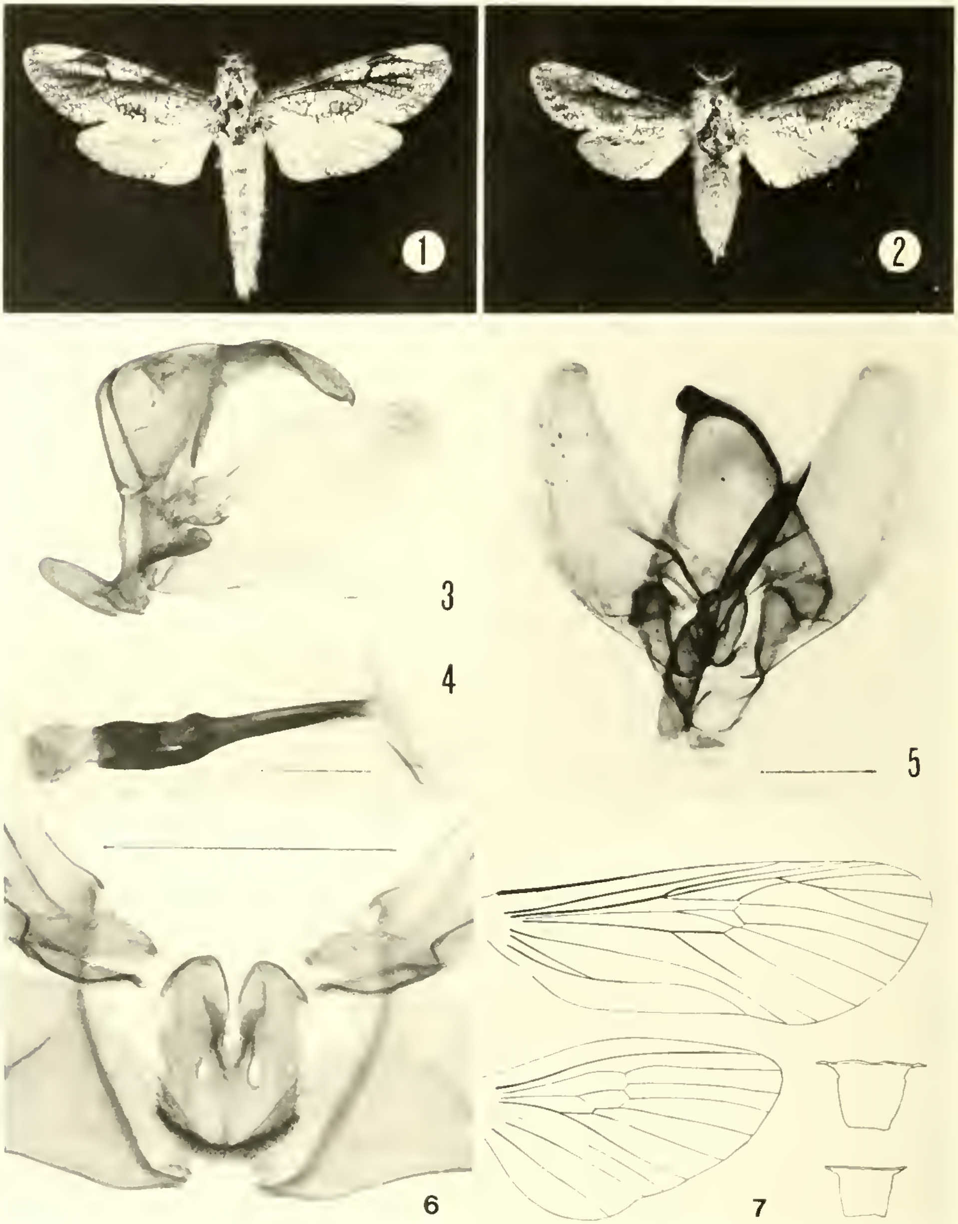
Abdomen.—Vestiture fine, hairlike, light gray, with slightly darker spots on each segment dorsally and a dark gray lateral line.

Maculation (Figs. 1, 2, 8–16).—Forewing light ochreous gray, rather evenly reticulated with a network of fine black lines. Basal ⅓ of costa black, followed by a series of spaced, black costal spots, that at ⅔ most conspicuous. Basal black costal patch continuous with a black streak above and along median vein. This median black streak extends well beyond the discal cell, more than half the distance between it and termen. Below median vein, there is great variability in the extent of black shading, which, in some cases (Fig. 14), is very heavy, nearly covering the entire discal cell and extending posteriorly to 1A shortly beyond the middle of the wing, In most specimens, the black shading is weakly indicated below the median vein. Anteriorly, a short black spur extends beyond median streak along the upper discocellular vein, joining the black costal spot at ⅔ the distance from base. This outer black costal spot is also variable in size and intensity. Hindwing light ochreous gray, with, or without blackish reticulation, which is most prominent along the distal half of vein 2A. Between vein 2A and anal margin, reticulation always absent. Fringes of both wings checkered with brown at vein ends, the spots smaller than the whitish interspaces.

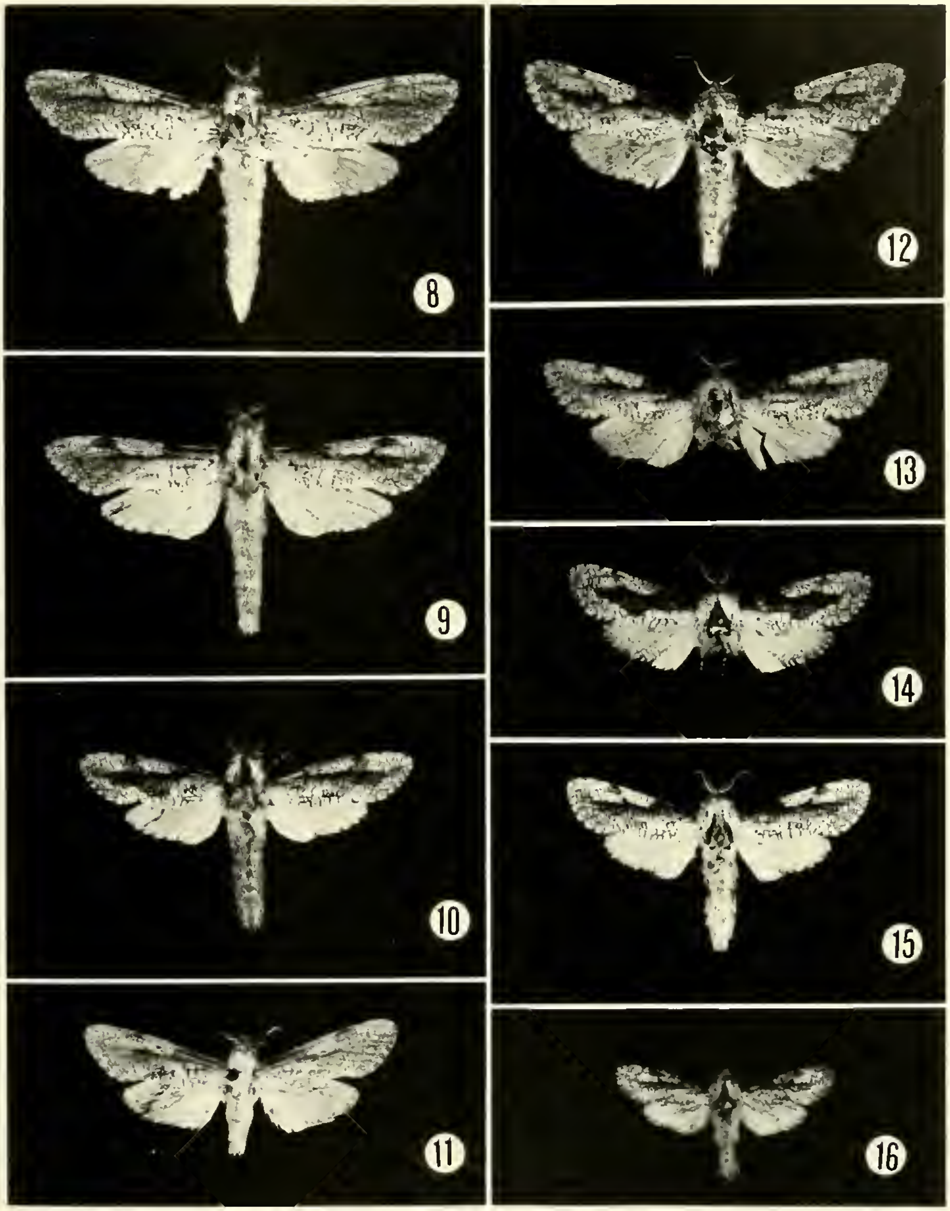
Length of forewing.—*Males:* Texas specimens (N = 14), 10.7–19.8 mm, average 16.1 mm; Mexican and Guatemalan specimens (N = 6), 16.0–25.0 mm, average 21.8 mm; average of all specimens 17.8 mm. "Expanse" of type, as stated in original description, 51 mm, which would be near the upper limit of size range of specimens examined.

Wing venation as shown in Fig. 7 (part).

Male genitalia (Figs. 3–7(part, all from Texas specimens). The genitalia of two specimens from Guatemala were also studied and no significant differences could be found from Texas specimens. The lectotype was dissected by Dr. Hodges, who found it identical to Guatemalan examples dissected by the senior author.



Figs. 1–7. *Psychonoctua masoni* (Schaus), all males. 1, Quirigua, Guatemala, USNMNH. 2, Santa Ana NWR, Hidalgo Co., Texas. 3, Genitalia, lateral view, aedeagus and left valve removed, on slide AB 4932, same locality. 4, Aedeagus with partially inflated vesica, showing single thin cornutus, on slide AB 5296, same locality as 2. 5, Genitalia, ventral view, aedeagus in situ, on slide AB 3264a, same data as 2. 6, Enlargement of juxta, in situ, tegumen, vinculum, and membranous portion of anellus removed, on slide ECK 992, same locality as 2. 7, Wing venation, on slide AB 4931, and outlines of sclerotization of 8th abdominal segment, sternite above, on slide AB 4932, same data as 3. Segments in Figs. 3, 4, 5, 6 represent 1 mm.



Figs. 8–16. *Psychonoctua masoni* (Schaus). 8, Quirigua, Guatemala, USNMNH. 9, Same data as 8. 10, Quirigua, Guatemala, USNMNH. 11, Cayuga, Guatemala, USNMNH. 12–15, Santa Ana NWR, Hidalgo Co., Texas, 21-V-74. 16, Same locality as Fig. 12, 15-IX-74.

Female, early stages, and host unknown.—Larvae of the related *Psychonoctua personalis* Grote are stem borers in several plants including coffee, in which they are considered a minor pest.

Lectotype, ♂, in USNMNH, bearing the following labels: (1) "Jalapa, Mex.";

(2) "*Zeuzera masoni* Schs. Type"; (3) "Collection Wm. Schaus"; (4) "Type 12569 U.S.N.M." (5) "Genitalia Slide By RWH Male USNMNH 12090."

Specimens examined: GUATEMALA: Quirigua, March, 3 ♂ (one with genitalia on slide USNM 52458, by A. Blanchard); same locality, May, 1 ♂, all in USNM; Cayuga, May, 1 ♂ (genitalia on slide C.699), in CMNH, all Schaus & Barnes collection. MEXICO: Cordoba, 4-IV-08, 1 ♂; Sinaloa, 1 ♂, both in USNMNH. TEXAS: Cameron Co., Brownsville, 8-V-67, 1 ♂, collected by A. & M. E. Blanchard; Southmost, 2-VI-84, 1 ♂, collected by E. Knudson. Hidalgo Co., Santa Ana National Wildlife Refuge, 21-V-65, 1 ♂ (wings on slide AB 4931.1, genitalia on slide AB 4931.2); 6-V-67, 3 ♂ (one with genitalia on slide AB 5297); 21-V-74, 8 ♂ (3 with genitalia on slides AB 3264 a, b, & c, AB 3945, and AB 5296); 15-IX-74, 1 ♂ (genitalia on slide AB 5310), all collected by A. & M. E. Blanchard; same locality, 31-X-83, 1 ♂; 1-VI-84, 11 ♂ (one with genitalia on slide ECK 992), collected by E. Knudson.

Remarks.—As indicated above, this species is evidently extremely variable in size and maculation. The examples from Guatemala and Mexico tend to average somewhat larger and less maculate than the Texas examples; however, Guatemalan specimens shown in Figs. 1 and 10 are fully as maculate as most Texas specimens, and Guatemalan specimens in Figs. 10 and 11 are equivalent in size to the larger Texas specimens. As there are no discernable genitalic differences between the lectotype studied by Dr. Hodges and all the examples studied by him and the authors, there is little choice but to consider all as conspecific. The lectotype designation for the specimen mentioned above, is made here by the authors, on the advice of Mr. Donahue and Dr. Hodges. Regrettably, this specimen could not be included in the plate, but according to Dr. Hodges (pers. comm.) it is exactly like the specimen shown in Fig. 1. In addition to the above mentioned specimens, there are 14 additional specimens from Quirigua or Cayuga, Guatemala in the USNM. There is also a single male specimen in the Natural History Museum of Los Angeles County, which was collected by R. L. Wescott in Hidalgo Co., Texas, Bentsen Rio Grande Valley State Park, 1-VII-61, identified by Donahue as *masoni.*

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LITERATURE CITED

Donahue, J. P. 1980. Resurrection of the genus *Morpheis* (Cossidae), with description of a new species in the *cognatus* group from southern Arizona. J. Lepid. Soc. 34(2): 173–181.

———. (in press). Cossidae. *In* Heppner, J. B., ed., Checklist of Neotropical Lepidoptera.

Dyar, H. G. & W. Schaus. 1937. Cossidae. Pp. 1264–1287. *In* Seitz, A., The Macrolepidoptera of the World. Vol. 6. The American Bombyces and Sphinges. Stuttgart.

Grote, A. R. [1866]. Notes on the Bombycidae of Cuba. Proc. Entomol. Soc. Phila. 5: 227–255.

Schaus, W. 1894. On new species of Heterocera from tropical America. Proc. Zool. Soc. Lond. 1894: 225–243.

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THE *GEOMYDOECUS* (MALLOPHAGA: TRICHODECTIDAE) FROM THE CENTRAL AMERICAN POCKET GOPHERS OF THE SUBGENUS *MACROGEOMYS* (RODENTIA: GEOMYIDAE)[1]

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Abstract.—Six species and subspecies of *Geomydoecus* from *Orthogeomys* (*Macrogeomys*) pocket gophers are described and illustrated: *G. panamensis panamensis* Price and Emerson from *O.* (*M.*) *cavator* (Bangs); *G. p. dariensis* Price and Emerson from *O.* (*M.*) *dariensis* (Goldman); *G. setzeri* Price and *G. davidhafneri* new species from *O.* (*M.*) *underwoodi* (Osgood) and *O.* (*M.*) *cherriei* (J. A. Allen); *G. costaricensis* Price and Emerson from three subspecies of *O.* (*M.*) *heterodus* (Peters); and *G. cherriei* Price from *O.* (*M.*) *cherriei* and *O.* (*M.*) *matagalpae* (J. A. Allen). Keys are provided for the identification of these six taxa.

Price and Emerson (1971), in a revision of the mallophagan genus *Geomydoecus* Ewing, recognized three new species of lice from the Central American pocket gophers of the genus *Macrogeomys* Merriam, now considered a subgenus of *Orthogeomys* Merriam by Hall (1981): *G. panamensis* from *M. cavator* Bangs; *G. dariensis* from *M. dariensis* Goldman; and *G. costaricensis* from *M. heterodus cartagoensis* (Goodwin). Subsequently, Price (1974) described two more new species: *G. setzeri* from *M. underwoodi* Osgood and *G. cherriei* from *M. cherriei* (J. A. Allen). These five species were based on a relatively limited number of louse specimens representing only one or a few localities per taxon, with the extreme case being *G. cherriei* described from a single male. Recently, one of us (MSH) had the opportunity to do extensive collecting of *Macrogeomys* gophers in Panama and Costa Rica. This has resulted in the procurement of excellent series of lice for each of the five described taxa as well as material representing a sixth as yet undescribed species. It is our purpose here to present descriptions of these six taxa and to provide keys for their identification.

Quantitative data for the *panamensis* complex lice combined with host and

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locality information form part of a computerized pocket gopher-louse data base which is maintained at the University of Notre Dame. The retrieval and analysis of the data for this study were performed with an integrated group of computer programs called the BUG system. A description of this system and its use in taxonomic decision-making, and for the analysis, summarization, and display of louse character and distribution data are given in Hellenthal and Price (1980). Locality information for the hosts included in this study, including latitude, longitude, and in some cases elevation, is available from the authors.

Counted or measured characters in the following descriptions are followed by the minimal and maximal observed values, and, in parentheses, the sample size, mean, and standard deviation. All measurements are in millimeters. Illustrations are from material off the type-host. In evaluating character usefulness for specific discrimination, critical values for each character were calculated at the point where the likelihood of single character misidentification of the two compared taxa was equal, given normality and equal variance, and ignoring the probability of collection. For characters offering moderately good discriminating ability, these critical values and the corresponding probabilities of misidentification are given. In an abbreviated comparative description for a species or subspecies, quantitative data are given only for those characters whose means differ at a significance level of $P \leq 0.01$. In the "Material examined" section, a number in parentheses following a locality indicates the total number of gophers from which lice were taken. Original locality data expressed in miles are followed parenthetically by the metric equivalent to 0.1 km; the English figure, rather than the metric, expresses the precision of the location estimate. Price and Hellenthal (1980) provide labelled illustrations of pertinent structural and dimensional characters.

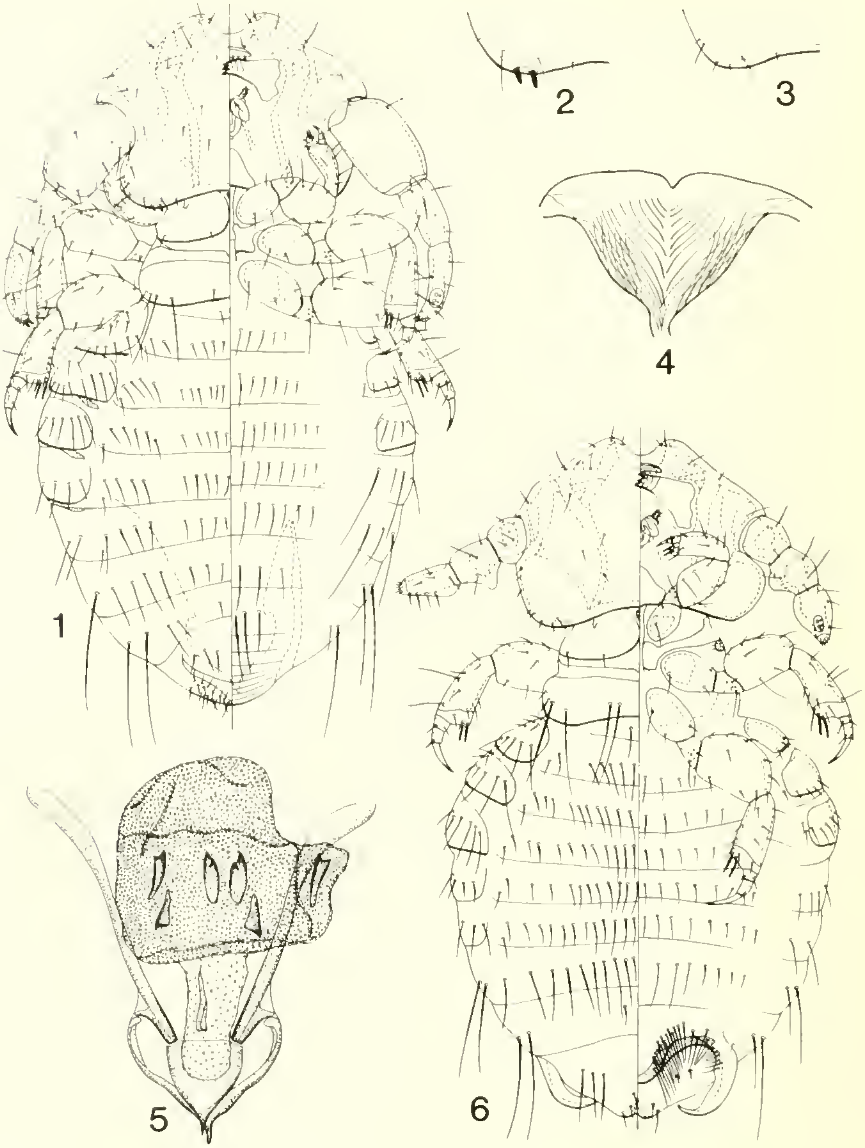
The six taxa included in the *panamensis* complex are the only *Geomydoecus* known from gophers in the subgenus *Macrogeomys* and they share the following characteristics: (1) both sexes with submarginal temple seta on line with to mediad of inner marginal seta (Figs. 2, 3); (2) male with pair of spiniform setae on temple margin (Figs. 2, 11); (3) male without process on posterior scape margin (Fig. 1); (4) male genital sac with 3–6 prominent spines (Figs. 5, 7–10); (5) female with 3 lateral setae of last tergite close together on each side (Fig. 6); (6) female subgenital plate and postvulval sclerite with setal lengths and distribution as in Fig. 6; and (7) female genital sac with concave anterior margin and without conspicuous transverse loops (Figs. 4, 12–14).

***Geomydoecus panamensis* Price and Emerson**

Figs. 1–6

Geomydoecus panamensis Price and Emerson, 1971: 251. Type-host: *Macrogeomys cavator* = *Orthogeomys* (*Macrogeomys*) *cavator* (Bangs).

Male.—As in Fig. 1. Temple width 0.530–0.655 (28: 0.591 ± 0.0314); head length 0.405–0.455 (27: 0.421 ± 0.0138); submarginal and inner marginal temple setae 0.025–0.040 (17: 0.032 ± 0.0040) and 0.015–0.030 (24: 0.024 ± 0.0028) long, respectively. Antenna with scape length 0.230–0.275 (19: 0.250 ± 0.0121), scape medial width 0.130–0.180 (18: 0.153 ± 0.0146), scape distal width 0.140–0.180 (18: 0.158 ± 0.0126). Prothorax width 0.385–0.455 (26: 0.421 ± 0.0185). Tergal setae: I, 2; II, 10–17 (27: 13.2 ± 1.80); III, 19–27 (27: 22.8 ± 2.09); IV, 21–28 (27: 24.6 ± 1.57); V, 19–26 (27: 22.1 ± 1.82); VI, 13–20 (26: 16.8 ±



Figs. 1–6. *Geomydoecus panamensis panamensis.* 1, Male. 2, Male temple margin. 3, Female temple margin. 4, Female genital sac. 5, Male genitalia. 6, Female.

1.65); tergal and pleural setae on VII, 18–24 (26: 20.5 ± 1.58). Sternal setae: II, 6–11 (25: 9.5 ± 1.23); III, 10–13 (25: 12.1 ± 0.91); IV, 12–18 (26: 15.0 ± 1.47); V, 8–16 (26: 12.9 ± 1.80); VI, 6–12 (27: 9.9 ± 1.80); VII, 3–9 (27: 6.4 ± 1.48); VIII, 5–8 (26: 6.3 ± 0.67). Total length 1.520–1.795 (26: 1.634 ± 0.0719). Genitalia as in Fig. 5; sac having 6 large spines, with outer anterior pair long, slender; parameral arch width 0.190–0.235 (28: 0.216 ± 0.0094); endomeral plate tapered to sharp point, width 0.105–0.125 (28: 0.116 ± 0.0054), length 0.115–0.145 (28: 0.136 ± 0.0070).

Female.—As in Fig. 6. Temple width 0.570–0.690 (30: 0.637 ± 0.0367); head length 0.390–0.445 (29: 0.417 ± 0.0158); submarginal and inner marginal temple setae 0.025–0.040 (20: 0.031 ± 0.0048) and 0.015–0.025 (30: 0.018 ± 0.0028) long, respectively. Prothorax width 0.395–0.485 (30: 0.448 ± 0.0245). Tergal setae: I, 2; II, 13–18 (30: 14.6 ± 1.43); III, 21–27 (30: 23.7 ± 1.49); IV, 22–30 (30: 26.6 ± 1.50); V, 22–29 (30: 25.7 ± 1.77); VI, 21–30 (30: 24.9 ± 1.96); tergal and pleural setae on VII, 22–35 (29: 29.1 ± 2.55). Longest seta of medial 10 on tergite VI, 0.065–0.100 (29: 0.080 ± 0.0097); on tergite VII, 0.115–0.170 (24: 0.146 ± 0.0153), with 7–8 (22: 8.0 ± 0.21) of these longer than 0.100. Longest seta of medial pair on tergite VIII, 0.035–0.090 (28: 0.052 ± 0.0149). Each side of last tergite with outer seta 0.075–0.130 (21: 0.109 ± 0.0142), middle seta 0.085–0.145 (23: 0.113 ± 0.0124), inner seta 0.090–0.120 (24: 0.107 ± 0.0080) long. Sternal setae: II, 8–11 (27: 8.9 ± 0.83); III, 10–14 (27: 11.6 ± 1.01); IV, 10–16 (27: 13.2 ± 1.78); V, 8–15 (29: 12.3 ± 1.96); VI, 9–17 (29: 12.6 ± 2.16); VII, 10–17 (29: 13.1 ± 1.87). Subgenital plate with 31–46 (30: 38.4 ± 3.61) setae. Total length 1.395–1.770 (30: 1.593 ± 0.0847). Genital sac as in Fig. 4, width 0.365–0.515 (30: 0.443 ± 0.0337), length 0.255–0.340 (30: 0.302 ± 0.0214), with about 12 subparallel lines on each side, lateroanterior "horns" essentially without lines, and medioanterior indentation varying from "V" to "U" shaped.

Discussion.—The shape of the male endomeral plate and number of genital sac spines allies *G. panamensis* with *G. setzeri* and the new species (Fig. 5 vs. Figs. 7, 8), thereby separating it from both *G. costaricensis* and *G. cherriei.* However, both sexes of *G. panamensis* are consistently larger in most dimensions than either *G. setzeri* or the new species. Further details for separation will be given in the subsequent descriptions.

***Geomydoecus panamensis panamensis* Price and Emerson, New Status**

Figs. 1–6

Male.—Temple width 0.530–0.625 (22: 0.580 ± 0.0246). Submarginal temple seta 0.025–0.040 (16: 0.032 ± 0.0036) long. Prothorax width 0.385–0.455 (20: 0.416 ± 0.0175). Sternal setae: II, 6–11 (19: 9.2 ± 1.23); V, 11–16 (20: 13.4 ± 1.32); VI, 7–12 (21: 10.5 ± 1.44); VII, 6–9 (21: 7.0 ± 1.05).

Female.—Temple width 0.570–0.685 (22: 0.609 ± 0.0274). Prothorax width 0.395–0.480 (22: 0.431 ± 0.0219). Tergal setae on II, 12–17 (22: 14.0 ± 1.27). Longest seta of medial 10 on tergite VI, 0.070–0.100 (21: 0.085 ± 0.0096); on tergite VII, 0.115–0.170 (18: 0.139 ± 0.0155). Sternal setae: IV, 11–18 (16: 14.2 ± 1.90); V, 10–16 (18: 13.4 ± 1.61); VI, 9–17 (19: 13.5 ± 2.12); VII, 11–17 (21: 13.7 ± 1.62). Subgenital plate with 31–43 (22: 36.9 ± 3.69) setae. Genital sac length 0.255–0.330 (22: 0.293 ± 0.0213).

Material examined.—25 ♂, 30 ♀, *O.* (*M.*) *cavator,* Panama, Prov. Chiriqui, Boquete Trail (3), Boquete (2), Cerro Punta (2), Santa Clarita, 32.5 km W Volcan (2); Costa Rica, Prov. San Jose, Division (1). 3 ♀, *O.* (*M.*) *cavator pansa* (Bangs), Panama, Prov. Chiriqui, Bugaba (2). Questionable host records: 6 ♂, 10 ♀, *O.* (*M.*) [*heterodus* (Peters)?], Costa Rica, Prov. San Jose, La Piedra, 4 km SW Cerro Chirripo (1), Fila la Maquina, 7.5 km E Canaan (1). 1 ♂, *O.* (*M.*) [*heterodus cartagoensis* (Goodwin)?], Costa Rica, Prov. Cartago, El Sauce Peralta (1).

***Geomydoecus panamensis dariensis* Price and Emerson, New Status**

Geomydoecus dariensis Price and Emerson, 1971: 251. Type-host: *Macrogeomys dariensis* = *Orthogeomys* (*Macrogeomys*) *dariensis* (Goldman).

Male.—Temple width 0.605–0.655 (6: 0.630 ± 0.0180). Submarginal temple seta 0.040 long. Prothorax width 0.415–0.450 (6: 0.436 ± 0.0129). Sternal setae: II, 9–11 (6: 10.3 ± 0.82); V, 8–14 (6: 11.0 ± 2.00); VI, 6–10 (6: 7.8 ± 1.47); VII, 3–6 (6: 4.5 ± 1.05).

Female.—Temple width 0.630–0.690 (13: 0.667 ± 0.0203). Prothorax width 0.445–0.480 (13: 0.465 ± 0.0092). Tergal setae on II, 13–18 (13: 15.2 ± 1.42). Longest seta of medial 10 on tergite VI, 0.065–0.090 (13: 0.076 ± 0.0069); on tergite VII, 0.140–0.170 (10: 0.155 ± 0.0087). Sternal setae: IV, 10–14 (13: 12.5 ± 1.66); V, 8–14 (13: 11.2 ± 1.86); VI, 9–15 (13: 11.6 ± 1.71); VII, 10–16 (13: 12.3 ± 1.80). Subgenital plate with 36–46 (13: 39.7 ± 2.90) setae. Genital sac length 0.290–0.340 (13: 0.314 ± 0.0146).

Discussion.—The best means for distinguishing males of *G. p. dariensis* from those of the nominate subspecies, with their critical values for discrimination and probabilities of misidentification, were the number of setae on sternite VII 5.75 (0.117), the temple width 0.605 (0.142), and the number of setae on sternite VI 9.15 (0.180); the best for distinguishing females of *G. p. dariensis* were the temple width 0.638 (0.125) and prothorax width 0.448 (0.173).

Material examined.—12 ♂, 23 ♀, *O.* (*M.*) *dariensis*, Panama, Prov. Darien, Cana (5), E slope Cerro Pirre, 6 km NW Cana (2), Jaque (1), Rio Tuira at Rio Mono (1).

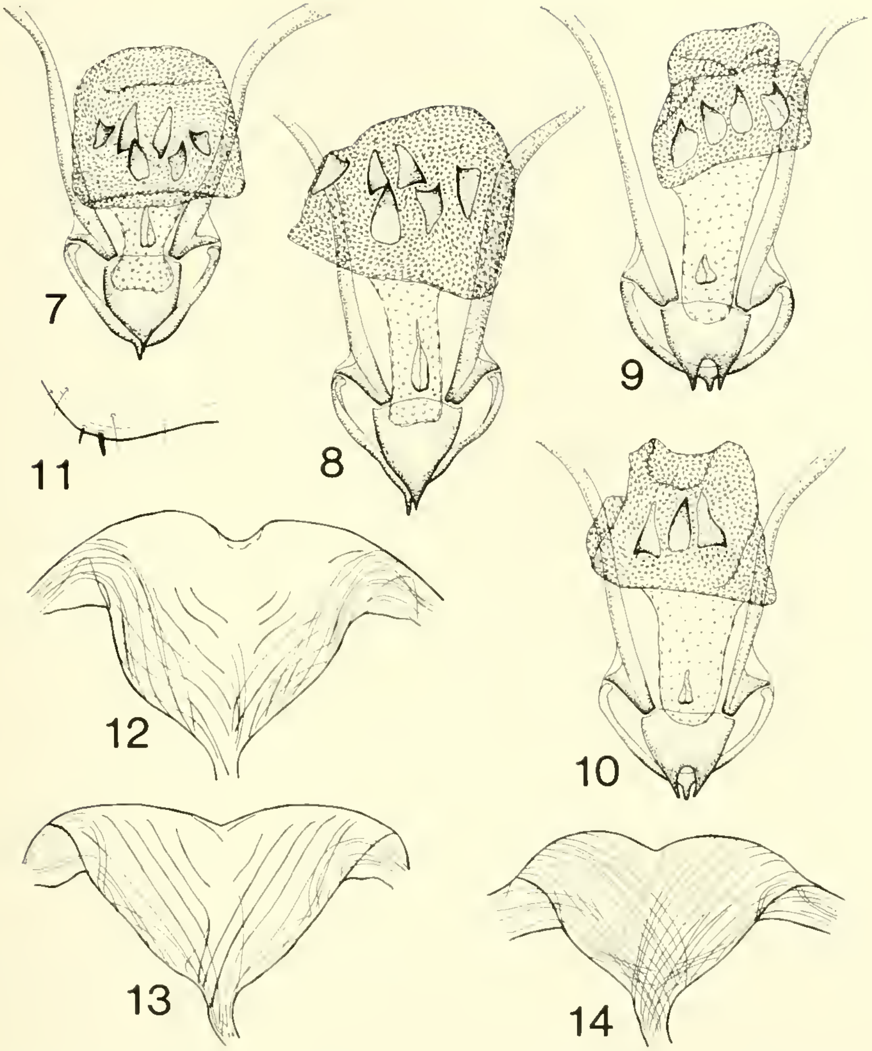
Geomydoecus setzeri Price

Figs. 7, 11, 12

Geomydoecus setzeri Price, 1974: 41. Type-host: *Macrogeomys underwoodi* = *Orthogeomys* (*Macrogeomys*) *underwoodi* (Osgood).

Male.—Much as in Fig. 1. Temple width 0.460–0.500 (15: 0.480 ± 0.0120); head length 0.305–0.355 (16: 0.326 ± 0.0131); submarginal and inner marginal temple setae 0.020–0.030 (9: 0.025 ± 0.0025) and 0.015–0.025 (13: 0.020 ± 0.0032) long, respectively, with outer marginal temple seta usually more slender and pointed than inner (Fig. 11). Antenna with scape length 0.170–0.195 (14: 0.186 ± 0.0074), scape medial width 0.100–0.130 (14: 0.115 ± 0.0082), scape distal width 0.105–0.135 (14: 0.121 ± 0.0075). Prothorax width 0.330–0.365 (17: 0.345 ± 0.0095). Tergal setae: I, 2; II, 8–11 (18: 9.8 ± 0.62); III, 16–21 (18: 18.1 ± 1.59); IV, 16–20 (19: 18.1 ± 1.41); V, 14–19 (19: 16.2 ± 1.40); VI, 12–17 (19: 14.2 ± 1.34); tergal and pleural setae on VII, 17–24 (19: 20.1 ± 1.49). Sternal setae: II, 7–9 (19: 8.1 ± 0.62); III, 6–12 (19: 9.3 ± 1.73); IV, 8–16 (20: 10.8 ± 2.13); V, 6–13 (20: 9.0 ± 1.70); VI, 4–9 (20: 6.2 ± 1.48); VII, 4–6 (20: 4.2 ± 0.52); VIII, 5–8 (20: 6.8 ± 1.01). Total length 1.040–1.280 (15: 1.195 ± 0.0591). Genitalia as in Fig. 7; sac having 6 large spines, with outer anterior pair relatively short; parameral arch width 0.125–0.145 (20: 0.136 ± 0.0050); endomeral plate tapered to sharp point, width 0.065–0.075 (20: 0.072 ± 0.0029), length 0.075–0.090 (20: 0.084 ± 0.0052).

Female.—Much as in Fig. 6. Temple width 0.495–0.545 (23: 0.518 ± 0.0130); head length 0.300–0.345 (23: 0.326 ± 0.0130); submarginal and inner marginal temple setae 0.020–0.030 (19: 0.027 ± 0.0029) and 0.010–0.015 (22: 0.015 ± 0.0015) long, respectively. Prothorax width 0.345–0.395 (26: 0.368 ± 0.0112). Tergal setae: I, 2; II, 10–15 (26: 12.3 ± 1.40); III, 18–23 (27: 20.3 ± 1.68); IV, 17–23 (27: 20.8 ± 1.73); V, 17–25 (27: 21.0 ± 2.21); VI, 18–25 (27: 20.7 ±



Figs. 7–10. Male genitalia. 7, *Geomydoecus setzeri*. 8, *G. davidhafneri*. 9, *G. costaricensis*. 10, *G. cherriei*. Fig. 11, *G. setzeri* male temple margin. Figs. 12–14. Female genital sac. 12, *G. setzeri*. 13, *G. costaricensis*. 14, *G. cherriei*.

1.86); tergal and pleural setae on VII, 24–32 (28: 28.0 ± 2.20). Longest seta of medial 10 on tergite VI, 0.050–0.070 (26: 0.064 ± 0.0055); on tergite VII, 0.100–0.155 (22: 0.116 ± 0.0129), with 0–9 (20: 5.4 ± 2.80) of these longer than 0.100. Longest seta of medial pair on tergite VIII, 0.020–0.050 (24: 0.029 ± 0.0077). Each side of last tergite with outer seta 0.065–0.100 (25: 0.082 ± 0.0077), middle seta 0.070–0.100 (24: 0.088 ± 0.0067), inner seta 0.075–0.100 (22: 0.088 ± 0.0069) long. Sternal setae: II, 7–10 (28: 8.1 ± 0.72); III, 6–11 (26: 8.3 ± 1.23); IV, 7–13 (26: 9.7 ± 1.57); V, 7–13 (27: 9.4 ± 1.69); VI, 8–12 (28: 9.7 ± 1.36); VII, 8–13 (28: 10.6 ± 1.23). Subgenital plate with 21–32 (28: 27.5 ± 2.40) setae. Total length 1.145–1.410 (20: 1.269 ± 0.0687). Genital sac as in Fig. 12, width

0.255–0.355 (27: 0.292 ± 0.0237), length 0.190–0.270 (26: 0.220 ± 0.0173), with at least 1 side having 10 or fewer subparallel lines, lateroanterior "horns" with number of conspicuous lines, and broad gently curved medioanterior indentation.

Discussion.—Qualitatively, the smaller outer anterior pair of genital sac spines (Fig. 7 vs. Fig. 5) and the more slender pointed outer marginal temple seta (Fig. 11 vs. Fig. 2) will separate males of *G. setzeri* from those of *G. panamensis.* Quantitatively, the males of *G. setzeri* are consistently much smaller, with the best characters and their critical values for discrimination and probabilities of misidentification being the genitalic parameral arch width 0.176 (0.000), the endomeral plate width 0.094 (0.000), the endomeral plate length 0.110 (0.000), the total length 1.414 (0.001), and the scape length 0.218 (0.001).

The only qualitative feature useful in separating female *G. setzeri* from *G. panamensis* consists of the genital sac shape and distribution of the lines (Fig. 12 vs. Fig. 4). Quantitatively, the females of *G. setzeri* are, as with the males, much smaller than those of *G. panamensis,* with the best characters being the head length 0.372 (0.001), the width of the genital sac 0.368 (0.005), the total length 1.431 (0.020), and the temple width 0.578 (0.021). We have been unable to distinguish the females of *G. setzeri* from those of the new species that follows, even though the males of these 2 taxa are readily separable; therefore, the above description for female *G. setzeri* likely includes females for both that species and the new species.

Material examined.—12 ♂, 11 ♀, *O.* (*M.*) *underwoodi,* Costa Rica, Prov. Puntarenas, Jabillo Pirris (3), Parrita (1); Prov. San Jose, San Geronimo Pirris (1). 34 ♂, 58 ♀, *O.* (*M.*) *cherriei,* Costa Rica, Prov. Guanacaste, Las Juntas (3), 2 km N, 8 km W Las Juntas (1). Questionable host record: 3 ♂, 7 ♀, *O.* (*M.*) [*heterodus*?], Costa Rica, Prov. Puntarenas, 5 mi (8.0 km) NE Palmar Norte (1).

Geomydoecus davidhafneri **Price and Hellenthal, NEW SPECIES**

Fig. 8

Type-host.—*Orthogeomys* (*Macrogeomys*) *cherriei* (J. A. Allen).

Male.—As for *G. setzeri,* except as follows. Temple width 0.490–0.515 (8: 0.505 ± 0.0100); head length 0.335–0.355 (8: 0.345 ± 0.0084); submarginal temple seta 0.025–0.035 (3: 0.030 ± 0.0050); marginal temple setae as for *G. panamensis* (Fig. 2). Antenna with scape length 0.200–0.230 (5: 0.216 ± 0.0119), scape medial width 0.115–0.150 (5: 0.133 ± 0.0155), scape distal width 0.120–0.150 (5: 0.138 ± 0.0135). Prothorax width 0.335–0.385 (15: 0.359 ± 0.0129). Tergal setae on II, 9–12 (16: 10.6 ± 0.81); tergal and pleural setae on VII, 19–24 (16: 21.4 ± 1.63). Total length 1.300–1.455 (8: 1.377 ± 0.0552). Genitalia as in Fig. 8; parameral arch width 0.175–0.205 (16: 0.188 ± 0.0085); endomeral plate subtriangular, tapered to sharp point, width 0.095–0.110 (16: 0.102 ± 0.0039), length 0.100–0.125 (12: 0.111 ± 0.0077).

Female.—Apparently inseparable from *G. setzeri.*

Discussion.—The principal difference between male *G. davidhafneri* and *G. setzeri* involves the former having a much larger genitalia accompanied by subtle differences in shape of the endomeral plate and genital sac spines. This is expressed quantitatively by the best characters, with their critical values for discrimination and probabilities of misidentification, being the width of the endomeral plate 0.087 (0.000), the width of the parameral arch 0.162 (0.000), the length of the endomeral plate 0.097 (0.015), and the length of the antennal scape 0.201 (0.040). The best quantitative characters separating male *G. davidhafneri* from *G. panamensis* are the head length 0.383 (0.001), the total length 1.506 (0.030), the prothorax width 0.390 (0.032), and the number of setae on tergite IV 21.61 (0.038).

The unusual occurrence of two species of the same louse complex on the same host individuals has contributed to our inability to separate females of *G. davidhafneri* from those of *G. setzeri*. This is based on our assumption that females of *G. davidhafneri* are indeed represented in our series of *G. setzeri* females; the number of *G. davidhafneri* males collected would certainly lead us to expect females of that species to be present.

This species is named for Dr. David J. Hafner, New Mexico Museum of Natural History, Albuquerque, in recognition of his interest in mammalian ectoparasites and his efforts in collecting many important gopher specimens.

Material examined.—Holotype ♂, *O.* (*M.*) *cherriei* (Louisiana State University Museum of Zoology-15775), Las Juntas, Prov. Guanacaste, Costa Rica, 3.IV.1970, A. B. McPherson; in collection of the University of Minnesota. Paratypes: 10 ♂, *O.* (*M.*) *cherriei*, Costa Rica, Prov. Guanacaste, Las Juntas (3), 2 km N, 8 km W Las Juntas (1); Prov. Alajuela, 7 km NE Quesada (1). Other specimens: 4 ♂, *O.* (*M.*) *underwoodi*, Costa Rica, Prov. Puntarenas, Jabillo Pirris (1), Parrita (1). 2 ♂, *O.* (*M.*) *heterodus*, Costa Rica, Prov. Puntarenas, 5 mi (8.0 km) NE Palmar Norte (1).

***Geomydoecus costaricensis* Price and Emerson**

Figs. 9, 13

Geomydoecus costaricensis Price and Emerson, 1971: 251. Type-host: *Macrogeomys heterodus cartagoensis* = *Orthogeomys* (*Macrogeomys*) *heterodus cartagoensis* (Goodwin).

Male.—Much as in Fig. 1. Temple width 0.495–0.555 (20: 0.531 ± 0.0155); head length 0.360–0.410 (19: 0.389 ± 0.0123); submarginal and inner marginal temple setae 0.030–0.035 (15: 0.031 ± 0.0023) and 0.015–0.025 (19: 0.021 ± 0.0028) long, respectively. Antenna with scape length 0.185–0.225 (19: 0.210 ± 0.0102), scape medial width 0.115–0.145 (19: 0.130 ± 0.0076), scape distal width 0.120–0.150 (19: 0.134 ± 0.0076). Prothorax width 0.345–0.385 (19: 0.369 ± 0.0127). Tergal setae: I, 2; II, 10–13 (20: 11.6 ± 0.99); III, 16–23 (20: 20.4 ± 1.85); IV, 19–26 (20: 22.6 ± 2.08); V, 17–23 (19: 20.2 ± 2.09); VI, 12–20 (19: 15.8 ± 1.74); tergal and pleural setae on VII, 18–26 (19: 21.8 ± 1.93). Sternal setae: II, 6–10 (19: 7.9 ± 0.88); III, 5–10 (19: 7.8 ± 1.34); IV, 7–15 (18: 10.7 ± 2.14); V, 7–13 (18: 9.8 ± 1.72); VI, 6–10 (20: 7.8 ± 1.32); VII, 5–7 (20: 6.0 ± 0.60); VIII, 5–8 (20: 6.1 ± 0.64). Total length 1.300–1.450 (20: 1.388 ± 0.0413). Genitalia as in Fig. 9; sac having 4 large spines; parameral arch width 0.135–0.150 (20: 0.145 ± 0.0052); endomeral plate with wide apical bifurcation, width 0.075–0.090 (20: 0.085 ± 0.0047), length 0.075–0.095 (19: 0.084 ± 0.0065).

Female.—Much as in Fig. 6. Temple width 0.540–0.605 (20: 0.576 ± 0.0175); head length 0.355–0.405 (20: 0.383 ± 0.0119); submarginal and inner marginal temple setae 0.030–0.045 (18: 0.034 ± 0.0047) and 0.015–0.020 (20: 0.018 ± 0.0026) long, respectively. Prothorax width 0.385–0.420 (20: 0.399 ± 0.0109). Tergal setae: I, 2; II, 12–17 (20: 14.7 ± 1.16); III, 20–27 (19: 23.5 ± 2.04); IV, 22–31 (20: 26.4 ± 2.23); V, 23–33 (20: 26.2 ± 2.55); VI, 22–30 (20: 24.9 ±

1.97); tergal and pleural setae on VII, 27–37 (20: 32.0 ± 2.92). Longest seta of medial 10 on tergite VI, 0.065–0.080 (20: 0.073 ± 0.0041); on tergite VII, 0.110–0.145 (20: 0.132 ± 0.0079), with 8–9 (20: 8.1 ± 0.31) of these longer than 0.100. Longest seta of medial pair on tergite VIII, 0.020–0.040 (17: 0.028 ± 0.0059). Each side of last tergite with outer seta 0.050–0.100 (18: 0.076 ± 0.0145), middle seta 0.095–0.120 (19: 0.109 ± 0.0076), inner seta 0.100–0.130 (17: 0.112 ± 0.0067) long. Sternal setae: II, 7–10 (17: 7.9 ± 0.90); III, 6–11 (18: 8.1 ± 1.47); IV, 9–13 (18: 10.8 ± 1.44); V, 8–14 (19: 10.2 ± 1.68); VI, 7–12 (19: 9.9 ± 1.41); VII, 9–15 (19: 11.4 ± 1.64). Subgenital plate with 26–36 (20: 31.2 ± 2.24) setae. Total length 1.380–1.620 (19: 1.461 ± 0.0662). Genital sac as in Fig. 13, width 0.255–0.305 (19: 0.283 ± 0.0142), length 0.155–0.210 (20: 0.180 ± 0.0152), with lines extending near to anterior margin and with shallowly concave medioanterior margin.

Discussion.—Qualitatively, males of *G. costaricensis* are readily separated from the foregoing three species by having genitalia with a widely bifurcate endomeral plate and the genital sac with only 4 large spines (Fig. 9 vs. Figs. 5, 7, 8). Quantitatively, for males of *G. costaricensis* compared to those of *G. davidhafneri*, the best characters and their critical values for discrimination and probabilities of misidentification were the genitalic parameral arch width 0.167 (0.001) and the number of setae on sternite VII 5.06 (0.019); compared to *G. setzeri*, the best were the head length 0.357 (0.006) and total length 1.291 (0.026); compared to *G. panamensis*, the best were the genitalic parameral arch width 0.180 (0.000) and endomeral plate length 0.110 (0.000).

The only qualitative feature for separating females of *G. costaricensis* from those of *G. setzeri*, *G. davidhafneri*, and *G. panamensis* involves the shape and line configuration of the genital sac (Fig. 13 vs. Figs. 4, 12). Quantitatively, for females of *G. costaricensis* compared to those of *G. setzeri* and *G. davidhafneri*, the best characters and their critical values for discrimination and probabilities of misidentification were the head length 0.355 (0.011), temple width 0.547 (0.030), and length of inner seta on each side of last tergite 0.100 (0.041); compared to *G. panamensis*, the best were the genital sac length 0.241 (0.001), genital sac width 0.363 (0.002), and number of setae on sternite III 9.81 (0.075).

Material examined.—108 ♂, 54 ♀, *O.* (*M.*) *heterodus cartagoensis*, Costa Rica, Prov. Cartago, 2 km W Santa Rosa (4); Prov. Limon, Cervantes (3); Prov. San Jose, Volcan Irazu, Rancho Redondo (2). 57 ♂, 46 ♀, *O.* (*M.*) *heterodus dolichocephalus* (Merriam), Costa Rica, Prov. Alajuela, La Palmita (2). 38 ♂, 36 ♀, *O.* (*M.*) *heterodus heterodus*, Costa Rica, Prov. San Jose, 1 km SW Poas (4). Questionable host record: 1 ♂, *O.* (*M.*) [*underwoodi*?], Costa Rica, Prov. San Jose, 14 km S La Gloria (1).

Geomydoecus cherriei **Price**

Figs. 10, 14

Geomydoecus cherriei Price, 1974: 43. Type-host: *Macrogeomys cherriei* = *Orthogeomys* (*Macrogeomys*) *cherriei* (J. A. Allen).

Male.—Much as for *G. costaricensis*, except as follows. Temple width 0.465–0.550 (17: 0.504 ± 0.0220); head length 0.305–0.380 (17: 0.343 ± 0.0191). Antenna with scape medial width 0.110–0.130 (15: 0.120 ± 0.0063), scape distal width 0.120–0.140 (15: 0.127 ± 0.0066). Prothorax width 0.335–0.395 (17: 0.357 ±

0.0185). Tergal setae on VI, 15–19 (16: 17.2 ± 1.48). Sternal setae: II, 8–10 (17: 8.6 ± 0.70); III, 6–11 (17: 9.0 ± 1.17). Total length 1.225–1.435 (17: 1.305 ± 0.0522). Genitalia as in Fig. 10; sac having only 3 large spines; parameral arch width 0.150–0.190 (16: 0.166 ± 0.0104); endomeral plate width 0.080–0.105 (16: 0.092 ± 0.0070).

Female.—Much as for *G. costaricensis,* except as follows. Temple width 0.515–0.590 (15: 0.546 ± 0.0239); head length 0.320–0.375 (15: 0.341 ± 0.0178); submarginal and inner marginal temple setae 0.025–0.035 (9: 0.030 ± 0.0025) and 0.010–0.015 (15: 0.014 ± 0.0021) long, respectively. Prothorax width 0.350–0.425 (15: 0.387 ± 0.0219). Longest seta of medial 10 on tergite VI, 0.060–0.075 (16: 0.069 ± 0.0048); on tergite VII, 0.105–0.135 (16: 0.120 ± 0.0102), with 4–8 (14: 7.1 ± 1.44) of these longer than 0.100. Longest seta of medial pair on tergite VIII, 0.015–0.030 (15: 0.023 ± 0.0046). Each side of last tergite with outer seta 0.045–0.080 (15: 0.063 ± 0.0117), middle seta 0.070–0.110 (13: 0.087 ± 0.0113), inner seta 0.080–0.100 (13: 0.093 ± 0.0075) long. Sternal setae: II, 7–11 (15: 8.7 ± 1.03); V, 8–13 (14: 8.9 ± 1.38); VI, 7–10 (15: 8.8 ± 1.01). Total length 1.195–1.415 (15: 1.329 ± 0.0612). Genital sac as in Fig. 14, width 0.280–0.340 (14: 0.300 ± 0.0220), length 0.175–0.235 (14: 0.211 ± 0.0175), with numerous lines most extending to anterior margin.

Discussion.—Qualitatively, males of *G. cherriei* are distinguished from all others in the *panamensis* complex by having genitalia with a widely bifurcate endomeral plate and the genital sac with only 3 large spines (Fig. 10 vs. Figs. 5, 7–9). Quantitatively, for males of *G. cherriei* compared to those of *G. costaricensis,* the best characters and their critical values for discrimination and probabilities of misidentification were the head length 0.366 (0.074) and genitalic parameral arch width 0.155 (0.098); compared to *G. davidhafneri,* the best were the length of the genitalic endomeral plate 0.096 (0.031) and number of setae on sternite VII 4.84 (0.095); compared to *G. setzeri,* the best were the width of the endomeral plate 0.082 (0.026) and width of the parameral arch 0.151 (0.028); compared to *G. panamensis,* the best were the endomeral plate length 0.108 (0.000), parameral arch width 0.191 (0.005), total length 1.470 (0.006), and head length 0.382 (0.007).

The only qualitative feature for distinguishing females of *G. cherriei* from those of the other taxa in the *panamensis* complex involves the shape and line configuration of the genital sac (Fig. 14 vs. Figs. 4, 12, 13). Quantitatively, for females of *G. cherriei* compared to those of *G. costaricensis,* the best characters were the head length 0.362 (0.073) and length of inner seta on last tergite 0.103 (0.087); compared to *G. setzeri* and *G. davidhafneri,* the best were the number of setae on tergite IV 23.71 (0.076) and number of setae on tergite V 23.91 (0.091); compared to *G. panamensis,* the best were the genital sac width 0.372 (0.009) and head length 0.379 (0.010).

Material examined.—20 ♂, 25 ♀, *O.* (*M.*) *cherriei,* Costa Rica, Prov. Alajuela, 7 km NE Quesada (1); Prov. Cartago, Santa Teresa Peralta (1); Prov. Limon, Pacuarito (3), Cariari (1). 7 ♂, 7 ♀, *O.* (*M.*) *matagalpae* (J. A. Allen), Nicaragua, Matagalpa (3), Rio Tuma (1).

The keys in Price and Emerson (1971) cannot be modified conveniently to include the taxa of the *panamensis* complex as they are presently defined. Therefore, the following keys may be used to identify *Geomydoecus* collected from gophers in the subgenus *Macrogeomys.*

KEYS TO TAXA OF THE *PANAMENSIS* COMPLEX

MALES

1\. Endomeral plate of genitalia with wide apical bifurcation; genital sac with only 3–4 large spines (Figs. 9, 10) 2

– Endomeral plate with single apical point; genital sac with 6 large spines (Figs. 5, 7, 8) 3

2\. Genital sac with 4 large spines (Fig. 9) ..... *costaricensis* Price and Emerson

– Genital sac with only 3 large spines (Fig. 10) .... *cherriei* Price

3\. Head length over 0.375; temple width over 0.525; total length over 1.490 4

– Head length under 0.375; temple width under 0.520; total length under 1.490 5

4\. Sternite VII with 6 or fewer setae; temple width 0.605 or more; on *O.* (*M.*) *dariensis* .... *panamensis dariensis* Price and Emerson

– Sternite VII with 6 or more setae; temple width 0.605 or less; on *O.* (*M.*) *cavator* .... *panamensis panamensis* Price and Emerson

5\. Endomeral plate shaped as in Fig. 8, with width over 0.085; parameral arch width over 0.160 .... *davidhafneri,* new species

– Endomeral plate shaped as in Fig. 7, with width under 0.085; parameral arch width under 0.160 .... *setzeri* Price

FEMALES

1\. Genital sac large (Fig. 3), over 0.360 wide, and mostly lacking lines in anterior area and lateroanterior "horns"; head length over 0.380 2

– Genital sac smaller (Figs. 12–14), under 0.360 wide, and with obvious lines in anterior area and/or lateroanterior "horns"; head length variably from 0.300–0.405 3

2\. Temple width usually 0.640 or more; on *O.* (*M.*) *dariensis* .... *panamensis dariensis* Price and Emerson

– Temple width usually not over 0.640; on *O.* (*M.*) *cavator* .... *panamensis panamensis* Price and Emerson

3\. Genital sac (Fig. 12) with deep medioanterior concavity and lacking lines in medioanterior area; head length not over 0.345; tergite IV with only up to 23 setae, V with only up to 25 .... *setzeri* Price
davidhafneri, new species

– Genital sac (Figs. 13, 14) with shallow medioanterior concavity and with lines extending to or near to anterior margin; either head length at least 0.350 or tergite IV with at least 22 setae and V with at least 23 4

4\. Head length not over 0.375 and length of inner seta on each side of last tergite not over 0.100; on *O.* (*M.*) *cherriei* and *O.* (*M.*) *matagalpae* .... *cherriei* Price

– Head length at least 0.355 and length of inner seta on each side of last tergite at least 0.100; on *O.* (*M.*) *heterodus* .... *costaricensis* Price and Emerson

LITERATURE CITED

Hall, E. R. 1981. The Mammals of North America. 2nd Ed. Vol. I. John Wiley & Sons, New York. xv + 600 + 90 pp.

Hellenthal, R. A. and R. D. Price. 1980. A review of the *Geomydoecus subcalifornicus* complex (Mallophaga: Trichodectidae) from *Thomomys* pocket gophers (Rodentia: Geomyidae), with a discussion of quantitative techniques and automated taxonomic procedures. Ann. Entomol. Soc. Am. 73: 495–503.

Price, R. D. 1974. Two new species of *Geomydoecus* from Costa Rican pocket gophers (Mallophaga: Trichodectidae). Proc. Entomol. Soc. Wash. 76: 41–44.

Price, R. D. and K. C. Emerson. 1971. A revision of the genus *Geomydoecus* (Mallophaga: Trichodectidae) of the New World pocket gophers (Rodentia: Geomyidae). J. Med. Entomol. 8: 228–257.

Price, R. D. and R. A. Hellenthal. 1980. The *Geomydoecus oregonus* complex (Mallophaga: Trichodectidae) of the western United States pocket gophers (Rodentia: Geomyidae). Proc. Entomol. Soc. Wash. 82: 25–38.

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A NEW SPECIES OF *HYDROPTILA* (TRICHOPTERA: HYDROPTILIDAE) FROM NORTH CAROLINA

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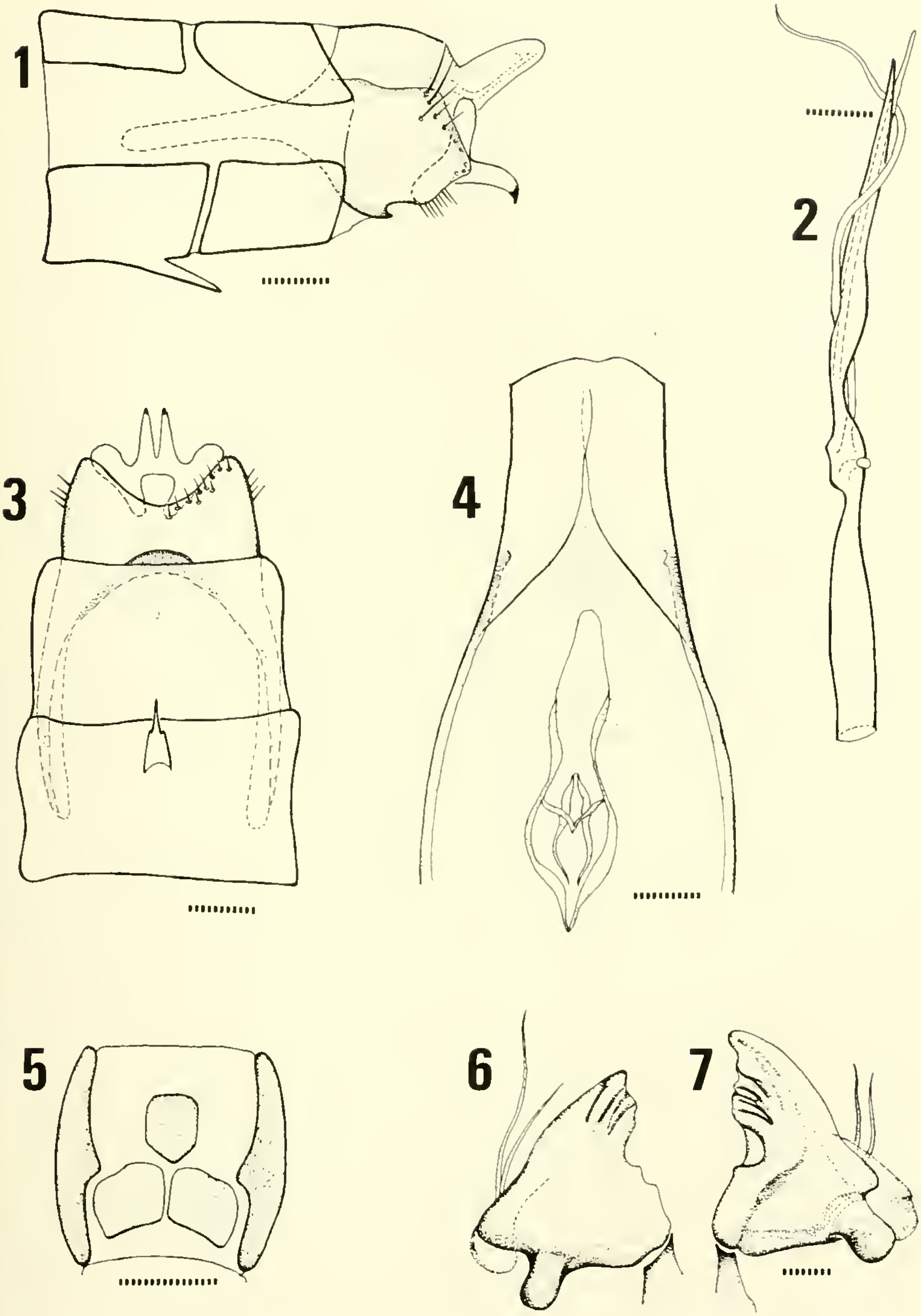
Abstract.—Adult specimens of a previously unknown member of the *tineodes* species group of *Hydroptila,* were reared from pupae collected from a high elevation catchment located in western North Carolina. The male, female and terminal instar larva of *Hydroptila* ***coweetensis*** n. sp. are described and available biological information is given.

Collections of Trichoptera from a mountain catchment located in the Coweeta Hydrologic Laboratory (Macon County, North Carolina) have resulted in the discovery of a previously undescribed species of *Hydroptila.* Adult specimens were reared from pupae collected from a madicolous granite outcrop. In this paper the male, female and terminal instar larva of *Hydroptila coweetensis* n. sp. are described and available biological information is given.

Hydroptila coweetensis, New Species
Figs. 1–7

Adult male.—Generally similar to other members of *Hydroptila.* Length of forewing 2.13 mm (n = 2). Setae of wings slate gray; sclerites of body brown. Antennae 23-segmented. Cephalic scent caps well developed, occupying entire dorsum of head. Genitalia (Figs. 1–3): Abdominal sternum VII with short, acuminate posteromesal process. Abdominal sterna VII and VIII with numerous long setae along posterior margin. Abdominal segment IX; anterolaterally, with internal paired processes extending anterad to midpoint of segment VII; posterolaterally, with heavily sclerotized flange-like structures, bearing numerous setae along margins; posteroventrally, with shallow, curved emargination bearing numerous fine setae along posterior margin; dorsally, abruptly truncated at point anterad of fusion with tergite X. Abdominal tergite X largely membranous with weakly sclerotized lateral bands internally; in dorsal aspect; tapered posterad, shallowly notched apically to form a slightly asymmetrical, bilobed posterior margin; in lateral aspect, convex along dorsal margin. Inferior appendages heavily sclerotized, trilobed; posterior lobe sparsely spinulose, extending directly posterad to form a hooked beak-like structure; dorsal lobe, slightly curved, blunt apically, extending dorsolaterad to a point about ⅔ the height of abdominal segment IX; ventral lobe tapered, extending ventromesally toward posteromesal margin of abdominal segment IX. Left and right inferior appendages apparently fused at base of posterior lobe. Phallus with proximal portion simple; apical portion tapering posterad,



Figs. 1–7. *Hydroptila coweetensis* n. sp. 1, Male terminalia, lateral. 2, Phallus. 3, Male abdominal segments VII–IX, ventral. 4, Female abdominal segment VII, ventral. 5, Larval prothorax, ventral. 6, Right mandible, ventral. 7, Left mandible, ventral. [Fig. 1–5, scale line = .05 mm; Fig. 7, scale line = .01 mm].

separating into 2 filaments near apex; basally, apical portion with small lobe, spiralling ½ revolution; titillator long, slender, tapered, spiralling 1 complete revolution.

Adult female.—Length of forewing 2.25 mm (n = 1). Antennae 21-segmented. Genitalia (Fig. 4): Eighth sternum simple, no setation evident, lightly sclerotized with acute, membranous emargination extending posterad from anterior margin. Eighth tergite with u-shaped reticulated area, about ½ the length of the sclerite, extending posterad from anterior margin. Vaginal sclerites arranged as in Fig. 4.

Due to the paucity of larval descriptions and the historical lack of characters reliable for specific diagnoses (Ross, 1944), species level characterizations of *Hydroptila* larvae are of limited use. However, since associated larval material for *H. coweetensis* is available, I offer a brief description below.

Larva.—General aspect nearly identical to the *Hydroptila* larva illustrated in Wiggins (1977, p. 133). Length 1.91–2.28 mm (n = 6). Head; dark grey-brown with extensive pale regions surrounding eyes; mandibles (Figs. 6, 7), asymmetrical, overlapping, dentition interlocking, each mandible bearing 2 stout setae posterolaterally. The right mandible (Fig. 6), overlaps the left mandible ventrally and probably functions in scraping food particles from the substrate. This observation is supported by the extreme wear characteristic of the leading edge of the right mandibles of specimens examined (n = 3). Thorax; notal sclerites and legs generally concolorous with head; curved transverse sulci of meso- and meta-nota, observed by Wiggins (1977) as occurring on some *Hydroptila* larva, not apparent; prothoracic sternites variable, generally sub-rectangular, collectively occupying a major portion of the venter of prothorax as indicated in Fig. 5. Abdomen; typical for terminal instar *Hydroptila,* cream colored, anal claws with 2 accessory teeth apparent. Case; typical silken purse-case (Wiggins, 1977), longest dimensions 2.46–3.08 mm (n = 6), laterally compressed, usually covered with single layer of mica particles or, occasionally, diatom frustules.

Type material.—Holotype ♂: North Carolina, Macon County, Coweeta Hydrologic Laboratory, Experimental Watershed 27, collected as pupa 29 May 1984, emerged 13 July 1984, ADH, deposited in the United States National Museum of Natural History; Paratypes, 1 ♂, 1 ♀, same data as holotype except emergence occurred 14 July, deposited in USNMNH (♀) and in the collection at the University of Georgia (♂).

Additional material.—Same collection data as holotype, 2 pupae, 7 larvae, deposited in USNM (1 pupa, 3 larvae) and UGA (1 pupa, 3 larvae). Same locality as holotype: 23 October 1983 (1 larva); 21 November 1983 (1 larva); 19 May 1984 (1 larva).

Remarks.—Various structures of the male terminalia of *H. coweetensis,* notably the inferior appendages, abdominal segment IX and tergite X, indicate close affinity with members of the *tineodes* species group (Marshall, 1979). Among the members of this species group, *Hydroptila coweetensis* is most similar to *H. amoena* Ross, *H. metoeca* Blickle & Morse and *H. remita* Blickle & Morse. It can easily be distinguished from the latter taxa by the lack of a long, sinuous median process on abdominal sternite VII (e.g., Ross, 1944, fig. 513 E).

HABITAT AND BIOLOGY

Terminal instar larvae and pupae of *H. coweetensis* were collected 29 May 1984 from a bare granitic outcrop [elevation = 1184 m (3885 ft)] over which a thin film (<0.5 cm) of water was flowing. Pupae placed in a laboratory incubator (11°C) yielded adults about 45 days later (13–14 July). In situ, pupal cases were laterally appressed to the rock surface with 3–4 corners of each case anchored to the substrate with silken bands.

Observations at the time of collection and subsequent scrapings of the rock surface from which larvae of *H. coweetensis* were collected, indicated that no filamentous green algae were present. However, the filamentous blue green alga, *Oscillatoria,* an unidentified unicellular colonial green alga, and diatoms were present. The apparent lack of any filamentous green algae in the larval habitat of *H. coweetensis* and the wear pattern of the leading edge of the right mandible (Fig. 6) indicated that this species feeds by scraping periphyton from rock surfaces. This observation was supported conclusively by gut analyses performed on field preserved specimens. Although the guts of two of the three specimens examined were empty, the gut of one specimen contained numerous diatoms. This finding is contrary to the typical belief that *Hydroptila* larvae feed by piercing and eating the contents of individual cells of filamentous green algae (e.g., Marshall, 1979). A similar finding was reported by Percival and Whitehead (1929) for a British *Hydroptila* species; however, the evidence for their conclusion was never clearly stated.

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LITERATURE CITED

Marshall, J. E. 1979. A review of the genera of the Hydroptilidae (Trichoptera). Bull. Br. Mus. (Nat. Hist.) Entomol. 39: 135–239.

Percival, E. and H. Whitehead. 1929. A quantitative study of the fauna of some types of stream-bed. J. Ecol. 17: 282–314.

Ross, H. H. 1944. The caddisflies, or Trichoptera, of Illinois. Bull. Ill. Nat. Hist. Surv. 23: 1–326.

Wiggins, G. B. 1977. Larvae of the North American caddisfly genera (Trichoptera). University of Toronto Press. Toronto. 401 pp.

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A LABORATORY STUDY OF GERMAN COCKROACH DISPERSAL (DICTYOPTERA: BLATTELLIDAE)

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Abstract.—Dispersal of German cockroaches within a system of interconnected aquaria was studied. Mixed age groups of two strains were released in one aquarium and held sufficiently long for aggregate groups to form within shelters that were provided, along with water and food. Subsequently, access to a second and third aquarium was opened. The second (middle) one was empty; the more distant was provided with water, shelter, and food. Distribution of each age class was recorded at the end of one week. Each class was divided equally between the two strains, but the data were pooled since no strain difference was evident. A second experiment was conducted that determined whether a loss of early instars in the first experiment was due to immediate escape rather than movement away from an aggregate group. The combined results of the two experiments showed that least movement from aggregations that formed in the first aquarium was by early instars and most movement by middle instars. Adult movement was intermediate. Movement of females and middle instars decreased significantly when female density in mixed age groups was increased.

The German cockroach, *Blattella germanica* (L.), has been the subject of many biological studies (Cornwell, 1968; Guthrie and Tindall, 1968). Nevertheless, there is little information available on dispersal of adults and nymphs. Movement within and between apartments was reported by Akers and Robinson (1981) and Owens and Bennett (1982), but these studies were either limited to observations on adults or life stage was unaccounted for. The latter found adult movement to be more prevalent where apartments shared plumbing. Whether such information is a reliable guide to the proportion of a population moving from one harborage to another depends on whether other members of the population show similar rates and amounts of dispersal. A laboratory study showed marked differences occurred in within-harborage aggregation according to age class and sex and to female density and reproductive state (Bret et al., 1983). The results left little doubt that these varying behaviors stemmed from communicatory activities, presumably involving pheromones. Dispersal might also be affected by these factors.

The research presented here describes the results of a laboratory study of movement of adults and nymphs of *B. germanica*. The objectives were to determine whether and in what manner movement from an established group (aggregation) varied according to age class and adult sex, and whether these patterns were affected by the density of adult females.

MATERIALS AND METHODS

Three 32 cm × 22 cm × 21 cm glass aquaria were used for each experiment with mixed age groups. Two ends were replaced with plexiglass that had 3.2 cm diameter holes centered 2.5 cm from the bottom. The aquaria were connected linearly by Tygon® tubing (30.5 cm long; diam. 3.2 cm). This was wider than spaces favored for aggregation (Berthold and Wilson, 1967) so that cockroaches would use the tubes for movement but not harborage. The inside walls of the aquaria were coated with a film of petroleum jelly, and lids were placed on each aquarium to limit escape. The aquaria were numbered 1, 2, and 3. Aquaria 1 and 3 were provided with four 1.0 cm × 4.0 cm × 10.0 cm shelters made out of black construction paper. Aquarium 2 was left empty. Dog food pellets and water containers were placed near the shelters in Aquaria 1 and 3 in order to minimize movement related to search for water and food (foraging). Aquaria and tubing were washed thoroughly with detergent and rinsed several times before reusing.

Groups of cockroaches were released in Aquarium 1. It was sealed off from the other aquaria. The cockroaches were allowed to acclimate to their surroundings for 2 days. A prior study using the same materials as in the first aquarium showed that the majority of the population aggregated in the shelters within 2 days (Bret et al., 1983). At the end of the 2nd day, the connections between the aquaria were opened. One week later, each aquarium was sealed and censused.

Cockroaches were drawn from two strains, the VPI strain and a black-body mutant (*Bl*) strain. The VPI strain is a wild-type strain that has been in culture for approximately 40 years, and thus has never been exposed to insecticides. It is used frequently in toxicological and genetic studies. The *Bl* cockroaches were homozygotes selected from the F_2 of crosses between the original *Bl* strain and a freshly-collected field strain. The black-body mutant was isolated following irradiation of a strain collected in Alabama in 1959 (Ross and Cochran, 1966).

Each group consisted of 4, 8, or 16 adult females; 4 adult males; 16 middle instars (3rd–4th stadium); and 16 early instars (1st–2nd stadium). They were equally divided between VPI and *Bl* cockroaches. Individuals of each instar group tested were known to have hatched within the same weekly period. This synchronization was sufficient to insure two readily separable nymphal age classes at the end of one week. Late instars were not used because they might mature and thus be inseparable from the adults. Adults were from a breeder jar in which the oldest individuals were less than 2 months old. Adult females either carried oothecae at the start of the experiment or, if not, most formed oothecae prior to censusing. Experiments using 4 and 8 females were replicated 12 times; those with 16 females had 14 replicates.

A major problem occurred in the above experiments due to escape of early instars (>50%). It could not be determined whether this represented movement before or after they had settled into aggregate groups (a behavior typical of cockroaches). A 2nd experiment using early instars only (VPI strain) was conducted in order to resolve this problem. Since the results from the two strains in the first experiment were nearly identical (117 VPI vs. 118 *Bl* early instars in aquarium 1 at the end of one week), we used only the single strain in the 2nd experiment. Two rather than 3 inter-connected aquaria were used. Each was supplied with water, food, and shelter, similar to Aquaria 1 and 3 in the mixed age group experiments. Sixteen early instars were released and held in Aquarium 1. The

Table 1. Comparison between the numbers of wild-type and black-body cockroaches present in Aquarium 1 after one week.

Female Density	Number and Phenotype in Aquarium 1[a]									
	♀		♂		M		E		Total[c]	
	+	*Bl*	+	*Bl*	+	*Bl*	+	*Bl*	+	*Bl*
4	12	10	17	17	37	30	38	39	104	96
8	31	27	18	16	48	42	43	46[b]	140	131
16	93	95	25	25	75	76	36	33	229	229
Total[c]	136	132	60	58	160	148	117	118	473	456

[a] +—wild-type (VPI strain); *Bl*—black-body; ♀—adult females; ♂—adult males; M—middle instars; E—early instars.

[b] One early instar not included in calculations. Recent molt prevented classification as + or *Bl*.

[c] Numbers of wild-type and black-body have good fits to 1:1 ratios (χ^2 <0.50, and >0.40 for each female density and each age/sex class).

number remaining at 24 h post-release was counted. Access to Aquarium 2 was opened. The numbers present at 24 h and at 7 d post-opening were recorded. The experiment was replicated 11 times.

Dispersal of mixed age groups was measured using the following index: $DI = (X - Y)/X$, where X = number of cockroaches in the first aquarium at the beginning of the experiment, Y = number of cockroaches remaining the first aquarium after one wk, and $(X - Y)$ = number of cockroaches dispersed from the first aquarium in one week. The dispersal index ranges from 0 (no dispersal) to 1 (complete dispersal). The higher the index the greater the dispersal. Comparisons of the three densities were tested using the Kruskal-Wallace non-parametric n-way comparisons test. An alpha level less than 0.05 was used to determine significance.

RESULTS

Table 1 shows the results of the mixed age group experiment separated according to black-body (*Bl*) and wild-type individuals. The numbers of each strain that remained in Aquarium 1 at the end of one week were not significantly different. This was apparent in comparisons between each age/sex class at each of the three female densities. Since no strain difference in movement away from Aquarium 1 was found, the following analyses of dispersal are based on the pooled data from the mixed age groups (Tables 2 and 4).

Table 2 shows the results of the experiments using mixed age groups. Cockroaches that remained in the system of inter-connected aquaria had sufficient time for formation of within-shelter aggregations (Bret et al., 1983). Since relatively few adults and middle instars escaped from the system, it is assumed that those not in Aquarium 1 at the end of one week had moved away from aggregate groups that had formed in this aquarium. A similar assumption could not be made for early instars since over half of them had escaped. Therefore, the results pertaining to early instars are presented separately from the other age/sex classes, using data from both the mixed age class experiments and those designed to test the time of escape of early instars (Table 3).

Over 80% of the adults and middle instars were in the aquaria supplied with water, food, and shelter at the end of one week (Table 2, Aquaria 1 and 3). The

Table 2. Distribution of German cockroaches throughout a system of inter-connected aquaria one week after opening tubes that allowed movement out of Aquarium 1.

Age-Sex Class[a]	Observation[b]	Aquarium 1	Aquarium 2	Aquarium 3	Tubes	Escaped
♀	n	268	17	49	28	8
	$\bar{x} \pm$ SE	7.05 ± 2.18	0.45 ± 1.99	1.29 ± 1.32	0.74 ± 1.89	0.21 ± 1.45
	%	72.4%	4.6%	13.2%	7.6%	2.2%
♂	n	118	4	30	6	3
	$\bar{x} \pm$ SE	3.10 ± 0.62	0.10 ± 1.20	0.79 ± 0.98	0.16 ± 0.93	0.08 ± 0.97
	%	73.3%	2.5%	18.6%	0.7%	1.9%
M	n	308	32	145	41	71
	$\bar{x} \pm$ SE	8.10 ± 1.67	0.38 ± 1.67	3.82 ± 1.59	1.08 ± 1.88	1.89 ± 1.31
	%	51.6%	5.4%	24.3%	6.9%	11.9%
E	n	236	6	28	4	334
	$\bar{x} \pm$ SE	6.21 ± 1.59	0.16 ± 1.38	0.74 ± 1.57	0.10 ± 1.20	8.76 ± 1.42
	%	38.8%	1.0%	4.6%	0.7%	54.9%
	%[c]	86.1%	2.2%	10.2%	1.5%	—

[a] Symbols: see Table 1.

[b] Categories: n—total of all replications (no. of middle instars 11 less than released; that of adult males increased by 9 and females by 2); $\bar{x} \pm$ SE—mean and standard error from 38 replicates. %—relative proportions within each location (based on n).

[c] Distribution of early instars that remained within the experimental system.

largest proportion of each of these classes was still in Aquarium 1, but differences occurred in the relative proportions of those that had moved to other parts of the system. Middle instars dispersed more than either adult males or females; dispersal of males resembled that of females (but see results at differing female densities). The distribution of these classes in Aquarium 3 differed from that in the parent group in Aquarium 1. In Aquarium 1, the distribution was as follows: 38.6% females, 17.0% males, and 44.4% middle instars; that in Aquarium 3, 21.9% females, 13.4% males, and 64.7% middle instars.

The experiments using only early instars showed that most escapes from the experimental system occurred before the connection to Aquarium 2 was opened (Table 3). Subsequently, distribution stabilized. Little change occurred between the 1st and 7th day post-access to Aquarium 2. The total loss from Aquarium 1 represented 44.3% as compared to 54.9% in the mixed age group experiments. In the former, 40.3% was due to escape within the first 24 h. This left 112 early instars within the system, of which 98 (87.5%) were in Aquarium 1 at the end of one week. Among 274 early instars that remained in the system in the mixed age group experiments, 236 (86.1%) were in Aquarium 1.

Table 4 shows the effect of increased female density on dispersal in experiments with mixed age groups. A clear trend towards decreased dispersal with increased density occurred among the adult females, males, and middle instars. Males dispersed less than females and middle instars and responded less to changes in female density. A significant change occurred among the females and middle instars between the lowest and highest female densities. As noted above, it is reasonably certain that movement of adults and middle instars was away from groups established in Aquarium 1, in contrast to that of early instars. The ex-

Table 3. Distribution of early instars prior to and after opening tubes between Aquarium 1 and 2 in experiments using only early instars.

	First 24 h		24 h Post-opening			7 Days Post-opening		
Observation[a]	Aquarium 1	Escape	Aquarium 1	Aquarium 2	Escape	Aquarium 1	Aquarium 2	Escape
n	111	65	105	5	1	98	7	5
$\bar{x} \pm$ SE	10.2 ± 2.0	5.8 ± 2.7	9.5 ± 2.1	0.45 ± 0.77	0.9 ± 0.9	8.9 ± 2.1	0.64 ± 0.84	0.45 ± 1.22
%	62.5%	36.9%	59.7%	2.8%	0.6%	55.7%	4.0%	2.8%

[a] Like Table 2 except that the experiment was replicated 11 times; percent is based on the total released (176).

Table 4. The effect of female density on dispersal of mixed age groups out of Aquarium 1.

Female Density	Dispersal Index for Each Age/Sex Class[a]			
	♀	♂	M	E[b]
4	0.54	0.29	0.65	0.12
8	0.40	0.30	0.53	0.11
16	0.17[c]	0.11	0.33[c]	0.16

[a] Age/sex class as in Table 1. Dispersal index = difference between the no. of cockroaches released in Aquarium 1 and those present at the end of the experiment (1 wk) divided by the number released in Aquarium 1 (0 = no dispersal; 1 = complete dispersal).

[b] Calculated from nos. that remained in the experimental system (see text for explanation).

[c] Significant difference ($P < 0.05$) between lowest and highest female density (Kruskal-Wallace non-parametric n-way comparison).

periments on early instars (Table 3) provided strong evidence that the heavy loss of early instars in mixed age group experiments occurred soon after release rather than from an aggregate group. Therefore, the dispersal indices for early instars in Table 4 are based on the most nearly comparable data to that of the other classes, i.e., early instars known to have remained in the system. Little dispersal of early instars occurred among those that remained in the system and there was no decrease with increased female density.

Discussion

Three sources are generally recognized as being of fundamental importance to cockroach distribution—food, water, and harborage (concealment). They were available to mixed age groups only in the first and third aquaria. It is hardly surprising that most of the cockroaches were in these locations at the end of the experiment.

The movement studied in our experiments is alluded to as "dispersal" rather than foraging. Food and water were supplied close to the shelters in which the cockroaches aggregated in Aquarium 1, thereby negating the need to forage. Cockroaches that found these resources in Aquarium 3 left an aggregation, discovered and moved through openings into the middle aquarium, and also traversed this aquarium. This behavior seems to us more consistent with a dispersal behavior than a search for water or food.

The comparatively high dispersal of middle instars and low dispersal of early instars from groups formed in Aquarium 1 agrees well with expectations based on studies that have implicated the aggregation pheromone. Early instars have a particularly strong response to the pheromone (Pettit, 1940; Ledoux, 1945; Ishii and Kuwahara, 1967). They clustered more intensely within shelters in experiments on within-shelter aggregation than other age classes (Bret et al., 1983). Sommer (1975b) noted that a tendency of nymphs to be absent from hiding places increased with age. He suggested that older nymphs are less responsive to the aggregation pheromone. That seems to be the most likely explanation of the results reported here. We do not know whether initial escape of early instars reflected a slow response to aggregation pheromone and/or other signals by insects that had found concealment, the lack of adequate thigmotaxic stimulation (Berthold and Wilson, 1967), or simply the fact their small size could have facilitated escape from under the lid of the aquarium before there was sufficient time for formation of an aggregation. The greater movement of middle instars was responsible for their forming a larger proportion of the newly-formed group in Aquarium 3 than in their parent group. If this has an application to field situations, infestations in which middle to late stage nymphs predominate could be indicators of newly established populations. The present data support the idea that a recent infestation accounted for predominance of mid–late instars in a collection from an apartment (Sherron et al., 1981).

The data showing adult males dispersed less than either females or middle instars are more difficult to reconcile with the results of other studies. Sommer (1975a) reported adult males were the most active component of a population; Owens and Bennett (1982) found adult males more mobile than females in inter- and intra-apartment movement; Bret et al. (1983) found males showed less aggregation within shelters than any other member of the population, except where populations contained only four non-egg case bearing females and four males. One possibility is that the present experiments differed because movement was away from a nearby source of water and food, whereas a search for these resources may have been involved in experiments reporting greater male movements.

Dispersal, like within-harborage aggregation (Bret et al., 1983), was affected by female density. Within-harborage aggregation increased with increased density of egg case carrying females; dispersal of the experimental groups decreased with similar changes in female density. These behaviors can almost certainly be attributed to increased levels of aggregation pheromone associated with increased numbers of females. Predominance of egg case carrying females in the dispersal experiment probably contributed to the similarity. Among individual age/sex classes, early instars were unique in that dispersal remained low at all female densities. The amount of aggregation pheromone associated with the group in Aquarium 1 at the lowest female density was probably sufficient to exert a maximal attraction. A significant decrease in dispersal at highest female density occurred among both adult females and middle instars, but the magnitude of the decrease was less among the latter. The stronger tendency of middle instars than of other age/sex classes to disperse from the larger groups heightened the disparity between their dispersal behavior and that of other components of the experimental populations. Apparently aggregation pheromone and/or other factors associated with increased female density had a greater effect on adult females and also the males than on middle instars. Possibly middle instars are "colonizers" that disperse regardless of group size. In contrast, dispersal behavior of other age/sex classes might be affected by greater sensitivity to varying levels of aggregation pheromones, sex pheromones, or particular environmental situations such as crowding or food availability.

Deleterious changes in mating ability and other behaviors often occur when insects are transferred from the field to laboratory culture. However, transference of German cockroaches to a laboratory places them in a fairly optimal environment. Wright (1967) found that laboratory rearing increased the fecundity in a "field" strain. Therefore, it is not entirely surprising that we found no difference in dispersal between the long-time laboratory strain and the black-body strain that had been crossed to a freshly-collected "field" strain.

A second explanation of the absence of a strain difference in dispersal should also be considered. The observed behaviors may be typical of the species and thus unlikely to differ with strain. Innate, stereotyped behavioral patterns exist in animals—behaviors that have been shaped by evolution and that characterize the species (Scheller and Axel, 1984). The results of the present experiments are reminiscent of advantageous adaptive strategies of flying insects that involve dispersal before egg development and "while flight system is maximized and that of the reproductive system minimized" (Mathews and Mathews, 1978). Greatest dispersal of German cockroaches was by an age class, i.e., middle instars, that is almost certainly less susceptible to mortality than 1st–2nd instars but that has a near maximal time for movement before maturation and egg case formation by the females. Conceivably, the decrease in dispersal of all age classes with increased densities is also an adaptive strategy. It could decrease movement away from favorable situations where the available resources had encouraged development of a large group and egg case formation by the females.

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LITERATURE CITED

Akers, R. C. and W. H. Robinson. 1981. Spatial pattern and movement of German cockroaches in urban, low-income apartments (Dictyoptera: Blattellidae). Proc. Entomol. Soc. Wash. 83: 168–172.

Bret, B. L., M. H. Ross, and G. I. Holtzman. 1983. Influence of adult females on within-shelter distribution patterns of *Blattella germanica*. Ann. Entomol. Soc. Am. 76: 847–852.

Berthold, R. and B. R. Wilson. 1967. Resting behavior of the German cockroach, *Blattella germanica*. Ann. Entomol. Soc. Am. 60: 347–351.

Cornwell, P. B. 1968. The Cockroach. Vol. I. Hutchinson & Co. Ltd., New York. 391 pp.

Guthrie, D. M. and A. R. Tindall. 1968. The Biology of the Cockroach. Edward Arnold Ltd. London. 408 pp.

Ishii, S. and Y. Kuwahara. 1967. An aggregation pheromone of the German cockroach *Blattella germanica* L. (Orthoptera: Blattellidae) I. Site of the pheromone production. Appl. Entomol. Zool. 2: 203–217.

Ledoux, A. 1945. Étude experimentale du grégarisme et l'interattraction sociale chez les Blattides. Ann. Sci. Nat. Zool. 11: 75–104.

Mathews, R. W. and J. R. Mathews. 1978. Insect Behavior. John Wiley and Sons, N.Y. 507 pp.

Owens, J. M. and G. W. Bennett. 1982. German cockroach movement within and between urban apartments. J. Econ. Entomol. 75: 570–573.

Pettit, L. C. 1940. The effect of isolation on growth in the cockroach *Blattella germanica* (L.) (Orthoptera: Blattidae). Entomol. News. 51: 293.

Ross, M. H. and D. G. Cochran. 1966. Genetic variability in the German cockroach. I. Additional genetic data and the establishment of tentative linkage groups. J. Hered. 67: 221–226.

Scheller, R. H. and R. Axel. 1984. How genes control an innate behavior. Sci. Am. 250: 54–62.

Sherron, D. A., C. G. Wright, M. H. Ross, and M. H. Farrier. 1982. Density, fecundity, homogeneity, and embryonic development of German cockroach (*Blattella germanica*) (L.) populations in kitchens of varying degrees of sanitation (Dictyoptera: Blattellidae). Proc. Entomol. Soc. Wash. 84: 376–390.

Sommer, S. H. 1975a. Experimentelle Untersuchungen zur circadianen lokomotorischen Aktivität von *Blattella germanica* L. (Dictyoptera, Blattellidae). Biol. Zentralblatt. 94: 455–467.

———. 1975b. Zum Aggregationsverhalten bei *Blattella germanica*. Angew. Parasitol. 16: 135–141.

Wright, C. G. 1968. Comparative life histories of chlordane-resistant and non-resistant German cockroaches. J. Econ. Entomol. 61: 1317–1321.

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A NEW SPECIES OF *DICHOMERIS* FROM COSTA RICA (LEPIDOPTERA: GELECHIIDAE)

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Abstract.—*Dichomeris* **santarosensis,** new species, is described from Costa Rica. The larvae are serious defoliators of *Quercus oleoides*.

D. H. Janzen (Department of Biology, University of Pennsylvania, Philadelphia) is attempting to rear all lepidopteran species from Santa Rosa National Park, Costa Rica, in preparation for long-term ecological investigations on insects and plants in the park. Among the many species reared by him is an undescribed *Dichomeris* whose larvae completely defoliate *Quercus oleoides* Schlechtendahl and Chamisso (Fagaceae) when the new leaves are unfolding. He has worked out the life history and plans to publish it separately. A formal description is presented here to enable use of the scientific name.

Dichomeris santarosensis **Hodges,** NEW SPECIES
Figs. 1–4

A small yellowish-brown moth with prominent labial palpi (Fig. 1).

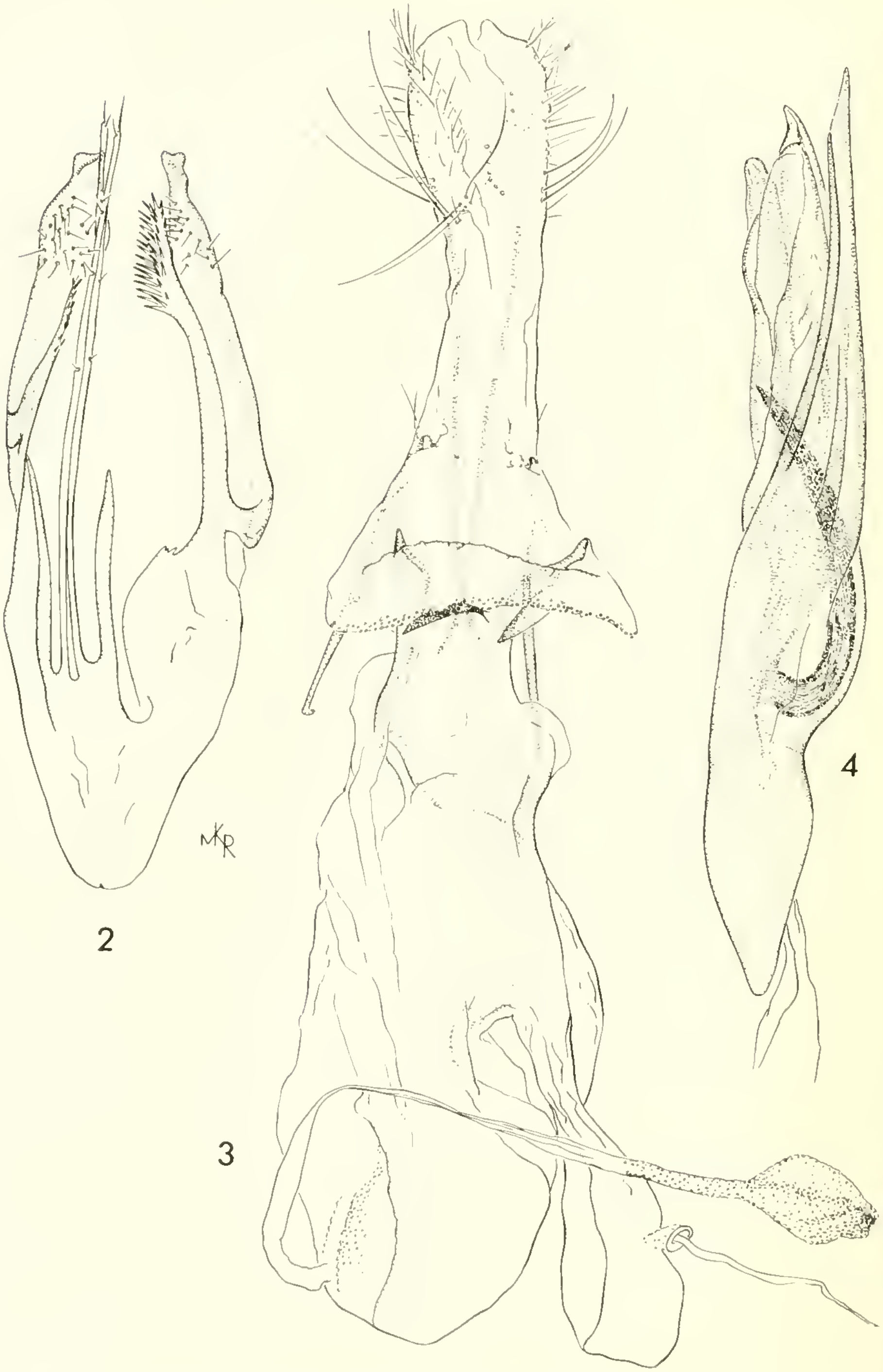
Description.—Upper surface as figured. Maxillary palpus and base of haustellum dark brown, individual scale bases pale yellow, rest of haustellum pale yellow; outer surface of first and second segments of labial palpus dark brown, individual scales pale yellow orange, second segment with strong dorsal and anteroventral scale tufts, scales of distal margin of tuft tipped with pale gray, inner surface of first and second segments nearly uniformly yellowish gray, most scales of anteroventral tuft tipped with gray brown, anterodorsal surface of second segment uniformly pale yellowish orange, third segment mottled dark orange and dark brown; antenna with dorsal surface of scape dark brown, shaft with individual scales tipped with dark brown, yellowish orange basally, ventral surface uniformly pale yellowish orange, sensory areas restricted to small area on alternate half segments of anteroventral surface; frons shining yellowish gray medially, with yellow or purple reflections, scales in front of eye dark brown; vertex and occiput pale orange or yellowish orange above eye, gray or gray brown medially, all scales tipped with pale margins and with shining yellow and purple reflections; a row of dark-brown scales behind eye; ocellus present. Tegula dark brown on anterior surface, orange brown dorsally. Dorsal surface of mesothorax mottled orange brown and gray brown. Foreleg mainly brown, individual scale bases yellowish gray or yellowish, epiphysis with pale yellowish-gray scales at apex; tibia and tarsus darker gray

Fig. 1. *Dichomeris santarosensis,* new species, holotype male.

brown, scales at apexes of tarsal segments pale yellowish white to white. Midleg much as for foreleg, ventral surface of tarsus uniformly pale, shining yellow. Hindleg: coxa shining pale yellow with yellow and lavender reflections; femur with dark-brown tipped scales ventrally, mainly shining pale yellow dorsally; tibia dark yellowish gray, most scale bases pale yellowish gray, outer tibial spurs dark gray, extreme apex yellowish white, inner tibial spurs longer and pale yellow dorsally; individual segments of tarsus mainly dark gray brown, scale bases pale and apex of each segment pale yellowish gray. Abdomen shining yellowish gray dorsally, mainly dark gray, segments becoming darker from base to apex; ventral surface pale yellow medially, segments with dark gray-brown scales laterally, posterior margin of each segment mainly pale yellow. Wing length: 5.7–7.0 mm. Forewing streaked with orange, orange brown, yellowish gray, and gray brown; fringe around apex orange to pale orange; ventral surface mainly dark gray brown, fringe somewhat paler and streaked with orange. Hindwing gray brown, veins darker and more intensely colored; cubitus with strong pecten from base to near origin of CuA2. Genitalia as illustrated in Figs. 2–4.

Types.—Holotype: ♂, Santa Rosa National Park, Guanacaste Province, Costa Rica; D. H. Janzen; 82.SRNP.311; Genitalia slide by RWH ♂ USNM 12099. In USNM. Paratypes: 26 ♂, 28 ♀, with same data as for holotype. All reared from new leaves of *Quercus oleoides.* In AMNH, BMNH, National Museum of Costa Rica (San Jose), USNM.

Discussion.—*Dichomeris santarosensis* is nearest *Dichomeris stratigera* Meyrick on characters of the male genitalia. *Dichomeris stratigera* is known from a



Figs. 2–4. *Dichomeris santarosensis*, genitalia. 2, 4, Male. 3, Female.

single specimen collected at Parintins, Brazil (about 300 km east of Manaus on the Amazon River). The major difference is in the juxta: the two lobes are divided to the base in *santarosensis*, whereas they are broadly fused in *stratigera*. Clarke (1969: 38, pl. 19-4a, b) illustrates the genitalia of *stratigera*.

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LITERATURE CITED

Clarke, J. F. G. 1969. Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick. Vol. 7. Trustees of the British Museum (Natural History). London. 531 pp.

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TWO NEW SPECIES OF THE GENUS *CLUNIO* (DIPTERA: CHIRONOMIDAE)

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Abstract.—*Clunio* ***virginianus*** n. sp. from the Virgin Islands and *Clunio* ***chilensis*** n. sp. from Mornington Island, Chile are described, figured, and compared with related species.

Intertidal midges of the genus *Clunio* Haliday are found in all regions of the world, with 18 described species (Hashimoto, 1976). These include the Neotropical species *Clunio marshalli* Stone and Wirth (1947), *C. schmitti* Stone and Wirth (1947), *C. brasiliensis* Oliveira (1950), *C. fuscipennis* Wirth (1952), and *C. californiensis* Hashimoto (1974). Through the courtesy of W. W. Wirth, Systematic Entomology Laboratory, Agricultural Research Service, Washington, D.C., I have been able to borrow and study two collections representing two previously undescribed species.

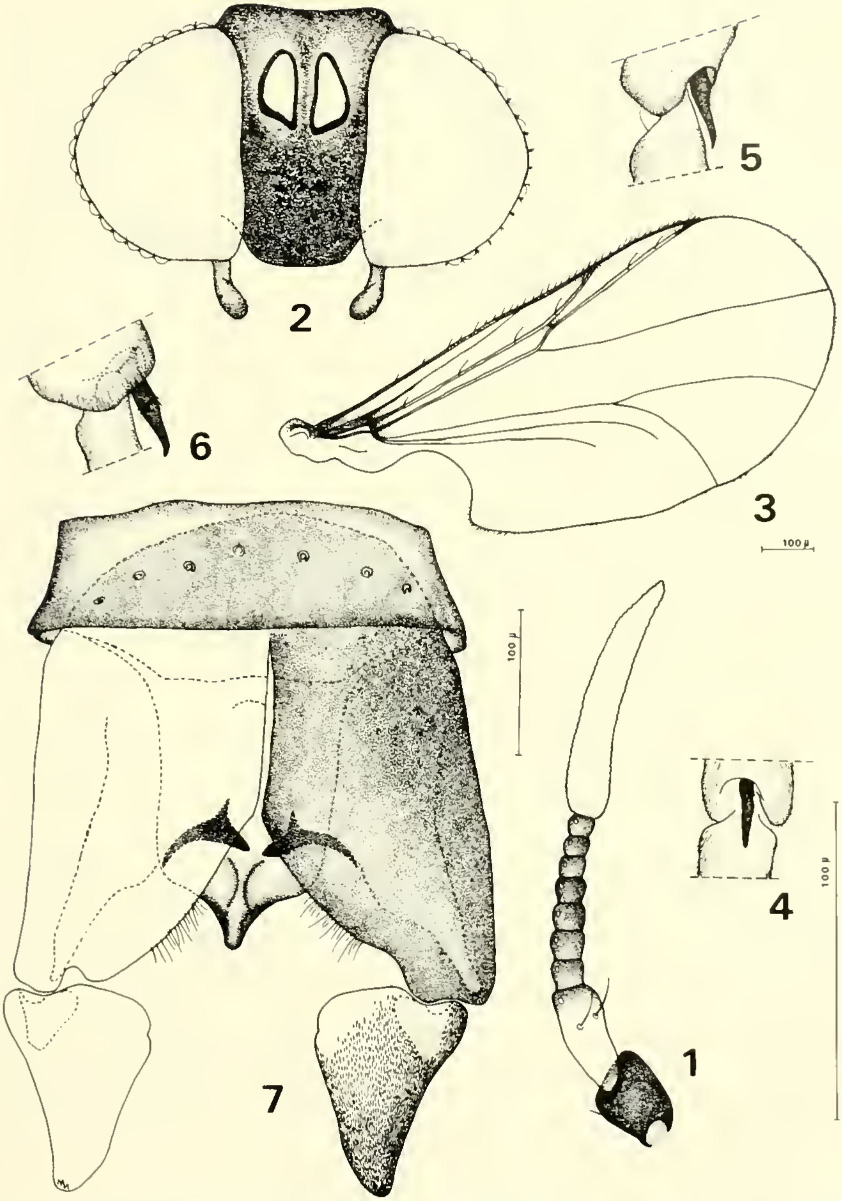
Holotypes are deposited in the U.S. National Museum, Washington, D.C.; paratypes as available will be deposited in the USNM, the Instituto de Limnologia, Universidad Nacional de La Plata, and the Museu de Zoologia, Universidade de São Paulo, Brazil.

The terms and methods of measurement used in this paper follow Saether (1971, 1980) and Strenzke (1959); the leg and hypopygium ratios follow Schlee (1966). Measurements are given as range, followed by mean and sample size.

Clunio virginianus New Species

Figs. 1–7, 18, 20

Male.—Wing length 1 mm (10); width 0.44–0.48, 0.46 mm (8). Coloration (specimens mounted in Canada balsam) brownish. Head: clypeus and vertex dark brownish, maxillary palpus light brownish, eyes black. Antenna: (Fig. 1) pedicel dark brownish, flagellum yellowish white, darkening on distal ⅓ of 1st flagellomere and the 7 intermediate ones. Thorax: scutum dark brownish; scutellum, anepisternum II and preepisternum II light brownish. Wings grayish white, veins grayish, well defined. Legs yellowish white, except coxae, trochanters, and articulations of femora and tibiae light brownish; tibial spurs and claws blackish. Abdomen and hypopygium brownish. *Head* (Fig. 2): Interocular width 87 μm, total width 216–238, 223 μm (6); ocular height 130–151, 137 μm (4). Antenna with 1–2 setae on pedicel and 2 setae on 1st flagellomere. Antennal proportions 10:19:4:4:4:4:3:3:3:38. A.R. (11/7–10) 2.46–307, 2.82 (8) and (11/3–10) 0.71–0.88, 0.84 (8). Length of maxillary palpus 30–45, 36 μm (6); width: 15–20, 16 μm (6). Clypeus/pedicel



Figs. 1–7. *Clunio virginianus.* 1, Antenna. 2, Head, frontal view. 3, Wing. 4–6, Tibial spurs of fore, mid, and hindlegs, respectively. 7, Hypopygium, ventral view.

ratio 1.66–2.0 1.83 (7). *Thorax:* Scutum with 3–5, 4 (10) dorsolateral setae from light colored ocellate spots and 2–3 prealar setae. Scutellum with 6–8, 7 (8) setae. Length of all these setae about 45 μm. *Wing* (Fig. 3): V.R. = 1.31 (10). Membrane and squama bare. $R + R_1$ with 5 setae, R_{4+5} with 2–3 setae; R_1 about ⅓ of R_{4+5} length, the latter nearly straight, ending as does C, before reaching wing apex; R_{4+5} almost the same length as R; M straight, not upcurved at distal end, and together with Cu$_1$ and Cu$_2$ clearly reaching wing margin; fCu not narrow at its base; Cu$_2$ slightly curved; A$_1$ ending beyond fCu, A$_2$ just reaching fCu. *Legs:* Coxa and trochanter each distally with tuft of 4–5 setae on foreleg, each with 2 moderately long setae on midleg, and each with a very small seta on hindleg. Femora and tibiae of all legs with sparse rows of short setae. First tarsomere 4× as long as broad on foreleg and 3× as long as broad on mid and hindlegs. Length of tibial spurs: on foreleg 15–20, 18 μm (5) (Fig. 4); midleg 20 μm (5) (Fig. 5); hindleg 25 μm (5) (Fig. 6). Lengths (μm) and proportions of legs (n = 5): Leg I: Fe 281 (260–303); Ti 399 (368–433); Ta1 113 (104–103); Ta2 34 (30–35); Ta3 29 (26–35); Ta4 29 (26–35); Ta5 44 (43–44); L.R. 0.28 (0.26–0.30); B.V. 5.83 (5.14–6.66); S.V. 6.01 (5.66–6.46). Leg II: Fe 349 (303–390); Ti 357 (336–390); Ta1 55 (48–65); Ta2 29 (23–30); Ta3 25 (22–26); Ta4 25 (23–26); Ta5 41 (35–43); L.R. 0.15 (0.13–0.16); B.V. 6.37 (5.60–7.13); S.V. 12.95 (11.8–15.33). Leg III: Fe 378 (360–411); Ti 375 (359–407); Ta1 67 (65–70); Ta2 30 (26–35); Ta3 50 (43–58); Ta4 24 (22–26); Ta5 41 (35–43); L.R. 0.18 (0.17–0.18); B.V. 5.65 (5.23–6.03); S.V. 11.27 (10.28–11.85). *Abdomen:* Each tergite with transverse row of 6–8 setae. *Hypopygium* (Fig. 7): Gonocoxite length 336 μm (9), gonostylus length 139 μm (9). H.R. = 2.41 (9). Gonocoxites fused on basal ⅓, each dorsal inner margin showing a concave surface in contact with parameres. The latter heavily sclerotized, slightly curved, and with a proximal projection. Ninth tergite consisting of a subquadrate plate ending conically and with dense pubescence, not reaching level of tips of gonocoxites.

Female and immature stages.—Unknown.

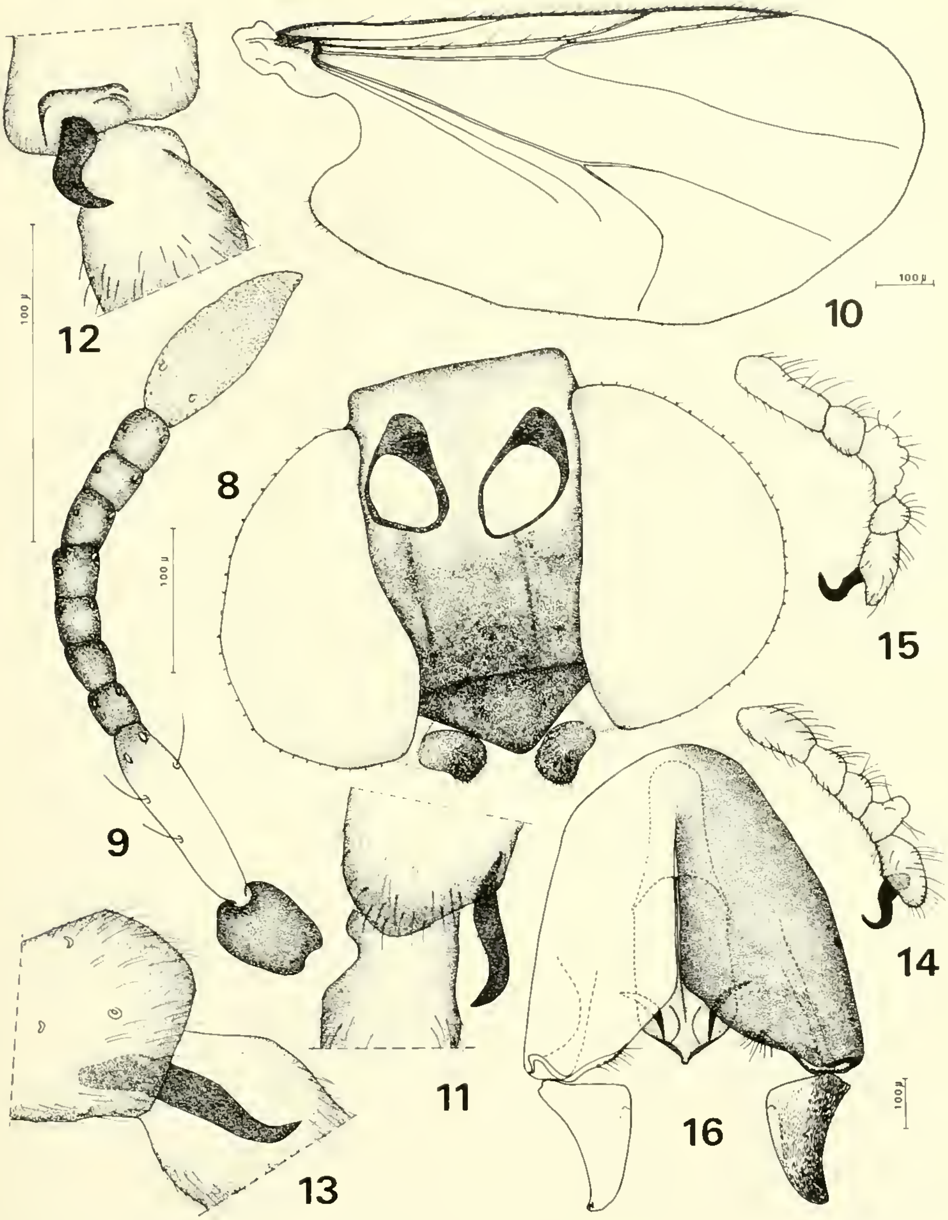
Material examined.—Holotype ♂, St. John, U.S. Virgin Islands, Lesser Antilles, Nov. 1959, R. W. Williams col. (deposited in USNM). Paratypes, 9 ♂, same data as holotype.

Discussion.—This new species closely resembles *Clunio marshalli* Stone and Wirth (1947), described from Biscayne Channel, Dade County, Florida and also recorded from the Virgin Islands. *Clunio virginianus* differs in having a high antennal ratio with the last flagellomere longer and more tapering than in *marshalli*. In *C. marshalli* the pedicel bears two setae, wing veins M, Cu$_1$, and Cu$_2$ do not distinctly reach the wing margin, wing vein M is distinctly upcurved distally, A$_1$ and A$_2$ are indistinct, tarsomere 1 is two times as long as broad on foreleg and three times as long as broad on mid and hindlegs. The U-shaped sclerotized ridge on the 8th tergite is rounded and basally opened in *C. marshalli* (Fig. 17), while it is subquadrate and with parallel sides in *virginianus* (Fig. 18).

***Clunio chilensis* NEW SPECIES**

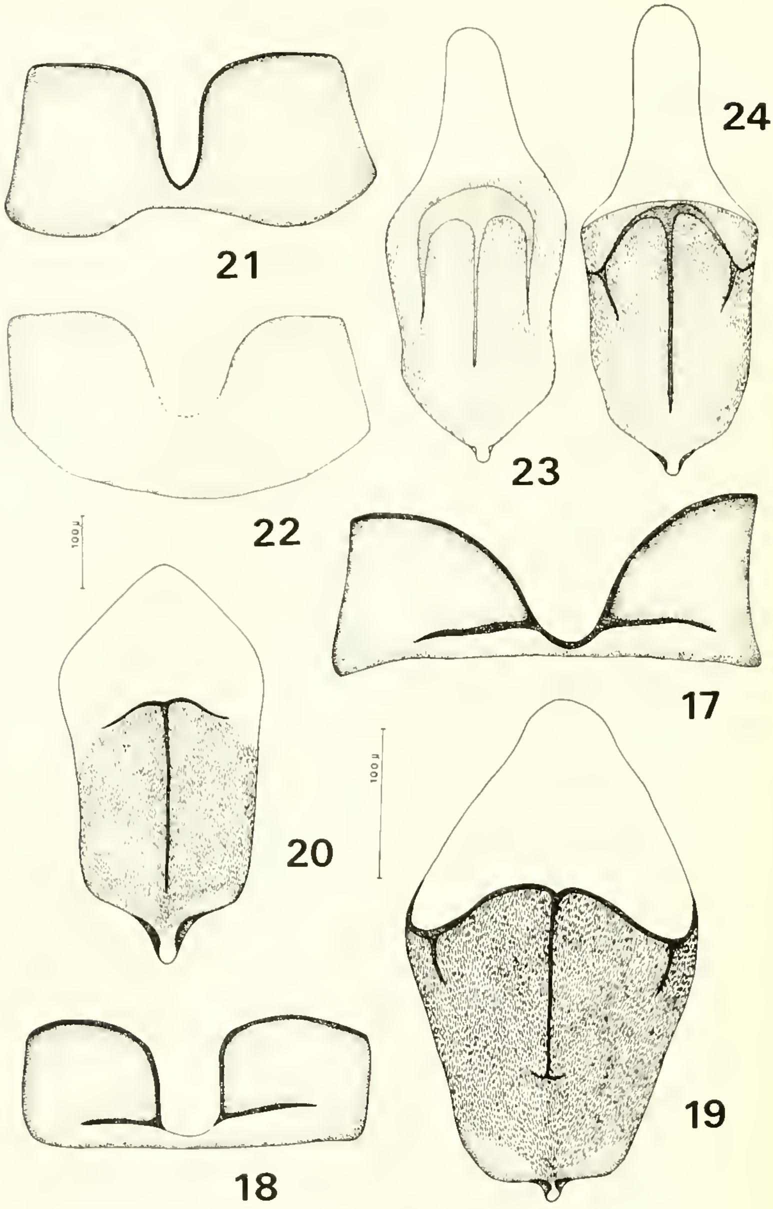
Figs. 8–16, 21, 24

Male.—Wing length 2.6–2.7, 2.66 mm (3); width 1.16 mm (3). Coloration (specimens mounted in Canada balsam) brownish. Head: clypeus dark brownish (Fig. 8), eyes black. Antenna (Fig. 9): scape and pedicel dark brownish, 1st flagellomere light brownish to yellowish, its distal ⅓ and the 7 intermediate flagellomeres more pigmented, last flagellomere light as the 1st. Thorax dark brownish. Wings yellowish. Legs: coxae, trochanters, and articulations of femora and tibiae dark brownish, the rest yellowish; tibial spurs and claws blackish. Abdominal segments including hypopygium dark brownish. *Head:* Interocular width 173 μm (3), total width 390 μm (3), ocular height 238 μm (3). Antenna: pedicel without setae, 1st



Figs. 8–16. *Clunio chilensis*. 8, Head, frontal view. 9, Antenna. 10, Wing. 11–13, tibial spurs of fore, mid, and hindlegs, respectively. 14, Tarsus of midleg. 15, Tarsus of hindleg. 16, Hypopygium, ventral view.

flagellomere with 2 setae; segments with lengths in proportion of 15:38:8:8:8:8:8:8:8:40. A.R. (11/7–10) 1.19–1.34, 1.26 (3); (11/3–10) 0.42–0.46, 0.43 (3), and (11/4–10) 0.68–0.77, 0.72 (3). Maxillary palpus 55 μm long by 30 μm wide. Clypeus/pedicel ratio 2 (3). *Thorax:* Scutum with 5–7, 6 (3) dorsolateral setae (arising from light ocellate spots) and 5–7, 6 (3) prealar setae. Scutellum with



Figs. 17–24. U-shaped ridge on 8th tergite, 17–18, 21–22; plate of 9th tergite, 19–20, 23–24. 17, 19, *Clunio marshalli*. 18, 20, *C. virginianus*. 21, 24, *C. chilensis*. 22–23, *C. schmitti*.

about 20 setae. All setae 65–80 µm long. *Wing* (Fig. 10): V.R. = 1.11. Wing membrane and squama bare. R + R_1 with 5–6 setae, R_{4+5} with 6–7 setae; R_1 ⅓ the length of R_{4+5}, the latter straight and the same length as R; M straight, not upcurved, ending as do Cu_1 and Cu_2 before wing margin; fCu broad at base; Cu_2 nearly straight on basal ½, then bending abruptly and bent almost straight back on distal half, the extreme tip not recurved. A_1 ending beyond level of fCu, A_2 ending at level of fCu. *Legs:* Coxa and trochanter each distally with tuft of 5–10 strong setae on foreleg, those of trochanter arranged in 1 row; each with 4–5 small setae on fore and hindlegs. Femora and tibiae of all legs with sparse rows of strong and long setae, that measure 65–108 μm long, longer on femur of foreleg (130 μm). First tarsomere 4 × as long as broad on foreleg and 3× as long as broad on mid and hindlegs. Length of tibial spurs: on foreleg 32–40, 35 μm (3) (Fig. 11); midleg 35–40, 37 μm (3) (Fig. 12); hindleg 40–60, 48 μm (Fig. 13). Fourth tarsomere of midleg with a protuberance as shown in Fig. 14; 3rd tarsomere of hindleg tri-lobed (Fig. 15). Lengths (μm) and proportions of legs (n = 3): Leg I: Fe 534 (499–580); Ti 889 (812–928); Ta1 155 (151–162); Ta2 63 (58–74); Ta3 48 (34–65); Ta4 43 (35–48); Ta5 94 (81–108); L.R. 0.17 (0.16–0.18); B.V. 6.46 (6.43–7.59); S.V. 9.20 (8.83–9.45). Leg II: Fe 634 (626–638); Ti 673 (626–696); Ta1 116; Ta2 46; Ta3 39 (35–46); Ta4 39 (35–46); Ta5 93 (81–104); L.R. 0.16 (0.16–0.18); B.V. 6.60 (6.28–6.94); S.V. 11.26 (10.79–11.5). Leg III: Fe 696 (580–754); Ti 735 (696–754); Ta1 116; Ta2 46; Ta3 81; Ta4 46; Ta5 97 (93–104); L.R. 0.15 (0.15–0.16); B.V. 5.73 (5.23–6.16); S.V. 12.33 (11–13). *Abdomen:* Each tergite with row of setae about 87 μm long. *Hypopygium* (Fig. 16): Gonocoxite length 638–731, 692 μm (3); gonostylus length 232–255, 247 μm (3); H.R. 2.75–2.86, 2.79 (3). Gonocoxites fused on proximal ⅓. Parameres well sclerotized and slightly curved, almost in vertical position. Plate of 9th tergite short, ovoid, with parallel sides, ending somewhat conically and scarcely reaching level of tips of gonocoxites, with strong pubescence. Gonostylus triangular, densely pubescent on ⅔ of its surface, lateral margin slightly concave, apically with 2 or 3 small retrorse spine, internal mesal angle rounded, bare, and with a blunt tooth directed anteriorly.

Female and immature stages.—Unknown.

Material examined.—Holotype ♂, Pt. Alert, Mornington Island, Chile, 26–27.ix. 1969, O. S. Flint, Jr., col. (deposited in USNM). Paratypes, 2 ♂, same data as holotype.

Discussion.—*Clunio chilensis* n. sp. closely resembles *C. schmitti* Stone and Wirth (1947) from the Galapagos Islands, but *schmitti* differs in having the last flagellomere more tapering and densely pitted, wing vein Cu2 straight at base, abruptly bent caudad at midportion and then recurved posteroditally towards wing margin, vein M is upcurved towards its apex, and the gonocoxites are fused on proximal ¾ of their length. The differences between the species in the appearance of the U-shaped ridge on tergite 8 are shown in Figs. 23–24, and of the median plate of tergite 9 in Figs. 21–22. Both *chilensis* and *schmitti* are separated from *Clunio californiensis* Hashimoto (1974) by having traces of two to three incisions on tarsomere 3 of the hindleg, the tibial spurs of the fore and midlegs well developed, the distinctive U-shaped ridges on tergite 8, and the median plate of tergite 9 distinctly narrowed on the distal half rather than oblong with shield-shaped tip.

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I am indebted to Willis W. Wirth of the Systematic Entomology Laboratory, Agricultural Research Service for giving me the opportunity to study these marine midges and for his helpful comments on the manuscript. This research was supported by the National Council of Scientific and Technical Investigations (CONICET), Republic of Argentina, and is Scientific Contribution No. 230 of the Instituto de Limnologia, ILPLA, La Plata, Argentina.

LITERATURE CITED

Hashimoto, H. 1974. A new species of Clunionine chironomid from North America. Entomol. Tidskr. 95, Suppl.: 108–114.

———. 1976. Non-biting midges of marine habitats (Diptera: Chironomidae). Chapter 14, pp. 377–414. *In* Cheng, L., ed., Marine Insects. New York. North Holland Publishing Company. 581 pp.

Oliveira, S. J. de. 1950. Sobre uma nova especie Neotropica do genero "*Clunio*" Haliday, 1855 (Diptera, Chironomidae). Rev. Brasil. Biol. 10: 493–500.

Roback, S. S. 1971. A new record and immature stages of *Clunio brasiliensis* Oliveira, with additional notes on adults (Chironomidae: Clunioninae). Not. Nat. 444: 1–12.

Saether, O. A. 1971. Notes on general morphology and terminology of the Chironomidae (Diptera). Can. Entomol. 103: 1237–1260.

———. 1980. A glossary of chironomid morphology terminology (Diptera: Chironomidae). Entomol. Scand. Suppl. 14: 1–51.

Schlee, D. 1966. Präparation und Ermittlung von Messwerten an Chironomidae (Diptera). Gewässer Abwasser 41/42: 169–193.

Stone, A., and W. W. Wirth. 1947. On the marine midges of the genus *Clunio* Haliday (Diptera: Tendipedidae). Proc. Entomol. Soc. Wash. 49: 201–224.

Strenzke, K. 1959. Revision der Gattung *Chironomus* Meig. 1. Die Imagines von 15 norddeutschen Arten und Unterarten. Arch. Hydrobiol. 56: 1–42.

———. 1960. Metamorphose und Verwandtschaftsbeziehungen der Gattung *Clunio* Hal. (Dipt.). Terrestrische Chironomiden XXIV. Ann. Zool. Sci. "Vanamo" 22: 1–30.

Wirth, W. W. 1952. Los insectos de las Islas Juan Fernandez 7. Heleidae and Tendipedidae (Diptera). Rev. Chil. Entomol. 2: 87–104.

———. 1969. New species and records of Galapagos Diptera. Proc. Calif. Acad. Sci. 36: 571–594.

PROC. ENTOMOL. SOC. WASH.
87(2), 1985, pp. 467–474

RECOGNITION OF THE FEMALE OF *TRACHELIODES FOVEOLINEATUS* (VIERECK), WITH DESCRIPTION OF THE MALE AND LARVA (HYMENOPTERA: SPHECIDAE: CRABRONINAE)

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Abstract.—Pate's redescription of the type female of *Tracheliodes foveolineatus* (Viereck) is importantly emended. The first description of the male is given, and attributes permitting recognition of the males of all three existent Nearctic species are specified. The diapaused mature larva is also described and compared with those of what is probably the Nearctic *T. amu* Pate, and the Palearctic *T. quinquenotatus* (Jurine). Larvae of all three are readily distinguished, but the Nearctic species are more similar to each other than either is to *T. quinquenotatus.*

Six female wasps from an elder trapnest, placed at Julian, San Diego Co., California, are the fairly rare *T. foveolineatus* (Viereck) by Pate's (1942) key, as are two females loaned by Prof. R. M. Bohart and identified by him as this species. All eight, apart from pygidial puncturation, agree reasonably well with Viereck's (1909) description. However the clypeal teeth, shape of the supraorbital foveae, the foretarsal "pecten," admedian line and notauli, propodeal flanks, and puncturation of the pygidium apparently differ from the female type as described by Pate. Because Pate claimed that his detailed description of the type agrees "in all essential particulars" with a second specimen before him, but not described, it seemed possible that the specimens at hand represented another species. Restudy of Viereck's type shows that is not so. The following emendations to Pate's description need to be made:

The clypeus of the female type is adorned with three apical teeth, as Pate says, but the medial tooth is actually broad and truncate, not rounded as stated and portrayed in his figure 1; in fact, the clypeal margin is strikingly similar to that of his figure 4 (= the male *T. amu* Pate). Figure 1 is also misleading with respect to the supraorbital foveae which are drawn far too low onto the frontal area, are too far removed from the eye margins (from which they are separated by slender beads, in part evanescent in the type and some others), and incorrect in outline. The foveae are noticeably flared anteriorly, of minimal breadth for a distance in the posterior third, and abruptly bent away from the eye margin at their posterior ninths (range in the eight females = R_8 = 0.87–0.93); ratio of relative length to diameter of median ocellar lens = 5.2 (R_8 = 6.1–8.6).

The type is the largest of the nine female specimens that I have seen, with a mean forewing length (tip to costal sclerite) from 1.1–1.3 × the length of the other eight specimens (R_8 = 4.7–5.5). The barely definable (perhaps vestigial) "pecten" of 5 or so "short, stout bristles" on the fore basitarsus is unlike that figured by Kohl (1915) for *T. curvitarsis* Herr.-Schaeff. Below and about the "pecten" there are similar bristles and hairs, and in smaller specimens a comb is—at best—barely discernible.

The admedian line and notaulus are confined to the anterior third of the mesonotum, the propodeal flanks are not glabrous, and the pygidium has coarse punctures separated by 1–2 diameters. It must also be mentioned that the sparse, short pubescence of the eyes (a generic attribute) is striking in the type, but is barely evident as a few, widely scattered hairs in three fresh emergents among the specimens.

The "basal acarid chambers" of the metasoma, mentioned but not described by Pate, are extremely difficult to detect in the type, if at all, and were probably observed by Pate in his second specimen. When the terga are separated, thin, posteriorly-directed membranous projections from acrotergites 2 through 5 are exposed. Differing progressively in pattern among the terga, these membranes create shallow pockets (<0.3 mm high), over a basal portion of their tergal laminae, within which deutonymphs might shelter and which are wholly covered by the overlying broad apical margin of the preceding tergum. When, as is the case in 5 specimens, an apical margin has not become opaque or the abdomen is strongly bowed ventrally, the margins of the acrotergal membranes are more or less visible without manipulation.

There are several large deutonymphs *on* the type, but it is questionable whether there are any within the putative acarinaria. No mites are present on the other females studied, and there are none within the chambers of a reared disarticulated specimen, nor within the nest from which it was reared. It is not unlikely that, at least occasionally, the very small deutonymphs of a species of *Crabrovidia* are phoretic within the chambers (see Fain, 1973).

The male.—The following description is based upon two male siblings of the six reared females, plus two specimens loaned by Prof. Bohart. All run to *T. foveolineatus* in Pate's (1942) key, the male of which has not been described.

Length of forewing (tip to costal sclerite): $m_8 = 4.4$ ($R_8 = 4.0$–4.9) mm. Slenderer, but resembling female overall, including somewhat weaker apical clypeal teeth: median tooth broad, truncate, tooth on each side half as wide (or nearly so), blunt. As in other described species of *Tracheliodes*, secondary sexual characters not unusual or striking: 13-segmented antennae; strong bands of decumbent silvery pubescence between inner orbits and scapal basin; silvery pubescence extending over clypeus; clypeus flat in profile; supraorbital foveae small, very slender, gradually tapering anteriorly over most of their length (in female narrowed posteriorly), widest posteriorly where flexed, relative length to diameter of median ocellar lens: $m_8 = 2.2$ ($R_8 = 1.8$–2.8), flexed toward hind ocelli at posterior eighth ($R_8 = 0.82$–0.89); dense, decumbent silvery pubescence over subpleural surface of mesothorax (in whole or in part); foreleg trochanter (relative to the forefemur) shorter (female 0.59×, male 0.48×); long sparse cilia (greater than trochanter width) on ventral surface of foreleg trochanter and basal half of forefemur; shorter, more uniform and dense pubescence on midtrochanter and basal half of midfemur; midfemur nearly circular in mid-section; hind tibia not notably "pinched" or subcarinate antero-apically as in female, subellipsoidal in apical third; hind basitarsi nearly straight; metasomal "acarinaria" as in female, on metasomal tergum-2 to the penultimate tergum; no demarcated pygidial area.

Coloration: as in female; ground colors ferruginous, piceous, or black, maculation very variable; the following yellow in all four males: palps, clypeus, scape, flagellum below, pronotum, venter of mesopleuron (nearly all, or in part), scutellum in part, coxae (all or in part), fore and midlegs mostly, most of external surface of hindtibia; dark markings of legs variable, but hindfemora dark in all; metasomal terga 1–3 (2 males), 1–5 (2 males), maculate.

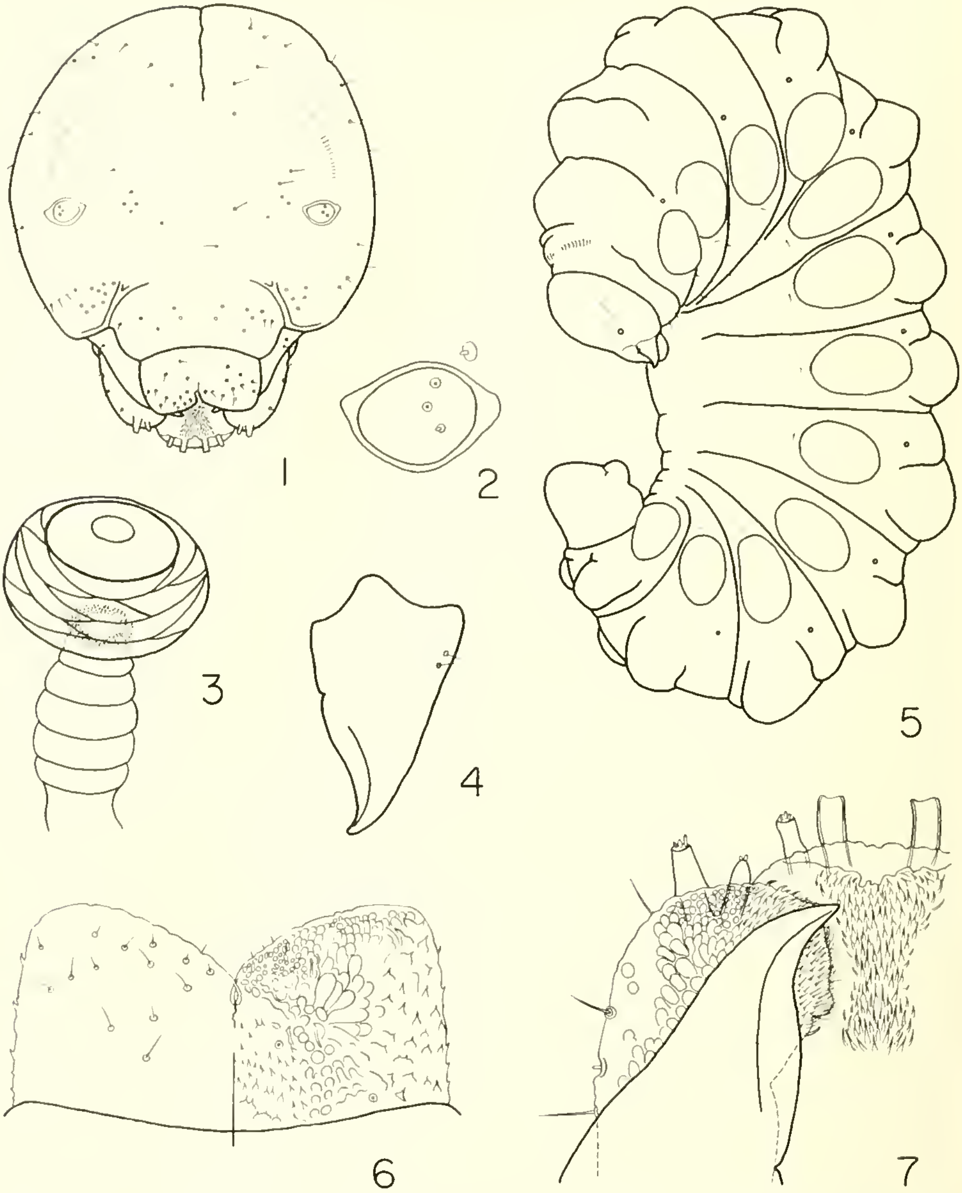
Specimens examined.—Type ♀. California, Shasta Co. Type No. 4994, Academy of Natural Sciences of Philadelphia. ♀, California, Sacramento Co., Davis, 10-26-1950, A. T. McClay; ♀, California, Los Angeles Co., Tanbark Flat, VII-6-1952, J. H. Nakata; ♂, California, Glenn Co., Orland, 6-W, Mar. 1920; ♂ (with cocoon), Nevada, Washoe Co., Verdi, F. D. Parker. All the preceding except the type from the Richard M. Bohart Entomological Museum, University of California, Davis; all determined by R. M. Bohart. California, San Diego Co., Julian, 1,234 m altitude; 6 perfect ♀, 1 pharate imago (partially dismembered within cocoon by siblings) and 2 ♂ from elder trap nest 83-579 (out VIII-27-1983, in IX-11-'83); emergence IX-19-'83: 2 ♀ and 2 ♂; emergence IX-20-'83: 4 ♀; basal cell with a cocooned, diapausing larva.

Diagnosis.—The male of *T. foveolineatus* is distinguished from the closely allied *T. amu* (as judged from Pate's description) by possession of supraorbital foveae, finely striate mesonotum and more coarsely striate pleura, nearly straight hind basitarsis and maculate metasoma, but *not* by its clypeus which is flat in profile like that of male *T. amu*. From *T. hicksi* Sandhouse, it is separated by its tridentate clypeus (quinquedentate in *T. hicksi*), absence of a median tubercle above the antennal sockets, presence of supraorbital foveae, ocelli in a high (not low) equilateral triangle, bluntly rounded humeri (not "bluntly angular"), striate mesonotum and pleura, maculated metasomal terga (not all black), and sternum 7 with its deep, wide, parallel-sided (not trigonal) cleft. The males of all three species have metasomal tergal "acarid chambers."

Of the five known living Holarctic species, judging from Kohl's (1915) account of the two Palearctic species and Pate's (1942) of *T. hicksi* and *T. amu*, *T. quinquenotatus* and *T. hicksi* differ most from the remaining three, but are dissimilar to each other. The Palearctic *T. quinquenotatus* is the most remote from all other species of *Tracheliodes*. *T. amu* and *T. foveolineatus* seem morphologically closely akin to each other and to the Palearctic *T. curvitarsis*, with *T. foveolineatus* being the more strikingly similar to the Palearctic species—as Pate has commented. Discovery of the male sex of *T. foveolineatus* does not resolve the relationship of this species to *T. curvitarsis*, however, as Pate had hoped it would; perhaps discovery of the latter's larva would do so. The sole known Neotropical species, *T. carnavalus* Leclercq (1980), is strikingly different in morphology and livery from all of the above.

The larva.—A single cocooned larva, described below, remained in the trap nest following emergence of the six females and two males. It is to be noted that Evans (1959) judges the larva of *Tracheliodes* to be among the most specialized of the larrine-trypoxyline-crabronine complex.

Larva in diapause: with the characters of the subfamily as successively set forth



Figs. 1–7. Diapausing larva of *Tracheliodes foveolineatus* (Viereck). 1, Head—all outlines and the coronal "suture" from a camera lucida sketch of the fresh specimen; details of setation and foveae entered from the balsam mount. 2, Left antenna—isolated lowermost sensillum drawn above rim of orbit. 3, Spiracle and subatrial trachea. 4, Left mandible—anterior face (the right mandible is similar, but has only 1 basolateral bristle—see Fig. 1). 5, Larva—camera lucida sketch of living larva. 6, Labrum—left half the outer surface, right half the epipharyngeal surface. 7, Maxilla, labium, medial tract of hypopharynx, and apical half of right mandible.

by Evans (1957, 1959, 1964), except that the apical margin of the labrum is not bristly (Fig. 6), and the inner margin of the maxilla has a small lobe (Fig. 7).

Body (in life, Fig. 5): stout, grub-like with head and thorax, and abdominal segments 10–12, flexed ventrally; length (straightened) about 8 mm, widest at abdominal segment 4, 3.1 mm; a transverse, medially divided, brownish, dorsal sclerotization on anterior prothorax; pleural and dorso-lateral lobes prominent, the latter transverse, well-separated medially; apical dorsal lobe of 10th abdominal segment rounded, blunt in profile, overhanging anus; anus directed posteriorly.

Integument of thorax: sparsely and minutely spinulate, spinules of varying sizes and shapes according to location, transforming regionally from acute spines, basally broadened, to smoothly arched plaques; spinulation elsewhere on body still more sparse, occurring nearly exclusively in vicinity of spiracles. Setae few, present along hinder margins of thoracic segments, (20–30 μm long); a single seta below each pleural lobe (Fig. 5).

Spiracles: atrium pale amber, globular in shape; peritreme colorless; atrial microsculpture forming a coarse, open, stretched meshwork; atrial and subatrial openings equal in diameter, the latter encircled by a thickened, darker annulus; subatrium not slender, widening immediately behind subatrial annulus (Fig. 3).

Head (Fig. 1): Width 0.77 mm, height (crown to anterior margin of clypeus) 0.81 mm; coronal "suture" conspicuous; parietal bands evident; epistomal suture weak (more clearly evident in the living larva); antennal orbits (Figs. 1, 2) slightly convex, ovate (54 × 47 μm), with thickened, discrete margin and three sensilla arranged in a low, obtuse triangle with the base ectad, lowest sensillum with a central peg; setae sparse, those on cranium 25–35 μm long; clypeus with a disordered, transverse band of foveae (= setal bases?) and setae at mid-length; a cluster of foveae on genae to each side of clypeus (Fig. 1), as well as on the posterior angles of the postgenae; anterior tentorial arms, hypostomal rod, mandibles and margin of labrum at midpoint, brown.

Mouthparts: Labrum (Figs. 1, 6) 0.3 mm wide, deeply and angularly emarginate, cleft medially (see comment, below), surface with 24 setae, primarily located within distal half; epipharynx (Fig. 6) with a basal and subcentral sensory peg on each side, surface with a complex arrangement of rounded plaques of many sizes and shapes forming an oblique band from labral base to apex and then spread along the apical margin; a medial, spinulose tract, a lateral spinose array. Mandibles (Figs. 1, 4, 7) 0.27 mm long × 0.20 mm wide, apex pointed, inner margin gently sinuate, slightly notched, and bevelled to a cutting edge in anterior half; with one (on right) or two (on left) basolateral bristles. Maxillary palpi (Figs. 1, 7) 30 μm long; galeae 20 μm long, lacinial area spinulose laterally, with fine hairs along inner margin with a distinct, small lobe at level of hypostomal bridge; maxillary palpi (Fig. 7) thicker, with 3 spines in membrane at tip; labial palpi (30 μm long) and galeae (Fig. 7) with at least 2 terminal spines each. Labial palpi similar in girth to galeae, both shorter than spinnerets (40 μm long); hypopharynx (Fig. 7) with a medial array of spines and spinules, broadening apically.

Comment.—The flexion of the body portrayed in Fig. 1 is normal for the living, diapausing larva, and corresponds with Ferton's observations (1890) on the larva of *T. quinquenotatus.* On fixation the larval shape changes markedly, the specimen straightening as in Evans' (1964) figure 10b. Apart from the outlined features of the head capsule and body, which were drawn by camera lucida before the larva was killed, all other details were obtained from the specimen after death in near-boiling water, decapitation, clearing with KOH, and mounting of the head capsule and the sagittally-divided integument in balsam.

The oblique, open cleft in the labrum (Fig. 1) was very clear prior to mounting the head in balsam. Following slide preparation, the medial tips had become overlapped and presented a quite different appearance—now appearing as though an elongated, very narrow loop (Fig. 6). Whether they could be overlapped this way in life, or indeed whether the cleft resulted from a developmental mishap cannot be ascertained. For the latter reason, the labral cleft (a condition not mentioned for other species) is omitted from the comparisons of the described larvae of *Tracheliodes*.

Another peculiar feature of this larva is the high degree of numerical and positional asymmetries in the distributions of setae and foveae on the head capsule, clypeus, labrum and mandibles, including the foveae in the posterior genal angles at the rear of the head (4 on right, 6 on left, not illustrated). It is not the case, however, for the setae of the maxillae, prementum (6) and mentum (4) (not illustrated); they are equal in number and symmetrically disposed on the two sides in a manner similar to that of *T. amu* (see Evans' fig. 104). Overall, there is no significant excess of bristles or of foveae on one of the two sides.

Comparison of *Tracheliodes* larvae.—With the above caveats in mind, and taking figures and descriptions of the larva of what is probably *T. amu* (Evans, 1964), taken from Krombein's (1967) Arizona trapnests, and of the larva of the Palearctic *T. quinquenotatus* from Grandi (1928, 1934, 1961) as the basis for comparisons, each of the three species appears to be distinct with respect to the complexity and relative distributions of plaques, spinules and spines of the epipharynx (*cf.* Fig. 6 with Evans' fig. 109 and Grandi's [1934] fig. 21-2), as well as with respect to the parietal bands. The latter, evidently lacking in *T. quinquenotatus*, are present in both *T. amu* and *T. foveolineatus*, but in the former they are relatively short and about 2 orbital diameters removed from the antennal orbits, whereas in *T. foveolineatus* the bands are long and removed from the orbits by less than 1 diameter (*cf.* Fig. 1 with Evans' fig. 104).

T. amu and *T. foveolineatus* are similar and differ from *T. quinquenotatus* by their ratios of clypeal width to length (*T. amu* 1.07, *T. foveolineatus* 1.05, *T. quinquenotatus* 1.17), by having 12 pleural lobes per side, not 10, and by not having labial palpi larger than the galeae.

T. amu and *T. quinquenotatus* differ from *T. foveolineatus* by lacking a coronal suture (or ecdysial line), and by having a cluster of 5 sensilla on each side of the epipharynx (foveae in *T. amu*, peg organs in *T. quinquenotatus* ?), whereas such clusters do not occur in the specimen of *T. foveolineatus*.

T. foveolineatus and *T. quinquenotatus* both differ from *T. amu* by an absence of obvious dorsolateral lobes on pro- and mesothorax (and on the metathorax of *T. quinquenotatus* as well), and by having their dorsolateral lobes well separated mediodorsally.

There are additional setational and foveal differences as well, but until many larvae of each species have been studied, the weight to attribute to them is uncertain. However, patterns of epicranial setation seem strikingly different in all three (a transverse row in *T. amu*, 2 convergent rows in *T. foveolineatus*, and sparse patches in *T. quinquenotatus* (*cf.* Fig. 1 with Evans' fig. 104, and Grandi's [1961] fig. 347-2); likewise each of the former two larvae have 2 convergent lines of 4–5 setae on the interorbital area, whereas *T. quinquenotatus* has 3 interorbital setae per side which form relatively high, obtuse triangles.

T. amu and *T. quinquenotatus* appear to lack interorbital pores, whereas *T. foveolineatus* has 3 per side. *T. foveolineatus* and *T. quinquenotatus* appear to differ from *T. amu* by having their antennal sensilla grouped in a low, obtuse triangular pattern, rather than in a nearly linear array. Finally, because the larva of *T. foveolineatus* has 1 basolateral mandibular seta on its right side, 2 on its left, the value of mandibular setal number in this comparison is doubtful. But were it assumed that the normal number for *T. foveolineatus* is 2, the condition in this species would nevertheless seem to be different from that of *T. quinquenotatus* because the two bristles of the latter (not portrayed by Grandi until 1961) are transverse to the external margin of the mandible, not parallel to it as in *T. foveolineatus.*

Spiracular structure is neither mentioned nor figured for *T. quinquenotatus* by Grandi, but it differs in the two Nearctic species. In *T. amu* the microsculpture of the atrial capsule consists of somewhat elongated polygons, less than twice as long as wide, but in *T. foveolineatus* it takes the form of markedly stretched meshes; only *T. foveolineatus* possesses a stout annulus enclosing the subatrial opening (*cf.* Fig. 3 with Evans' fig. 108).

It is thus clear that the three species are closely allied, but all are easily differentiated, yet none of the attributes shown uniquely by one or another larva is of a remarkable or weighty nature. However, not surprisingly, the two Nearctic species are more similar to each other than either is to *T. quinquenotatus.* Description of the larva of *T. curvitarsis* will therefore be of great interest because, as Pate (1942) points out, and as I comment above, the imago of *T. foveolineatus* is phenotypically far more closely related to it than to *T. quinquenotatus,* and like *T. curvitarsis* (Emery, 1893) it nests in wood borings. What is more, it preys upon an ant, *Liometopum occidentale* Emery first described as a variety of the prey of *T. curvitarsis,* namely as the subspecies *occidentale* of *L. microcephalum* (Emery, 1895). *Tracheliodes quinquenotatus,* on the other hand, preys exclusively on species of *Tapinoma.* Will the larva of *T. curvitarsis* prove to have a labral cleft?

ACKNOWLEDGMENTS

It is a pleasure to thank: Richard M. Bohart of the University of California, Davis, for loan of specimens and especially for a certain light-hearted act of generosity; Donald Azuma of the Academy of Natural Sciences, Philadelphia, for loan of the type of *Tracheliodes foveolineatus* (Viereck); my colleague Jean-Pierre Barricelli for assistance with Grandi's prose; Howard E. Evans (of Colorado State University) for loan of his personal copy of Hachfeld's fine study; and Karl V. Krombein of the U.S. National Museum, for a helpful review of the manuscript.

LITERATURE CITED

Emery, C. 1893. Sur un crabronide chasseur de fourmis. Ann. Soc. Entomol. France. 62: LXIII–LXIV.

———. 1895. Beiträge zur Kentniss der nordamerikanischen Ameisen-Fauna. Zool. Jahrb. Abt. Syst. Oekol. Geogr. Tiere 8: 257–360.

Evans, H. E. 1957. Studies on the larvae of digger wasps (Hymenoptera, Sphecidae). Part III. Philanthinae, Trypoxylinae, and Crabroninae. Trans. Amer. Entomol. Soc. 83: 79–117.

———. 1959. Ibid. Part V. Conclusion. Trans. Amer. Entomol. Soc. 85: 137–191.

———. 1964. Further studies on the larvae of digger wasps. (Hymenoptera: Sphecidae). Trans. Amer. Entomol. Soc. 90: 235–299.

Fain, 1873. Notes sur les hypopes des Saproglyphidae (Acarina: Sarcoptiformes). III. Le genre *Crabrovidia* Zachvatkin, 1941. Description de 8 espèces nouvelles symphorétiques sur les Sphecidae (Hyménoptères). Bull. Ann. Soc. R. Belge Entomol. 109: 153–189.

Ferton, Ch. 1890 (1891). Un hyménoptère ravisseur de fourmis. Actes Soc. Linn. Bordeaus. (Sér. 5). 4: 341–346.

Grandi, G. 1928. Contributi alla conoscenza biologica e morfologica degli imenotteri melliferi e predatori. VI. Boll. Ist. Entomol. Univ. Studi. Bologna. 1: 3–30.

———. 1934. Ibid. XIII. Boll. Ist. Entomol. Univ. Studi. Bologna. 7: 1–44.

———. 1961. Studio di un entomologo sugli imenotteri superiori. Boll. Ist. Entomol. Univ. Studi. Bologna. 25: XV + 659 pp.

Kohl, F. F. 1915. Die Crabronen (Hymenopt.) der Paläarktischen Region. Ann. Naturhist. Mus. Wien. 29: 1–453.

Krombein, K. V. 1967. Trap-nesting wasps and bees: life histories, nests, and associates. Smithsonian Press. Washington. vi + 570 pp.

Leclercq, J. 1980. Crabroniens d'Amérique Latine appartenant aux genres *Entomocrabro* Kohl et *Tracheliodes* Morawitz (Hymenoptera Sphecidae). Bull. Ann. Soc. R. Belge Entomol. 116: 233–245.

Pate, V. S. L. 1942. A review of the myrmecotherous genus *Tracheliodes* (Hymenoptera: Sphecidae: Pemphilidini). Lloydia 5: 222–244.

Viereck, H. L. 1909. Descriptions of new Hymenoptera. Proc. Entomol. Soc. Wash. 11: 42–51.

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87(2), 1985, pp. 475–479

TWO NEW PHYCITINAE (LEPIDOPTERA: PYRALIDAE) FROM TEXAS AND ALABAMA

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Abstract.—*Salebriaria* ***atratella*** and *Anderida* ***peorinella,*** two new species of phycitine pyralids, are described. Adults, wing venation (of *A. peorinella* only), and male and female genitalia are figured.

The following two new species in the pyralid subfamily, Phycitinae, are described from examples collected by the authors in Texas and Alabama. Although this subfamily was revised comparatively recently (Heinrich, 1956), at least 60 new species and 7 new genera have been described from America north of Mexico since this revision. There is little doubt that many more remain undescribed, especially from the American tropics. Phycitines frequently suffer from neglect, both from collectors and in museum drawers, perhaps because they are obscurely colored and marked and determinations are largely dependent on genitalic dissection. However, the male and female genitalia are highly variable within the subfamily and usually provide good characters for species determination. The wing venation is also quite variable among the genera, and was used by Heinrich as the basis for his scheme of classification. In the author's experience, adult phycitines are readily attracted to ultraviolet light. In most Texas habitats, they often constitute a large percentage of smaller moths collected in the author's light traps. The larvae exhibit a wide range of habits, including foliage feeders, stem borers, feeders on scale insects, and pests of stored cereal products.

Salebriaria atratella, **Blanchard & Knudson,** New Species

Figs. 1–6

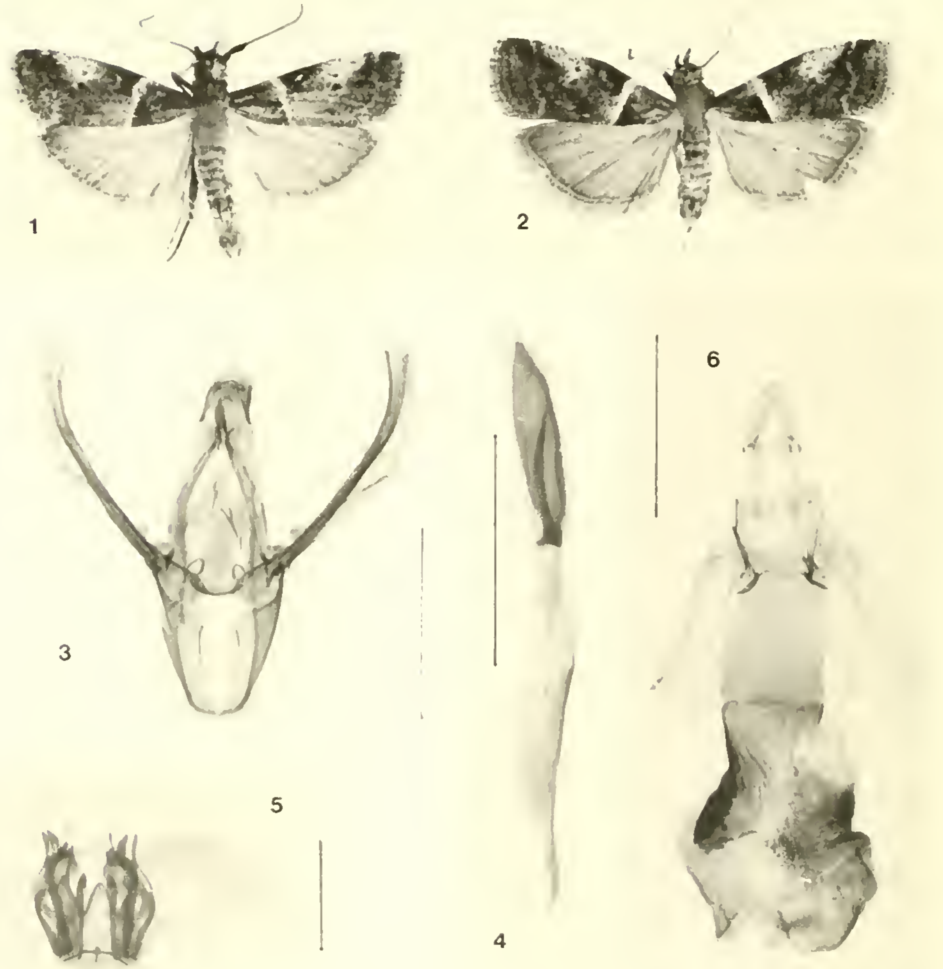
Head.—Front dark fuscous; vertex whitish ochreous; labial palpi upcurved, extending above vertex by ½ eye diameter, dark brown dorso-laterally, pale ochreous ventrally. Short third segments of labial palpi fuscous. Maxillary palpi dull orange aigrettes. Antennae light brownish ochreous, with black scale tuft in sinus at base of flagellum in male.

Thorax medium fuscous dorsally, ochreous ventrally.

Abdomen medium fuscous, with bands of ochreous scales at posterior margins of segments.

Length of forewing.—Males: (N = 4), 6.6–6.9 mm, average 6.8 mm. Females: (N = 10) 6.7–7.8 mm, average 7.2 mm.

Forewing.—Ground color dark fuscous, more intense basad of antemedial line and over middle of costal margin. Antemedial line white, outwardly oblique from



Figs. 1–6. *Salebriaria atratella.* 1, Holotype male. 2, Paratype female, Hunt Co. Texas. 3, Male genitalia (aedeagus removed) of paratype, on slide ECK 955, Hunt Co., Texas. 4, Aedeagus with partially everted vesica, same specimen and slide as Fig. 3. 5, Compound tufts on 8th abdominal segment of male paratype, same specimen and slide as Fig. 3. 6, Female genitalia of paratype, on slide ECK 951, Anderson Co., Texas, 14-VIII-82. Line in 3–6 = 1 mm.

costal margin at ¼ the distance from base, to dorsal margin at ⅓ the distance from base. Near costal margin, antemedial line is somewhat more diffuse, with white scales extending into basal area. Subterminal line white, weakly represented, nearly vertical and slightly sinuate. Along outer costal margin, just before subterminal line, is a diffuse patch of white scales, extending over upper portion of cell and surrounding upper black discal spot. Lower black discal spot poorly contrasted against ground color. Terminal line black, poorly contrasted against ground color. Along dorsal margin to basal ⅓ are a few orange brown scales and just beyond antemedial line are a few orange brown scales below fold. Fringe fuscous, with a darker inner band.

Hindwing light fuscous, paler toward base, darker at termen and along veins. Fringe fuscous.

Male genitalia (Figs. 3, 4, 5).—Apical process of gnathos elongate, pointed at tip; sclerotized portion of anellus consisting of an elongate median plate and short, rounded lateral processes; valvae extremely narrow, costa well sclerotized, with apical spine and two short, triangular projections near base. Aedegus (Fig. 4), with vesica extruded, containing large trapezoidal cornutus, closely appressed to narrow pointed cornutus. Compound tufts and sclerotizations of 8th abdominal segment are shown in Fig. 5.

Female genitalia (Fig. 6).—Short, oblique, sclerotized plates lateral to ostium bursae, armed with 4 or 5 slender spines; ductus bursae broad, compressed dorsoventrally, well sclerotized; corpus bursae globular, with extensive scobinate patches and striations.

Holotype (Fig. 1).—♂, Hunt Co., Texas, Lake Tawakoni, Wind Point Park, 15-VII-84, collected by E. Knudson and deposited in the National Museum of Natural History.

Paratypes.—Texas: Same data as holotype, 3 ♂ (genitalia on slides ECK 946, 955, and 958), 5 ♀; Anderson Co., Tennessee Colony, 14-VIII-82, 1 ♀ (genitalia on slide ECK 951); 16-VI-84, 1 ♀, all collected by E. Knudson. Montgomery Co., Conroe, 15-V-70, 2 ♀ (genitalia on slide AB 2399); Tyler Co., Town Bluff, 6-VI-67, 1 ♀ (genitalia on slide AB 1823), collected by A. & M. E. Blanchard. Alabama: Mobile Co., Saraland, 5-IX-82, 1 ♀, collected by E. Knudson.

Remarks.—*Salebriaria atratella* may be distinguished from previously described species of *Salebriaria* Heinrich by its relatively smaller size and dark coloration with sharply defined, white antemedial line. It is closest in superficial appearance to *Salebriaria fructetella* (Hulst) and *Quasisalebria admixta* Heinrich, but is smaller and has less whitish suffusion on the forewing. Both the male and female genitalia are most similar to those of *Salebriaria pumilella* (Ragonot). From this species, the male genitalia of *atratella* differ in the much narrower valvae, the differently shaped sclerotization of the anellus, and the large, broad cornutus in the vesica. The female genitalia differ from that of *pumilella* chiefly in the broader ductus bursae, the more globular corpus bursae, and the presence of spined plates lateral to the ostium bursae. These last mentioned, unusual structures are not found in the other species of *Salebriaria*. Both the male and female genitalia of *Q. admixta* are extremely different from *S. atratella*.

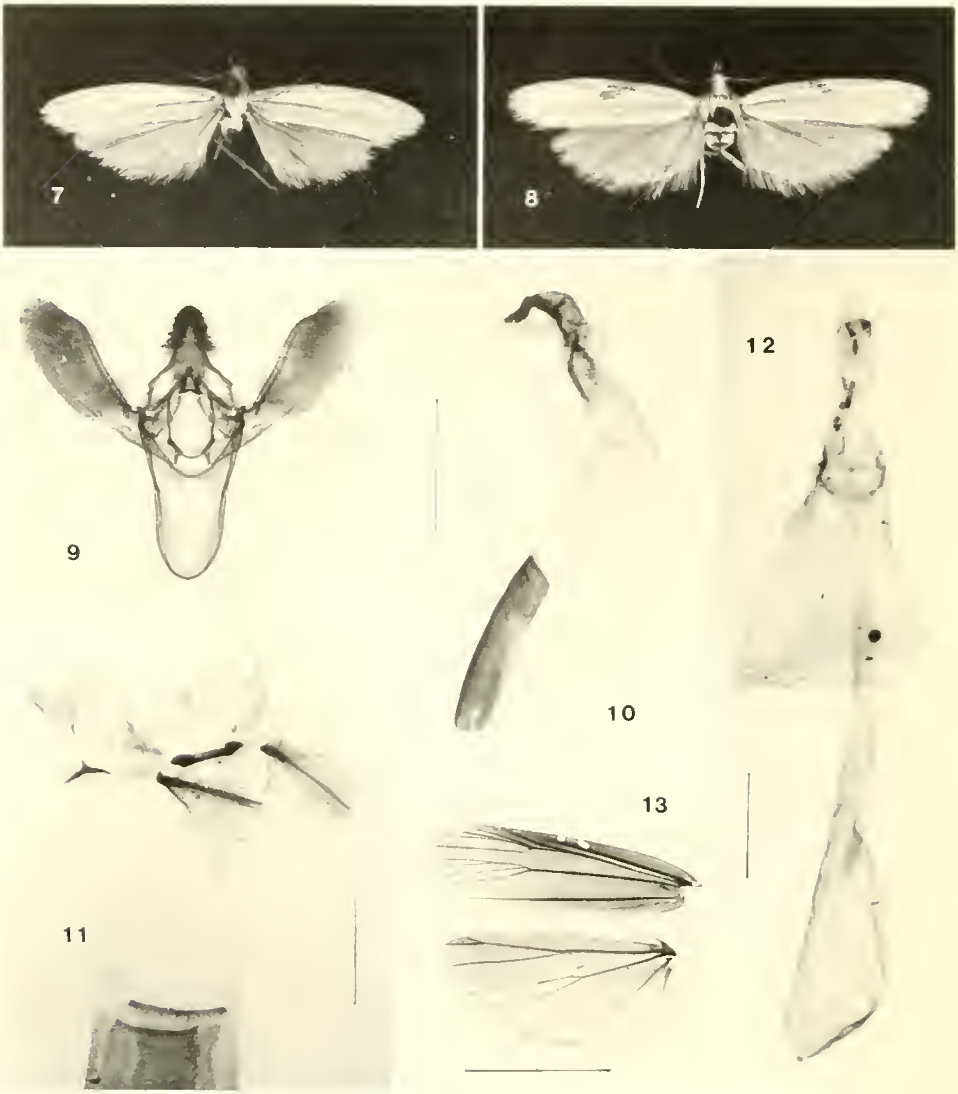
Anderida peorinella **Blanchard & Knudson, NEW SPECIES**

Figs. 7–13

Head.—Front and vertex yellowish white; labial palpi obliquely upturned, yellowish white on inner surface, outer surface brownish, exceeding front by 1 eye diameter; maxillary palpi filiform, ochreous; antennae simple, ochreous, with very short setae ventrally.

Thorax.—Patagia yellowish white; tegulae and mesonotum slightly darker. Undersurface and legs yellowish white.

Abdomen light yellowish brown.



Figs. 7–13. *Anderida peorinella*. 7, Holotype male. 8, Paratype female. 9, Male genitalia (aedeagus removed) of holotype. 10, Aedeagus, with inflated vesica, of holotype. 11, Scale tufts and sclerotizations on 8th segment of holotype (sternite to the right). 12, Female genitalia of paratype, on slide ECK 864. 13, Wing venation of male paratype, on slide ECK 976 (by A. Blanchard), Comal Co., Texas. Line in 11–12 = 1 mm.

Length of forewing.—Males: (N = 3), 8.1–11.2 mm, average 9.7 mm. Female: (N = 1), 12.5 mm.

Wing venation as shown in Fig. 13.

Forewing.—Costal half, above median vein, glossy yellowish white, with brownish streaks in intervenular spaces over apical half. Dorsal half below median vein pale brownish yellow, with a darker streak immediately below median vein.

Branches of median vein beyond cell, yellowish white. Apical half of fringe yellowish white, tornal half pale brownish yellow.

Hindwing pale fuscous, fringe yellowish white.

Male genitalia (Figs. 9, 10, 11).—Uncus tapering to a blunt point, heavily setose; gnathos subtriangular, divided slightly at base and apex; transtilla incomplete; aedeagus with inflated vesica shown in Fig. 10. Vesica densely scobinate toward apex. Fig. 11 represents unfolded 8th segment of abdomen of male, with sternite on right, bearing ventrolateral scale tufts.

Female genitalia (Fig. 12).—Ostium bursae broadly funnel shaped, lightly sclerotized; ductus bursae membranous; corpus bursae membranous, without signum.

Holotype (Fig. 7).—♂, Brewster Co., Texas, Big Bend National Park, K-Bar Research Station, 1-IV-84, genitalia on slide ECK 853, collected by E. Knudson and deposited in the National Museum of Natural History.

Paratypes.—Same data as for holotype, 1 ♀, genitalia on slide ECK 864; Brown Co., Texas, Lake Brownwood State Park, 30-IV-84, 1 ♂; Comal Co., Texas, Canyon Lake, 20-V-79, genitalia on slide ECK 111, left wings on slide ECK 976, all collected by E. Knudson.

Remarks.—Although *Anderida peorinella* bears little superficial resemblance to *A. sonorella* (Ragonot), the only other species in the genus, the structure of the head appendages, male and female genitalia, and wing venation argue strongly for placement in *Anderida* Heinrich (1956). Except for slight differences in the juxta and vinculum, the male genitalia are virtually identical to those of *sonorella.* The female genitalia are also very similar to those of *sonorella,* but lack a signum. Like *sonorella,* this new species is apparently quite variable in size. The name of the new species was suggested by its superficial resemblance to several Peoriinae which occur in the same region. It is easily distinguished from these by venation, and its well developed tongue.

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LITERATURE CITED

Heinrich, C. 1956. American moths of the subfamily Phycitinae. U.S. Natl. Mus. Bull. 207: 1–581.

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87(2), 1985, p. 480

NOTE

Lectotype Designation for *Pseudococcus affinis* (Maskell) (Homoptera: Coccoidea: Pseudococcidae)

In a recent paper (Miller, D. R., R. J. Gill, and D. J. Williams 1984, Proc. Entomol. Soc. Wash. 86: 703–713) we pointed out that *Pseudococcus affinis* (Maskell), 1894 (Trans. Proc. N. Z. Inst. 26: 65–105) is a senior synonym of the common mealybug pest *Pseudococcus obscurus* Essig, 1909 (Pomona Coll. J. Entomol. 1: 35–46). We included a comparative section on the diagnostic characters that can be used to distinguish between *P. affinis* and a commonly confused species, i.e., *P. maritimus* (Ehrhorn), and included detailed illustrations of adult females. For each name primary types were designated when such a specimen had not been designated previously. Unfortunately, we were unable to designate a lectotype for *P. affinis* because the best syntype specimen had been misplaced. The missing specimen now has been located, so a lectotype is designated for *P. affinis.*

From the three syntype slides of *Dactylopius affinis* we here designate as lectotype an adult female mounted alone on a slide with the following labels: left label "Dactylopius/affinis/adult female/1893 W. M. M."; right label "Lot no./7-74/no 4"; label on reverse of slide "Dactylopius/affinis Maskell/Lectotype/designated 1984/Miller and Williams." The left label is in Maskell's handwriting. The remaining two syntypes (an immature and a portion of the head of an adult female) are considered to be paralectotypes. All are deposited in the New Zealand Collection of Arthropods, Department of Scientific and Industrial Research, Auckland, New Zealand.

The lectotype possesses the following diagnostic characters (Miller et al., 1984, see above): 3 discoidal pores associated with each eye; 13 oral-rim tubular ducts on the dorsum of the abdomen; the longest seta on the ventral area of segment VII is 87 μ long; 150 and 154 translucent pores on the left and right hind tibiae respectively; 98 and 138 translucent pores on the left and right hind femora respectively; 1 ventral multilocular pore on the thorax; the anal-lobe setae are broken; without mediolateral oral-rim tubular ducts on the dorsum of segments III, IV, and V; the tenth cerarius is absent on one side and is present on the other; the hind tibiae are noticeably swollen; without oral-collar tubular ducts in a ventral submarginal cluster between cerarii 10 and 11.

These characteristics fall within the range of variation described in Miller et al. (1984, see above) for *P. affinis* except there are more translucent pores on the hind pairs of legs and the ventral seta on segment VII are longer. We do not consider these differences to be sufficient to distinguish *P. affinis* from *P. obscurus* considering the large range of variation observed in other material.

We are grateful to the following individuals for reviewing the manuscript: Manya B. Stoetzel and Donald R. Whitehead, Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, USDA; Jennifer Cox, Department of Entomology, British Museum (Natural History), London, England.

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87(2), 1985, p. 481

NOTE

Utilization of Tiger Beetle Larval Burrows by a Nest-provisioning Wasp, *Leucodynerus russatus* (Bohart) (Hymenoptera: Eumenidae)

Little is known about the nesting behavior of *Leucodynerus,* a genus of six species recently treated in Bohart (1982. J. Kans. Entomol. Soc. 55: 442–446). He reported finding females of *Leucodynerus cockerelli* (Cameron) nesting in a road cut and provisioning their nests with small gelechiid larvae.

My observations were made in the Sulphur Springs Valley, just south of Willcox, Cochise County, Arizona. The habitat was a saltbush flat dominated by fourwing saltbush and tobosa grass. Adult wasps were observed on several occasions in the summers of 1982 and 1983 in and adjacent to a shallow drainage swale which temporarily held small puddles of water during the summer rainy season. Vegetation cover was sparse (10–15%) in this specific microhabitat. Soil was a very hard packed, saline, sandy clay loam. Along the edges of the swale the soil was more loosely packed and higher in sand content.

On two occasions in mid-July, 1982, I noticed an adult of *Leucodynerus russatus* enter a third instar larval burrow of *Cicindela lemniscata* LeConte from which an adult tiger beetle had previously emerged. Tiger beetles pupate in the larval burrow and exit through the burrow opening at the soil surface. The burrows of *C. lemniscata* (one of the smallest U.S. species) were 1.9–2.3 mm in diameter and 15–24 cm deep and an appropriate size for the wasp. I excavated each of these burrows and found only the old larval head capsule and pupal exuvia. On July 29, 1983, I noticed a dead or paralyzed larva of *C. lemniscata* adjacent to a marked burrow. An adult female *L. russatus* and 4 lepidopteran larvae were found in the burrow and collected for identification. The prey were 2 Psychidae, 1 Gelechiidae and 1 Gelechioidea, probably Cosmopterygidae. It seems likely that the tiger beetle larva was stung and removed from its burrow by the wasp since larvae rarely leave their burrows.

These observations confirm that *L. russatus* uses tiger beetle larval burrows for nesting. Since the burrows had been precisely marked it is certain that they were made by tiger beetle larvae and not dug by wasps. However, the actual frequency of this behavior is not known. An indication is suggested by the observation of 5–6 wasps entering or exiting from burrows in an area where 200–250 burrows were being regularly followed during July and August of 1983.

I thank James M. Carpenter (Museum of Comparative Zoology, Cambridge, Massachusetts) for identifying the wasp and Donald M. Weisman (Systematic Entomology Laboratory, Agricultural Research Service, Washington, D.C.) for identifying the lepidopteran wasp prey. My work on tiger beetles was supported by the National Science Foundation (DEB8119256).

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SUMMARY REPORTS OF SOCIETY OFFICERS FOR 1984

EDITOR

This year the Proceedings published 986 pages, the greatest number in its history. This large number was due in part to the extra articles added on that were devoted to the Centennial celebration. Nevertheless, while more articles and pages were published, the number of submitted manuscripts also continued to increase. The time from date of submittal of a manuscript to publication grew inordinately long, to 12–14 months. I feared that the more timely and some of the more generally interesting manuscripts would be submitted elsewhere, thus reducing the diversity of our articles. To reduce the backlog, I decided to return new manuscripts that were: mere lists of insects from restricted localities, lists that perhaps do not need to be in the primary literature; descriptions of insects known from single specimens, with nothing specific known of their biology, and that do not appreciably change or enlarge generic concepts; and overlong manuscripts, those that would print to more than 15 pages. The Proceedings has for a long time had this 15 page guideline, but some years ago when there was no appreciable backlog the editors were able to accommodate some long manuscripts. As Associate Editor during 1983 I accepted all of those that were submitted. Since beginning the new policy early this year, I have returned 15 new submittals for the reasons listed above, but most because they were overlong. The backlog is now reduced to 8–10 months, at least mostly due to this policy. I do reserve the right to publish articles of longer length when I think they are extraordinary and would interest the general readership.

I take this opportunity to thank the many anonymous reviewers on whose judgment and recommendations I depend greatly. I consider them ad hoc members of the Publications Committee for the manuscripts they review. I do not list their names here because I thank the reviewers individually and keep them apprised of the progress on some of the manuscripts, and because of the anonymous nature of the review process (unless a reviewer wishes to be known to an author). The Publications Committee, made up of D. R. Smith, T. J. Spilman, and G. C. Steyskal, has been of great help on larger issues of policy. Mr. Steyskal helped further by checking scientific names in all manuscripts.

To help bring attention this year to the centennial of our Society, the cover of the Proceedings was changed to blue. Because all comments about the change were favorable, the color of the cover will remain blue.

Raymond J. Gagné, Editor.

TREASURER

(1 November 1983 to 31 October 1984)

Summary	General Fund	Special Publication Fund	Totals
On hand, 1 November 1983	34,790.45	53,017.10	87,807.55
Total receipts	63,361.04	18,784.59	82,145.63
Total disbursements	67,385.30		87,803.70
On hand, 31 October 1984	30,766.19	51,383.29	82,149.48

Thomas J. Henry, Treasurer.

PROC. ENTOMOL. SOC. WASH.
87(2), 1985, pp. 483–487

SOCIETY MEETINGS

906th Regular Meeting—June 7, 1984

The 906th Regular Meeting of the Entomological Society of Washington was called to order by President Neal O. Morgan in the Naturalist Center, National Museum of Natural History, at 8 p.m. on June 7, 1984. Twenty-five members and five guests were present. The minutes of the previous meeting were read and approved. Membership Chairman Geoffrey White read the names of the following applicants for membership: John J. Drea, Agricultural Research Service, Beneficial Insect Introduction Laboratory, Beltsville, Maryland; and Paul J. Johnson, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

It was moved by T. E. Wallenmaier and properly seconded that the Society implement an annual scholarship award; this implementation would only occur if the financial and administrative aspects are shown to be feasible. The vote was twelve for and thirteen against; the motion was not carried.

J. R. Aldrich showed a freeze-dried specimen of a hickory horned devil *Citheronia regalis* (Fab.) larva. T. J. Spilman showed an article from the newsweekly "Star," 29 May 1984, describing a dog that detects termites by smell. Stewart, the termite terrier, is used by an exterminator in Boston, Massachusetts. R. G. Robbins displayed two jars containing the heads of voles. Dr. Robbins explained why vole heads are good sources of ticks and chiggers. R. J. Gagné showed a slide of some unusual eggs in xylem of wood; he inquired if any members present could identify the eggs further.

The speaker for the evening was Jeffrey R. Aldrich, Insect Physiology Laboratory, USDA-ARS, Beltsville, Maryland, whose talk was entitled "Insect Husbandry: Attracting the Good Bugs." Dr. Aldrich first presented some background information regarding secretory aspects of some common Hemiptera. Research was done on the spined soldier bug, *Podisus maculiventris* (Say) (Pentatomidae), which contained very large pheromone glands. The pheromone was analyzed, and a synthetic was developed and put out in field tests in 1982 and 1983. The pheromone is very effective in luring large numbers of this predatory insect, and Dr. Aldrich sees interesting possibilities for crop protection activities by this capability to attract predators. Many other facets of Dr. Aldrich's research were presented including work on the pheromone of a predator of the Colorado Potato Beetle.

The meeting was adjourned at 9:30 p.m. after which refreshments were served.

Thomas E. Wallenmaier, *Recording Secretary*

907th Regular Meeting—October 4, 1984

The 907th Regular Meeting of the Entomological Society of Washington was called to order by President Neal O. Morgan in the Naturalist Center, National Museum of Natural History, at 8 p.m. on October 4, 1984. Twenty-three members and thirteen guests were present. The minutes of the previous meeting were read and approved with a minor correction. Membership Chairman Geoffrey White read the names of the following applicants for membership: Brian D. Farrell, Department of Entomology, University of Maryland, College Park, Maryland; David A. Grimaldi, Department of Entomology, Cornell University, Ithaca, New York; Rick L. Henry, 1713 Woodlawn Avenue, Logansport, Indiana; Paul K. Lago, Department of Biology, University of Mississippi, University, Mississippi; Charles H. Porter, 570 Villa Court, Norcross, Georgia; and Charles G. Wright, Department of Entomology, North Carolina State University, Raleigh, North Carolina.

Geoffrey White brought to the members' attention the death on August 18, 1984, of Truman B. Clark of a heart attack in Mexico. Dr. Clark had made many contributions to insect pathology including major advances in the area of spiroplasmas in insects. Mr. White reported that Lewis Berner, retired from the University of Florida, was granted emeritus status by the Executive Committee on October 3, 1984. Another member noted the passing of Dwight Delong at the age of 93. R. G. Robbins mentioned that members might wish to exchange journals with an entomologist in Brazil. Edd Barrows announced that Glen Echo, Maryland, has named the spicebush swallowtail as the town insect. Joyce Utmar showed a new publication titled "A Selected Bibliography of Insect-Vascular Plant Associational Studies" compiled by John M. Kingsolver, Suzanne W. T. Batra, and Joyce A. Utmar. This work is published as USDA Bibliographies and Literature of Agriculture, Number 27. George Steyskal read a few entertaining passages from a book titled "Dictionary of Usage and Style." Jeff Aldrich showed another freeze-dried caterpillar. Richard A. Newkirk showed his new book titled "Eriophyid Mites of Alfred Nalepa" published by the Entomological Society of America. Richard Robbins showed specimens of the world's most beautiful tick, *Amblyomma splendidum* Giebel, collected from an African buffalo.

The speaker for the evening was Dr. Austin P. Platt, Associate Professor of Biological Sciences, University of Maryland, Baltimore County, whose talk was titled "Evolution of North American Butterflies." Dr. Platt's emphasis was on intraspecific intergradation and interspecific hybridization of admiral butterflies, especially *Limenitis arthemis* (Drury), *L. astyanax* (Fabricius), and *L. archippus* (Cramer). Dr. Platt provided many details of his work, including a discussion of the methods used in his research, details of egg-laying and feeding behavior, predation, mimicry, and protective coloration. Many excellent slides were shown.

At the conclusion of the meeting two foreign visitors were introduced: Robert Brown of Liverpool Polytechnic, United Kingdom, and Rachel Galun, Hebrew University, Israel. The meeting was adjourned at 9:30 p.m. after which refreshments were served.

Thomas E. Wallenmaier, *Recording Secretary*

908th Regular Meeting—November 8, 1984

The 908th Regular Meeting of the Entomological Society of Washington was called to order by President Neal O. Morgan in the Naturalist Center, National Museum of Natural History, at 8 p.m. on November 8, 1984. Twenty-one members and ten guests were present. The minutes of the previous meeting were read and approved.

The President read a letter from Michael Kosztarab, Virginia Polytechnic Institute and State University, concerning the National Biological Survey proposal that we had endorsed previously. He is asking members to contact Congressmen to include in the Superfund Bill 10 million dollars per year for 10 years, one-half to go to the National Science Foundation and one-half to a government agency for the establishment of a central office for the survey.

T. L. Bissell told of collecting adults of the northern corn rootworm, *Diabrotica barberi*, on roses at Silver Spring, Maryland, and on roses and rose of sharon at Hyattsville, Maryland. He also reported that Rose Ella Spilman had collected 45 adults in one pink rose blossom in Hagerstown, Maryland, but found none in white rose blossoms.

W. E. Bickley showed pictures taken at the recent International Congress of Entomology. In addition, he showed two books: XVII International Congress of Entomology, Hamburg, Federal Republic of Germany, August 20–26, 1984, Abstract Volume (a full proceedings will not be published); Progress in World's Neuropterology, Proceedings of the 1st International Symposium on Neuropterology in Graz (Austria), 1984, editors J. Gepp, H. Aspock, and H. Holzel.

R. G. Robbins showed the world's largest ticks: *Amblyomma varium* (Ixodidae) from Central and South America and *Ornithodoros delanoei acinus* (Argasidae) from the Sahara.

Helen Sollers-Reidel again reported on the status of cat fleas in her home. She read a poem, written by herself, entitled Cat Flea Tales.

The Nominating Committee, D. R. Miller, T. J. Spilman, and W. E. Bickley, Chairman, presented a slate of candidates for office for the new year.

President-elect: Edward M. Barrows
Corresponding Secretary: Richard G. Robbins
Recording Secretary: Thomas E. Wallenmaier
Treasurer: Thomas J. Henry
Editor: Raymond J. Gagné
Program Chairman: Michael E. Schauff
Custodian: Victor L. Blackburn
Membership Chairman: Geoffrey B. White

The featured speakers for the evening were Richard W. Miller, Edward T. Schmidtmann, and Lawrence G. Pickens, all of Livestock Insects Laboratory, Agricultural Research Service, USDA, Beltsville, Maryland. Their presentation was entitled "Domestic and Foreign Survey for *Musca vitripennis* (Diptera: Muscidae)." A specimen of this species, the glass-wing fly, was found in 1982 in a warehouse at McGuire Air Force Base in New Jersey on cargo that had recently arrived from the Azores on a military aircraft. Nematodes were protruding from the labella of the mouthparts. This fly does not occur in North America, but in the Old World is a serious cattle pest that transmits nematodes that encyst under the skin of cattle and ruin meat for marketing. One week later at the same air base, one specimen was found on an aircraft from the Azores. A search was begun adjacent to the landing field at McGuire AFB to see if the fly had become established. Techniques were the same as those developed for surveying for face fly, house fly, and other flies that are attracted to cattle. These devices, such as pyramid traps, diamond traps, blood traps, etc., yielded 60,000 flies, but not one *Musca vitripennis* was found. In 1984, Miller and Pickens went to the Azores to determine if the fly, which is very common there, is attracted to the traps used in New Jersey. The glass-wing fly was common on cattle and thousands were captured in the traps. In addition, many *Hippobosca equina* flies (Hippoboscidae) were seen on cattle and even in a human beard. Those flies, too, are a serious pest of cattle. That species also does not occur in North America but could be accidentally introduced on aircraft; many specimens of this species and *M. vitripennis* were seen hovering around a dog and elsewhere on the aircraft in which the survey team returned to the United States.

At the conclusion of the meeting, Dr. Gerald W. Krantz, Oregon State University and National Science Foundation, was introduced.

The meeting was adjourned at 9:30 p.m. after which Helen Sollers-Reidel graciously served refreshments.

Theodore J. Spilman, *Acting Recording Secretary*

909th Regular Meeting—December 6, 1984

The 909th Regular Meeting of the Entomological Society of Washington was called to order by President Neal O. Morgan in the Naturalist Center, National Museum of Natural History) at 8 p.m. on December 6, 1984. Nineteen members and seven guests were present. The minutes of the previous meeting were read and approved. Membership Chairman G. B. White read the names of the following applicants for membership: Vernon A. Brou, Abita Springs, Louisiana; Stephen J. Harrison, Martin Marietta Environmental System, Columbia, Maryland; Austin P. Platt, University of Maryland, Baltimore County, Department of Biological Sciences, Catonsville, Maryland; and Russell D. Stewart, Annapolis, Maryland. He also reported that there were 44 new members for the year.

The annual Treasurer's report was given by T. J. Henry. As of October 31, 1984, the Society had a balance of $82,149.48. This included the general fund and the special publication fund. The Treasurer also reported that because of increased publication costs it may be necessary to increase page charges slightly.

The annual Editor's report was given by R. J. Gagné. He reported on activities for the year, the current backlog, and various aspects of publishing the proceedings.

W. E. Bickley, Chairman of the Nominating Committee, presented the slate of candidates for Society offices. With no additions from the floor, the slate was approved by acclamation.

J. Aldrich exhibited a freeze-dried specimen of an Imperial Moth. A member showed a copy of the 2nd edition of R. W. Merritt and K. W. Cummins' "Aquatic Insects of North America." W. E. Bickley informed members of some of the topics discussed at the recent meeting of the American Society of Tropical Medicine and Hygiene in Baltimore. He noted the incidence of an equine disease in whooping cranes in Maryland and the emergence of two new diseases in northeastern United States, lyme fever and Nantucket fever.

The speaker for the evening was Dr. Dennis F. Howard, U.S. Department of Agriculture—Agricultural Research Service, Subtropical Horticulture Research Station, Miami, Florida. His talk was entitled "Thysanoptera defense: turning tail to an advantage." *Bagnaliella yuccae,* a thrips that feeds on yucca plants, was studied in the field and in the lab to determine the extent of repellency of an anal exudate on ants which are predators of the thrips. Another thrips, *Gynaikothrips ficorum,* was then studied to determine how strong its anal exudate was in response to attack by predatory ants. The repellency was significant and the chemistry of the defense exudate was examined. A third thrips, *Elaphrothrips tuberculatus,* was also studied and a similar chemical defense was discovered. The talk included a good discussion of the behavioral changes caused by these chemical defenses and an analysis of their chemistry and possible origin in the thrips.

The meeting was adjourned at 9:25 p.m. after which refreshments were served.

Thomas E. Wallenmaier, *Recording Secretary*

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld	3.00
Both papers on cynipid galls	6.00
Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	1.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal	2.00

Memoirs of the Entomological Society of Washington

No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 167 pp. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
No. 8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No. 9.	The Flower Flies of the West Indies (Diptera: Syrphidae), by F. Christian Thompson. 200 pp. 1981	10.00
No. 10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky. Edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No. 11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kanmiya. 370 pp. 1983	18.00
No. 12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $25.00 per volume to non-members and $13.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra except on prepaid orders. Dealers are allowed a discount of 10 per cent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Custodian, Entomological Society of Washington, c/o Department of Entomology, NHB 168, Smithsonian Institution, Washington, D.C. 20560.

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of the
ENTOMOLOGICAL SOCIETY of WASHINGTON

PUBLISHED
QUARTERLY

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THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

ORGANIZED MARCH 12, 1884

OFFICERS FOR 1985

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, c/o Department of Entomology, NHB 168, Smithsonian Institution, Washington, D.C. 20560.

MEETINGS.—Regular meetings of the Society are held in the Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 8 P.M. Minutes of meetings are published regularly in the *Proceedings.*

MEMBERSHIP.—Members shall be persons who have demonstrated interest in the science of entomology. Annual dues for members are $15.00 (U.S. currency) of which $13.00 is for a subscription to the Proceedings of the Entomological Society of Washington for one year.

PROCEEDINGS.—Published quarterly beginning with January by the Society at Washington, D.C. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember subscriptions are $30.00 per year, domestic, and $35.00 per year, foreign (U.S. currency), payable in advance. Foreign delivery cannot be guaranteed. All remittances should be made payable to *The Entomological Society of Washington.*

The Society does not exchange its publications for those of other societies.

Please see p. 730 of the July 1984 issue for information regarding preparation of manuscripts.

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PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 489–497

AMBLYOMMA PAULOPUNCTATUM NEUMANN (IXODOIDEA: IXODIDAE): REDESCRIPTION OF THE MALE AND FEMALE, WITH AN ACCOUNT OF ITS KNOWN HOSTS AND DISTRIBUTION

JAMES E. KEIRANS

Department of Health and Human Services, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Department of Entomology, Museum Support Center, Smithsonian Institution, Washington, D.C. 20560.

Abstract.—The ♂ and ♀ of *Amblyomma paulopunctatum* Neumann are redescribed and illustrated. This porcine feeding tick species is found in forested areas of west and central Africa and is a candidate vector of *Coxiella burneti,* the causative agent of Q fever.

Amblyomma paulopunctatum Neumann primarily parasitizes members of the mammalian family Suidae but has occasionally been recorded from lizards, elephants and humans in equatorial Africa from Guinea-Bissau and Guinea eastward to Uganda and Burundi. Little information has been published on this uncommon tick, and the reports of the causative agent of Q fever (Tendeiro, 1953; Theiler, 1962) in *A. paulopunctatum* point to the need to investigate the role of this species as a disease vector in porcine and human infections.

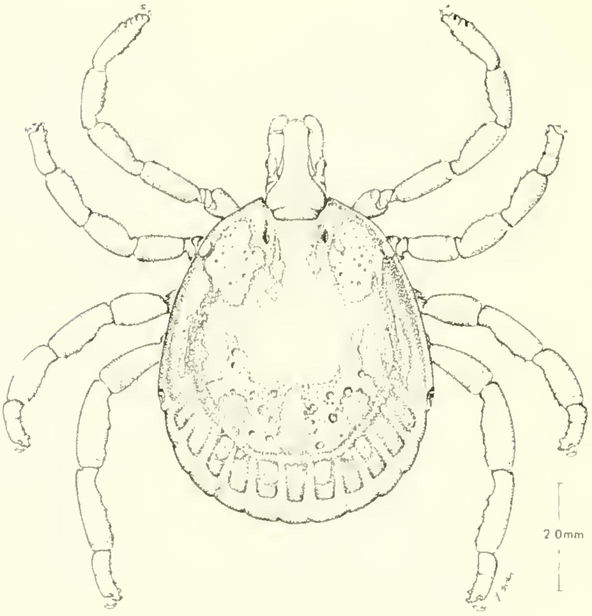
Amblyomma paulopunctatum was first described by Neumann (1899) from one male from an unknown host at Konakry, French Guinea, now Conakry, Guinea. Subsequently (Neumann, 1905), he had a change of mind and relegated *A. paulopunctatum* to a variety of *Amblyomma sparsum* Neumann, 1899. Three years later (Neumann, 1908) he described the female under the name *Amblyomma trimaculatum* from one specimen from an unknown host at Robertsport, Liberia. Nuttall (1916a, b) reproduced Neumann's figure of this female.

Following is a redescription of the male and female. All measurements are in millimeters. Fifteen males and 12 females were measured. A range is given followed by a mean in parentheses. Specimens were prepared for scanning electron microscopy by the method of Corwin et al. (1979).

Amblyomma paulopunctatum Neumann

Amblyomma paulopunctatum Neumann 1899: 248.
Amblyomma sparsum paulopunctatum Neumann 1905: 233.
Amblyomma trimaculatum Neumann 1908: 84, figs. 5–7.

Redescription.—Male (Figs. 1–6).—Length from scapular apices to posterior body margin 4.83–7.00 (5.74), width 4.10–5.85 (4.85), widest at level of spiracular plates, outline oval. Scutal length from scapular apices to anterior margin of



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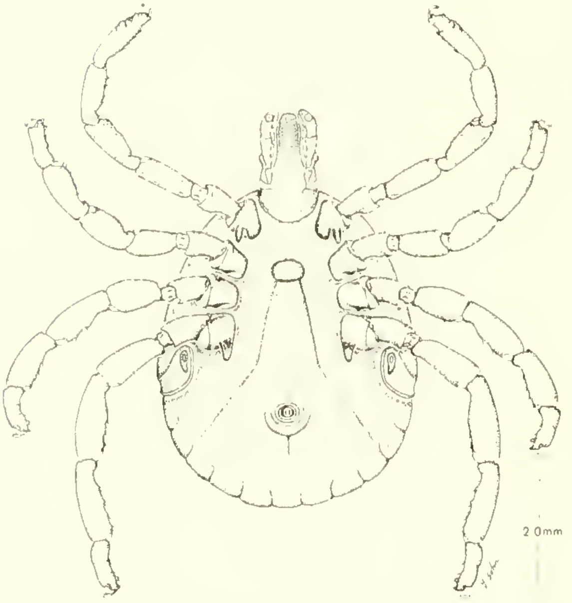

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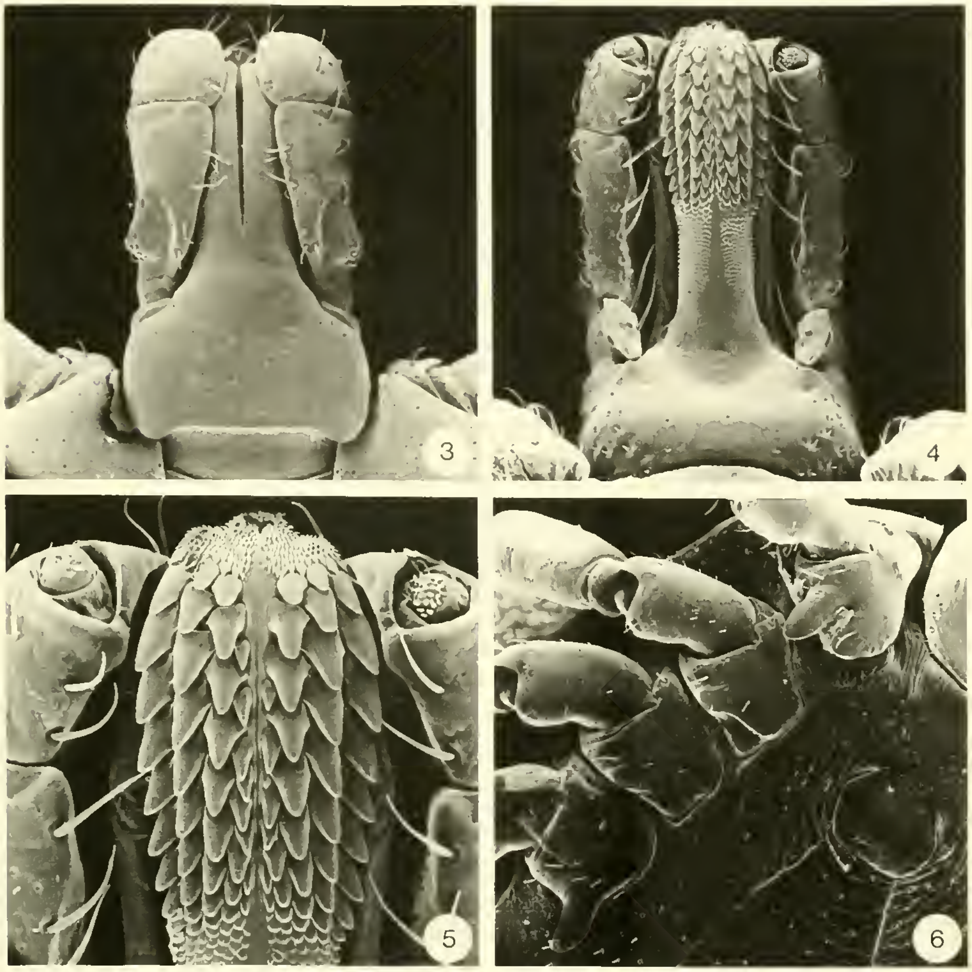
Figs. 1, 2. *Amblyomma paulopunctatum* ♂ ZAIRE (RML 116826). 1, Dorsal view. 2, Ventral view.

festoons 3.95–5.70 (4.69), width between marginal grooves 3.18–4.50 (3.73). *Scutum* (Fig. 1) ornate, typically with a large pale spot near each eye and pale spots near festoon 1 and festoons 4–5, posteroaccessory stripes and posteromedian stripe indicated by interruptions of coloration between these spots; marginal spots rep-



Figs. 3–6. *Amblyomma paulopunctatum* ♂ ZAIRE (RML 116826). 3, Capitulum, dorsal view (50×). 4, Capitulum, ventral view (63×). 5, Hypostome (138×). 6, Coxae I–IV (50×).

resented by a continuous pale stripe anterior to festoon 1; lateral spots fused into a stripe and usually present medial to but less obvious than marginal spots. Ornamentation typically on festoons 3–6 (32 specimens) or 3–5 (30), occasionally on 2–6 (5) and on one specimen each 2–5 and 3, 5. *Marginal groove* deep, well demarcated, punctate, extending to level of eyes. *Cervical grooves* short, with deep pits. *Eyes* large, flat, level with scutal surface. Scutal punctations few, large, scattered.

Venter (Fig. 2) without ventral plaques; genital aperture between coxae II; setae minute, randomly scattered.

Capitulum (Figs. 3, 4): Length from palpal apices to cornua apices 1.75–2.35 (2.02), width 0.95–1.30 (1.11); *basis capituli* dorsally subrectangular; all specimens examined lack ornamentation, posterior margin straight between subtriangular cornua. Ventrally with posterior margin broadly rounded; a few minute, white setae at each posterolateral angle. *Palpi* length 1.33–1.80 (1.50), width 0.43–0.55

(0.50); average lengths of segments I–III, 0.22, 0.87, 0.42, respectively. Palpal segment II with a small knob-like posteroexternal ridge. *Hypostome* (Figs. 4, 5) about as long as palpi; length of toothed portion (excluding posterior crenulations) 0.58–0.83 (0.67); dental formula 3.5/3.5. Usual number of teeth per file as follows: I-8, II-7, III-7, III.5—variable, from 3–9, often 5–7; apex with numerous fine denticles.

Legs (Fig. 6) long, femur and tibia with pale ring at segment's distal end. Coxae I with two moderately long broad spurs, the external slightly longer; II and III each with a short bluntly rounded spur; IV with a moderately long, slightly curved spur. Trochanters lack spurs. Tarsus I length 1.25–1.50 (1.36), width 0.40–0.50 (0.44), tarsus IV length 0.75–1.03 (0.95), width 0.30–0.45 (0.37).

Female (Figs. 7–12).—Dorsum convex as in ♂. Length (unfed, exclusive of capitulum 5.75–7.23 (6.53), width 4.88–5.75 (5.33). *Scutum* length 2.88–3.38 (3.17), width 3.58–4.13 (3.92), outline as illustrated; scapulae bluntly rounded. Ornamentation variable in distribution but essentially as illustrated; cervical stripe narrow, fused with limiting spot; marginal scutal coloration dark brown. *Eyes* and *cervical grooves* as in ♂. A few deep punctation in cervical areas and scattered over scutum; punctations shallower and more numerous in anterolateral areas. Dorsum of body leathery; *marginal groove* complete, deep; festoons 11, well delineated.

Venter (Fig. 8): Details of integument, genital area, and spiracular plate as illustrated. Genital aperture (Fig. 11) broadly U-shaped with lateral rim thickened, smooth.

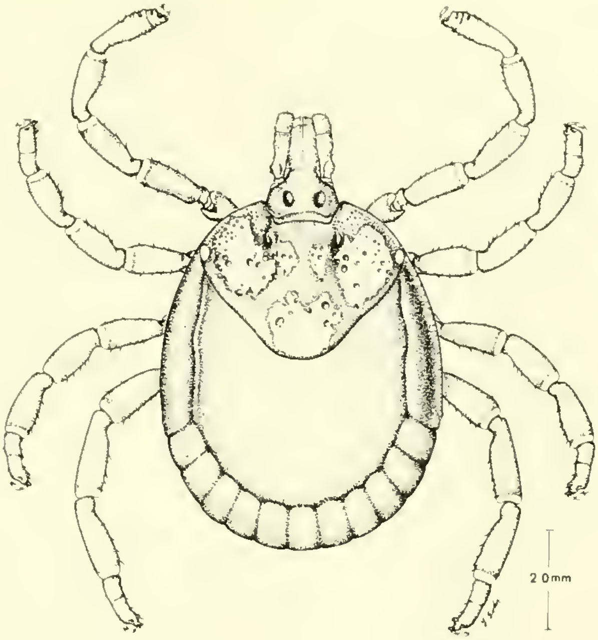
Capitulum (Figs. 9, 10) length from palpal apices to cornua apices 2.13–2.43 (2.28), width 1.25–1.40 (1.32); porose areas moderately large, diameter of one area 0.19–0.30 (0.25); interporose area 0.16–0.25 (0.24); setae absent; posterior margin straight between moderately large, rounded cornua; external margin of basis broadly convex. Ventrally as figured (Fig. 10) with several minute setae at each posterolateral angle. *Palpi* length 1.55–1.93 (1.74), width 0.50–0.60 (0.54); average lengths of segments I–III, 0.21, 1.03, 0.50 respectively; configuration of palpal segment II similar to that of ♂. *Hypostome* (Fig. 10) length of toothed portion 0.69–0.75 (0.72) (9 measured); dental formula 3.5/3.5 or 4/4, denticles in files of 7–10 with crenulations continuing posteriorly toward base; apex indented with a large corona of fine denticles.

Legs (Fig. 12) long, each free segment with a pale annular ring at the distal extremity. Coxae I with a broad, flat, triangular internal spur and a longer, narrower, bluntly rounded external spur; coxae II, III each with a single plate-like spur about as wide as long; coxae IV with a rounded, slightly elongate spur. Trochanters lack spurs. Tarsus I length 1.43–1.73 (1.59), width 0.43–0.48 (0.45); tarsus IV length 1.00–1.25 (1.13), width 0.33–0.45 (0.38).

MATERIAL EXAMINED

Two hundred and five specimens of *A. paulopunctatum* were examined during this study: 122 ♂, 66 ♀, 14 N, 3 L. Although not derived from a reared series, the immature stages are tentatively considered to be *A. paulopunctatum* based upon the descriptions and figures of Elbl (1977).

GUINEA 1 ♂ (holotype), (RML 117338), Conakry (09°31′N, 13°43′W), no host or date, Maclaud. SIERRA LEONE, 1 ♂ (RML 66663), Freetown (08°30′N,



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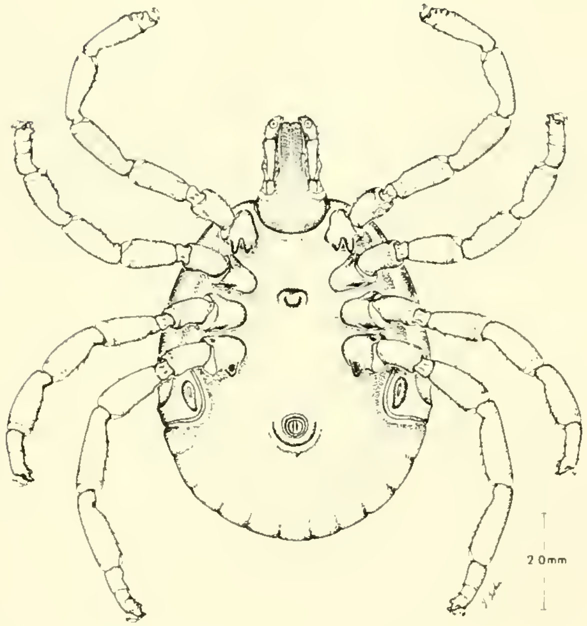

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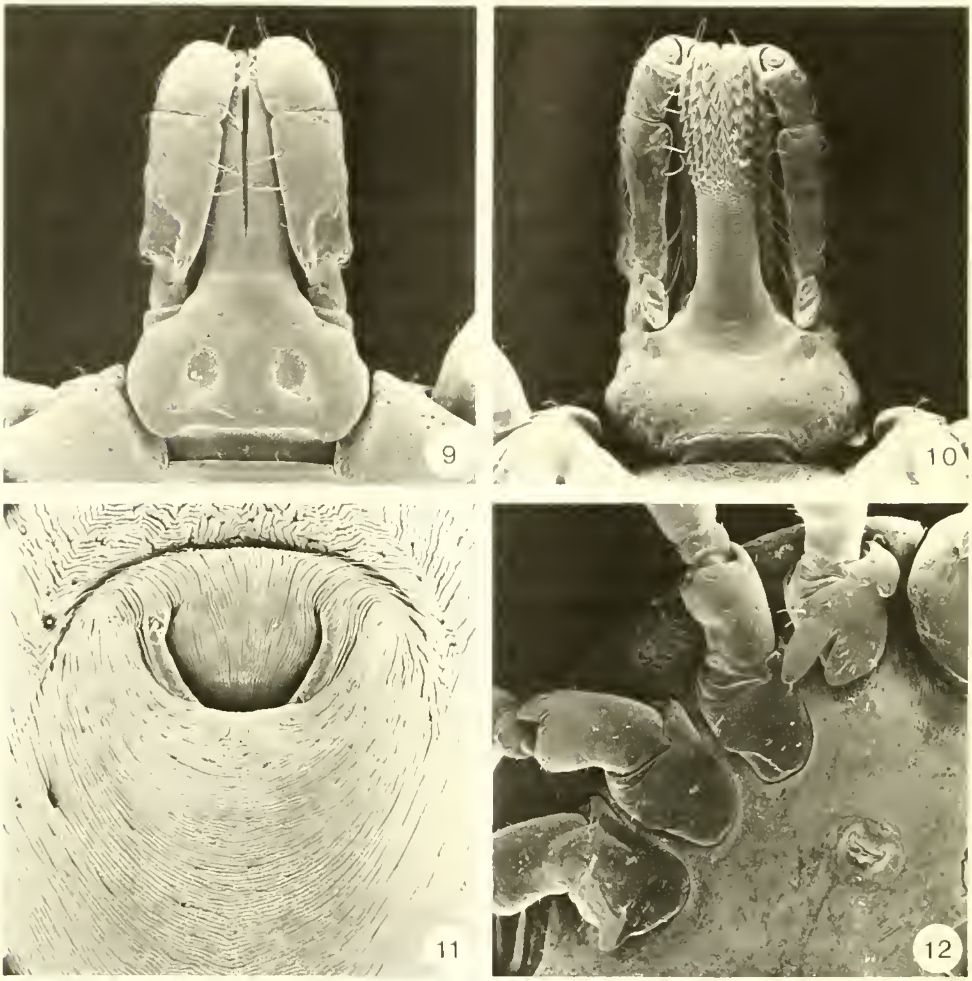
Figs. 7, 8. *Amblyomma paulopunctatum* ♀ ZAIRE (RML 116826). 7, Dorsal view. 8, Ventral view.

13°15′W), fell from grass onto collector's shoe, IX.1949, Dr. W. Peters; 1 ♂ (RML 116963), no specific locality, host, or date. [This ♂ had at one time been pinned. A small label with a pin hole in it has the words "From W. F. H. Rosenberg".] CAMEROUN, 1 ♂ (RML 117035), Yaoundé (03°52′N, 11°13′E), "sur Porc" (pre-



Figs. 9–12. *Amblyomma paulopunctatum* ♀ ZAIRE (RML 116826). 9, Capitulum, dorsal view (38×). 10, Capitulum, ventral view (38×). 11, Genital aperture (125×). 12, Coxae I–IV (38×).

sumably *Sus scrofa*), 4.VI.1951, J. P. Qolam (?). ANGOLA, 3 ♀ (RML 111286), (Nuttall 2478), São Salvador do Congo (06°16′S, 14°15′E), *Varanus* sp., IX.1913, received from Dr. Mercier Gamble; 1 ♂, 1 ♀ (RML 117055), Canzele (08°17′S, 15°11′E), *Potamochoerus porcus koiropotamus*, 17.II.1955, Gerd Heinrich; 3 ♂, 1 ♀ (RML 117056), Lua Passo (locality not verified), *Sus scrofa*, IX.1955, Dr. Victor Matos. CENTRAL AFRICAN REPUBLIC, 2 ♂ (RML 116936), Carnot (04°48′N, 16°03′E or 04°56′N, 15°52′E), Oubangui-Chari, *Potamochoerus porcus*, II.1952, R. Rousselot; 4 ♂, 1 ♀ (RML 116984), no specific locality, *Potamochoerus porus*, 29.V.1971, P. C. Morel; 5 ♂, 2 ♀ (RML 117339) (HH 112055), Boku River (05°16′N, 26°10′E), near Obo, Haut-Mbombou, *Phacochoerus aethiopicus* (3 yrs. old), XII.1979, B. J. Linquist (from F. Mwakima). UGANDA, 1 ♀ (RML 111971) (Nuttall 3091), Daro Forest, Toro District (00°30′N, 30°30′E), off grass, X.1911, S. A. Neave; 7 ♂, 3 ♀ (RML 116937), Masindi (01°03′N, 31°43′E), *Hylochoerus meinertzhageni*, 5.VII.1952, Fazal Haq; 1 ♀ (RML 117335) (HH 39175), Queen

Elizabeth National Park (00°15′S, 30°00′E), near Kayanja, Hyaena sp. (central den) I.1967, A. J. Sutcliffe; 3 ♂, 2 ♀ (RML 117336), no specific locality, *Potamochoerus porcus,* II.1911, Capt. A. D. Fraser. BURUNDI, 3 ♂, 3 ♀ (RML 117045), Rumonge (03°59′S, 29°26′E), *Phacochoerus aethiopicus,* 5.IV.1949, F. Y. Francois. ZAIRE, 2 N (RML 117038), Bagata (03°44′S, 17°57′E), *Potamochoerus porcus,* VIII.1945, A. Fain; 4 N (RML 117049, all data as above; 2 N (RML 117043), Bolo (03°40′S, 17°20′E), *Potamochoerus porcus,* no date, A. Fain; 2 N (RML 117042), Balibi (03°58′S, 18°28′E) [Elbl (1977) cited the locality as Bolobo], *Potamochoerus porcus,* V.1945, A. Fain; 4 ♂, 1 ♀ (RML 117052), Luiza (07°12′S, 22°25′E), *Potamachoerus porcus nyassae,* VIII.1956, M. Poll; 1 ♂ (RML 117041), Doruma (04°44′N, 27°42′E), host unknown, 16.XII.1928, Henrard; 2 ♂ (RML 117040), locality as above, *Phacochoerus aethiopicus,* no date, H. Schouteden; 11 ♂, 8 ♀ (RML 117044), Gwane (04°43′N, 25°50′E), Uele District, *Phacochoerus aethiopicus* [cited as *Potamochoerus* in Elbl and Anastos (1966)], 1931, Bentz; 1 ♀ (RML 117036), Arebi (02°45′N, 29°37′E), *Potamochoerus porcus,* 20.VII.1925, H. Schouteden; 2 ♂, 4 ♀ (RML 116964), Avakubi (01°20′N, 27°34′E), *Potamochoerus porcus,* no date or collector; 2 N (RML 117054), Beno (03°37′S, 17°48′E), *Potamochoerus porcus,* III.1945, A. Fain; 1 ♂, 2 ♀ (RML 117047), probably Bosolindo (04°14′N, 19°55′E), *Potamochoerus porcus,* 29.VI.1929, Y. Berteaux; 8 ♂, 2 ♀ (RML 117050), Valalonka (locality not verified), Kwango District, *Potamochoerus porcus,* 1945, A. Fain; 1 ♀ (RML 117039), Bolobo (02°10′S, 16°14′E), *Potamochoerus porcus,* IV.1921, H. Schouteden; 1 ♂ (RML 117051), all data as above; 3 ♂, 1 ♀ (RML 117037), Haut-Lopori (00°35′N, 22°53′E), *Potamochoerus porcus,* X.1927, I. Ghesquière; 2 ♀ (RML 116962), locality and host as above, no date or collector; 1 ♂ (RML 117046), Penge (04°27′S, 28°26′E), host unknown, VII.1932, Putnam; 1 N (RML 117053), Tshuapa, Ikela (locality not verified), *Afropavo congolensis,* 1956, R. P. Lootens; 1 N, 3 L (RML 117048), Simba (00°36′N, 22°55′E), *Afropavo congolensis,* no date, L. G. Benoit.

The following 7 collections were all originally part of a single collection made during the American Museum of Natural History Congo Expedition [see Dickerson (1910), Lang (1915)]. Over the years the collection has been split up and specimens deposited in several museums.

ZAIRE, Medje (02°25′N, 27°18′E), *Hylochoerus meinertzhageni,* VI.1914, H. Lang & J. P. Chapin: 40 ♂, 8 ♀ (RML 18562) in the AMNH collection; 6 ♂, 6 ♀ (RML 18562), 5 ♂, 5 ♀ (RML 116826), 1 ♂ (RML 46458) all in the USNM collection; 1 ♂, 3 ♀ (RML 116961) in the MCZ collection; 2 ♂, 2 ♀ (RML 117085) in the Ohio State University collection, formerly in the University of Maryland collection; 5 ♂, 4 ♀ (RML 112370) (Nuttall 3437) in the Nuttall collection, British Museum (Nat. Hist.), presented by S. Hadwen, VII.1922, and cited by Robinson (1926) as originating in West Africa although, in the Nuttall catalogue, the collecting locality is listed as Congo (Keirans, 1985). Bequaert (1930) also discussed this collection.

Hosts and Distribution

As can be seen from the host records above, *A. paulopunctatum* has a strong affinity for members of the mammalian family Suidae. Of the 36 collections examined, 26 are from members of this family, 6 collections from grass or unknown hosts, 2 from birds (Phasianidae), and one each from a hyaena den and a reptile, *Varanus* sp. The report of *A. paulopunctatum* on tortoise (Rageau, 1951) was actually of *A. nuttalli* (Rageau, 1953). Theiler and Salisbury (1959) saw a male *A. paulopunctatum* which had been collected on an elephant in Cameroun (Ziemann collection, Berlin) and Morel (1959) a male from a human, Yapo, Ivory Coast. Reports of *A. paulopunctatum* parasitizing man are very rare although there is a possibility that immatures of this species may attach to the nasal mucosa of humans (Walton, 1960).

Amblyomma paulopunctatum is found in forested areas with an average rainfall of over 1500 mm (Theiler, 1962) and is distributed roughly between 10°N and 10°S of the equator, from the Atlantic coast in the west to approximately 32°E in Uganda.

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I am grateful to the following individuals for the loan of *Amblyomma paulopunctatum* specimens: Anne S. Baker, British Museum (Nat. Hist.), London; Jean-Louis Camicas, ORSTOM, Dakar; Harry Hoogstraal, NAMRU-3, Cairo; John Kethley, Field Museum of Natural History, Chicago; Herbert Levi, Museum of Comparative Zoology, Harvard University, Cambridge; Michel Naudo, Muséum National d'Histoire de Zoologie, Paris; F. Puylaert, Musée Royal de L'Afrique Centrale, Tervuren; J. A. T. Santos Dias, Instituto de Investigacão Cientifica Tropical, Lisbon; Randall T. Schuh, American Museum of Natural History, New York City; Jane B. Walker, Veterinary Research Institute, Onderstepoort; W. Calvin Welbourn, Ohio State University, Columbus. The pen and ink illustrations and scanning electron photomicrographs were produced by the deft hands of Young Sohn and Dan Corwin, respectively.

LITERATURE CITED

Bequaert, J. 1930. Ticks collected by the American Museum Congo Expedition 1909–1915, with notes on the parasites and predaceous enemies of these arthropods. Am. Mus. Novit. (426): 1–11.

Corwin, D., C. M. Clifford, and J. E. Keirans. 1979. An improved method for cleaning and preparing ticks for examination with the scanning electron microscope. J. Med. Entomol. 16: 352–353.

Dickerson, M. C. 1910. In the heart of Africa. The first published account of the museum's Congo expedition. Am. Mus. J. 10: 147–170.

Elbl, A. 1977. Ixodid ticks (Acarina, Ixodidae) of central Africa. Volume V. The larval and nymphal stages of the more important species of the genus *Amblyomma* Koch, 1844. Ann. Mus. R. Afr. Cent. Sér. 8° Sci. Zool. N° 222: 158 pp.

Elbl, A. and G. Anastos. 1966. Ixodid ticks (Acarina, Ixodidae) of central Africa. Volume I. General introduction. Genus *Amblyomma* Koch, 1844. Ann. Mus. R. Afr. Cent. Sér. 8° Sci. Zool. N° 145: 275 pp.

Keirans, J. E. 1985. George Henry Falkiner Nuttall and the Nuttall tick catalogue. U.S.D.A. Misc. Publ. (1438): 1–1785.

Lang, H. 1915. An explorer's view of the Congo. Am. Mus. J. 15: 379–388.

Morel, P. C. 1959. Enquête sur les parasites des animaux domestiques en Republique de Côte d'Ivoire. Mission du 19 mai au 26 juin 1959. Laboratoire Central de L'Elevage "Georges Curasson"; Dakar. 63 pp. [Mimeographed].

Neumann, L. G. 1899. Revision de la famille des ixodidés (3ᵉ Mémoire). Mém. Soc. Zool. Fr. 12: 107–374.

———. 1905. Notes sur les ixodidés. III. Arch. Parasit. 9: 225–241.

———. 1908. Notes sur les ixodidés. VII. Notes Leyden Mus. 30: 73–91.

Nuttall, G. H. F. 1916a. Ticks of the Belgian Congo and the diseases they convey. Bull. Ent. Res. 6: 313–352.

———. 1916b. Les tiques du Congo Belge et les maladies qu'elles transmettent. Belgique Min. Colon. Serv. Agric. Etud. Biol. Agric. (2): 52 pp.

Rageau, J. 1951. Ixodidés du Cameroun. Bull. Soc. Path. Exot. 44: 441–446.

———. 1953. Note complémentaire sur les Ixodidae du Cameroun. Bull. Soc. Path. Exot. 46: 1090–1098.

Robinson, L. E. 1926. Ticks. A monograph of the Ixodoidea. Part IV. The genus *Amblyomma*. Cambridge Univ. Press. 302 pp.

Tendeiro, J. 1953. Alguns dados sobre as estirpes de *Coxiella burneti* isoladas na Guiné Portuguesa. Bol. Cult. Guiné Port. 8: 69–87.

Theiler, G. 1962. The Ixodidea parasites of vertebrates in Africa south of the Sahara (Ethiopian region). Rep. Dir. Vet. Serv. Onderstepoort, Proj. (S. 9958): 255 pp. [Mimeographed].

Theiler, G. and L. E. Salisbury. 1959. Ticks in the South African zoological survey collection—Part IX—"The *Amblyomma marmoreum* group." Onderstepoort J. Vet. Res. 28: 47–124.

Walton, G. A. 1960. A tick infesting the nostrils of man. Nature, Lond. (4756) 188: 1131–1132.

PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 498–511

NICHE SEPARATION AND COMPETITIVE COEXISTENCE IN MYCOPHAGOUS *DROSOPHILA* (DIPTERA: DROSOPHILIDAE)

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Abstract.—Four species of mycophagous *Drosophila* whose larvae experience food limitation in nature overlap broadly in their utilization of various mushroom species. Interspecific competition is intensified by the presence of other Diptera in mushrooms, by the attractiveness of particular mushrooms for *Drosophila*, and by a preference of two of the *Drosophila* species with slow development for older, more crowded mushrooms. Competitive exclusion should be slowed by the large fluctuations in population sizes of these flies, and also prevented by interspecific differences in host use. Variation in host use results from differences among fly species in habitat occurrence, host preferences by ovipositing females, and the suitability of various resources for larval development.

Among *Drosophila*, mycophagous species are especially suitable for ecological study since they are diverse and usually abundant, their larval feeding sites are discrete, and they must contend with a suite of sometimes harsh selection pressures imposed by their mushroom hosts. Although mushrooms vary in the physiological challenges they present to flies, specialization upon individual species would seem difficult since mushrooms are both spatially and temporally unpredictable in occurrence. This is because fructification is dependent on suitable rainfall, temperature, and edaphic conditions (Wilkens and Harris, 1946; Shorrocks and Charlesworth, 1980), and because the fruiting bodies themselves are so ephemeral. It is not surprising, then, that the common mycophagous drosophilids of the northeastern United States—*Drosophila falleni* Wheeler, *D. recens* Wheeler, *D. putrida* Sturtevant, *D. testacea* Roser—are polyphagous, each species having been bred from 10 to 20 genera of fleshy fungi (reviewed in Grimaldi, 1983). In contrast, *Mycodrosophila claytonae* Wheeler and Takada and *Drosophila duncani* Sturtevant in the United States and *D. phalerata* Meigen in England specialize on fungi that are particularly long-lasting and thus more predictable in occurrence (Shorrocks and Charlesworth, 1980, 1982; Lacy, 1984).

Given the facts that (1) mushrooms are unpredictable resources; (2) mycophagous drosophilids overlap broadly in the species of mushrooms they use as breeding sites as a result of their polyphagy; and (3) the four common mycophagous *Drosophila* of the Northeast often occur sympatrically, then one might conclude that these species rarely if ever experience food shortages. This interpretation, however, is not supported by the facts.

In a previous study (Grimaldi and Jaenike, 1984) it was shown that mushrooms occurring in the field are in limited supply for *Drosophila falleni, D. recens, D.*

putrida and *D. testacea* and for two other Diptera, the cranefly *Limonia triocellata* (Osten Sacken) (Tipulidae) and the woodgnat *Sylvicola alternatus* (Say) (Anisopodidae). Mushrooms were separated into halves, to one half of each more mushroom was added in order to release larvae from competition for food. Pairwise comparisons of halves for each mushroom revealed that mortality and sizes of flies bred from them were adversely affected in the control (unsupplemented) halves. Although the experimental design could not distinguish between the effects of conspecifics or not, it is very likely that both intraspecific and interspecific competition occurred.

Host use was compared for *Drosophila falleni, D. recens, D. putrida*, and *D. testacea* based on breeding records and inferences made from other characteristics. Presumably, trophic morphologies, such as egg and larval mouthpart shapes are associated intimately with the types of breeding site (Okada, 1963; Kambysellis and Heed, 1971). The habitats and seasons in which *Drosophila* occur determine which hosts flies can encounter. Since larvae are not vagile and because oviposition is generally restricted to fewer hosts than the number that larvae can actually use (Kearney, 1982), oviposition site preference is another ecologically important trait in *Drosophila*. Although their coexistence may result from a balance between the rates of migration and local competitive exclusion (Horn and MacArthur, 1972; Atkinson and Shorrocks, 1981; Kneidel, 1983), the ecological differences documented here among the four *Drosophila* species are probably important in allowing their coexistence during competition.

METHODS

Most field portions of the study were conducted from the spring through early fall of 1981 and 1982 at Chenango Valley State Park, the SUNY Binghamton Nature Preserve, and a site in Vestal, New York. *Drosophila* were reared from various field-collected substrates on top of moist sand and leaf litter in various gauze-covered containers. Lab portions of the study used flies raised on commercial mushroom, *Agaricus bisporus. Drosophila testacea* was difficult to rear because a strongly female-biased sex ratio became established in lab populations. Therefore, it was not used in tests of oviposition preference and in most larval development comparisons. Adult size was determined by measuring the length from the anterior thorax to the posterior tip of the scutellum at 30× magnification with an ocular micrometer. All measured flies were first preserved in 70% ethanol.

Trophic morphologies.—Larval mouthpart structure and egg morphology were compared for *Drosophila falleni, D. recens, D. testacea*, and *D. putrida* and some non-mycophagous species that were chosen for their ease in culturing, phylogenetic relationships, and breeding sites. Only newly laid eggs and third instar larval mouthparts were used. Mouthparts were first dissected from larvae and adhering tissue cleared away in hot 10% KOH.

Larval development.—Larvae were raised on two-gram pieces of mushroom. Three females per vial were first allowed to oviposit for 24 hours on each piece, then removed.

Development time for the four mycophagous species was determined in two trials. Trial one measured time from egg to eclosion on three different substrates: frozen and fresh *Agaricus bisporus*, and frozen *Amanita muscaria*. Nine replicates per substrate were made for each species except *D. testacea*, which could not be grown. Since only small differences for substrate effects were found in *D. recens*, the results for all three substrates were combined. Trial two measured the time from egg to pupation and to eclosion on only fresh *Agaricus*. Twelve replicates for each of the four species were set up in trial two, but only *D. falleni* was viable in all of them. Some *D. testacea* cultures were also used here. Development time was measured as $\sum_{i=1}^{n}$ (% flies developed) (day number) for each vial. An ANOVA for unequal N, done within trials only, compared development times among species.

Abilities of larvae of three of the mycophagous species to subsist on three commonly used fungus hosts at three temperatures were compared. Adult size was used as an indicator of how well larvae developed. *Amanita muscaria* was chosen as one rearing substrate since it is soft, deliquesces with age, and contains toxins (Wieland, 1968). *Russula compacta* has denser tissue, decays slower, and contains no known toxins. *Polyporus squamosus*, a very distinctive host, is leathery, decays slowest, and also has no known toxins. Fifteen, 21, and 27°C were chosen as representatives of the range of temperatures to which larvae are exposed in nature. There were three replicates per treatment. From each treatment 20 males and 20 females (if available) were pooled and measured. A 2-way ANOVA for unequal N tested for the main effects of temperature and substrate and for any interactions. Duncan's multiple range test delimited pairs of similar treatment effects for each species (Sokal and Rohlf, 1969).

Population size: seasonal and habitat variation.—A constant-effort trapping technique, using the trap in Fig. 1, assessed phenology. Each trap, suspended 1.5 m from the ground, was baited with equal amounts of whole banana mashed with yeast and smeared to the walls of the upper chamber. The trap was designed so that flies would enter the black bottom chamber, become attracted to the bait and light from the top chamber and fly into it. Since escape of the flies is limited by the small hole in the mesh cone, flies would accumulate in the upper chamber of the trap during the six-day trapping period. Between two and four traps were used at each sampling. Population size during a trapping period was denoted as the mean number of flies per trap in each of the two study sites. No statistics were done on the data; comparisons were made visually on plotted trends for the presence of any numerical changes.

Flies were trapped in three different locations in the eastern United States to see if species separated by altitude or forest type at each location. The geographic locations and collection periods were Mount Desert Isle, ME from 29 June to 1 July 1982, the Great Smoky Mountains National Park, TN from 18 July to 23 July 1982 (J. Jaenike, collector), and East Charleston, VT from 18 July to 27 July 1982. At each location a high elevation/coniferous forest site and a low elevation/deciduous forest site were sampled (for details of each site, see Grimaldi, 1983). Bait was always mushroom, sometimes mixed with bananas or tomatoes (but always the same between sites at each location), which was then kept out for five days and sampled intermittently. Flies were pooled according to habitat and collecting period. A chi-square test was used to examine differences in species distribution.

Oviposition site preference (OSP).—Possible differences in the use of rotted

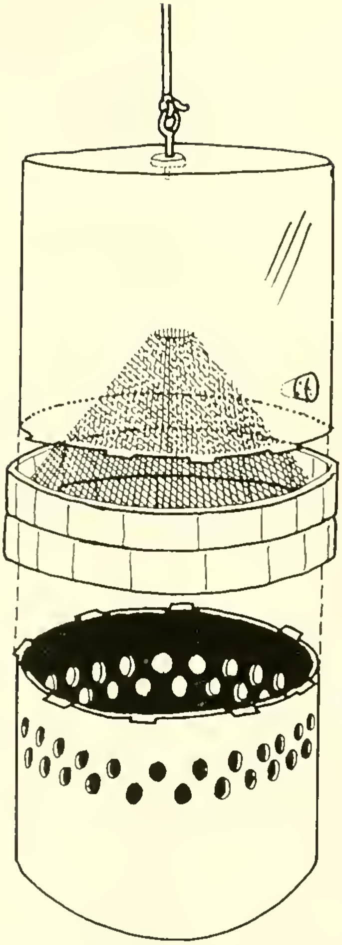

Fig. 1. *Drosophila* trap used to monitor population sizes.

versus fresh mushrooms were examined for the four mycophagous species. Seven rotted and nine fresh *Amanita* mushrooms growing in close proximity to each other were found at the SUNY Binghamton Nature Preserve (New York: Vestal, Broome County) on 21 July 1981. *Drosophila* adults on them were netted, identified, and counted. Since the mushroom surfaces had eggs on them, I assume that attractiveness to various *Amanita* is directly related to where the females oviposit (i.e. Fellows and Heed, 1971 for cactiphilic *Drosophila*).

The effects of host composition on OSP in *D. falleni, D. recens, D. putrida,* and also *D. immigrans* (a fruit breeder) were compared. Three mushroom and two plant substrates were prepared by blending each with water and agar, heating the mixture to 70°C, pouring it into test tubes and slicing equal sized plugs from each mold when the substance had solidified. The homogenization reduced the large variation in OSP found when unadulterated substrate pieces were offered because of differences in piece sizes, texture, and shape. The substrates used were *Amanita muscaria* (a toxic agaric with mild smell), *Russula compacta* (a nontoxic, fishy-

Table 1. Number of Diptera reared from mushrooms.

	Amanita				*Russula*				
	Chenango Valley		Vestal		Chenango Valley		Vestal		
	1981	1982	1981	1982*	1981*	1982	1981	1982	Total
Drosophila	276	523	1314	—	—	567	406	36	3122
Limonia	0	0	0	—	—	84	0	34	118
Sylvicola	0	0	0	—	—	268	0	0	268
Megaselia	0	501	0	—	—	0	0	0	501
Bradysia	0	0	0	—	—	0	0	122	122
Mycetophila	0	47	0	—	—	11	0	0	58

* *Amanita* or *Russula* mushrooms were not collected.

smelling agaric), *Leccinum scabrum* (a fruity-smelling bolete), skunk cabbage (*Symplocarpus foetidus*, a common aroid in which drosophilids breed), and lettuce (*Lactuca sativa*, a representative inocuous plant). Oviposition plugs were systematically arranged on the periphery of 8–10 large petri dishes per *Drosophila* species in which 100–150 adults were allowed to oviposit. An ANOVA and Newman-Keuls test (Sokal and Rohlf, 1969) on proportions of eggs laid on each substrate were used to rank OSP of each *Drosophila* species. Except for *D. putrida*, there were two OSP trials per species. Details of the experimental procedure are described elsewhere (Jaenike and Grimaldi, 1983).

RESULTS

Trophic morphology and breeding sites.—In total, 21 species of Diptera belonging to 11 families were reared from 54 mushrooms. There were 24 *Amanita*, 25 *Russula*, 2 *Cortinarius*, and 3 *Entoloma* mushrooms collected. *Drosophila* were the most common flies, and outnumbered all others 2:1 in *Russula* and 4:1 in *Amanita* (Table 1). *Bradysia* (Sciaridae) and *Megaselia* (Phoridae) were probably less important competitors for *Drosophila* than other flies since they are small and occured in only several mushrooms in large numbers. *Limonia tri-ocellata* and *Sylvicola alternatus*, however, are not only much larger than *Drosophila*, but are fairly abundant in *Russula*. No *Limonia* or *Sylvicola* were reared from *Amanita*.

Major differences in breeding sites were found among some mycophagous *Drosophila* species and were best reflected by differences in mouthpart structure. Of

Table 2. Drosophilidae bred from various mushrooms (N = 34) and from skunk cabbage plants, *Symplocarpus foetidus* (N = 92) at Chenango Valley, N.Y. in 1982.

	Host: Numbers Bred	
	Mushrooms	*Symplocarpus*
Drosophila falleni	559	9
D. recens	78	146
D. putrida	182	10
D. testacea	334	0
Scaptomyza graminum	1	522

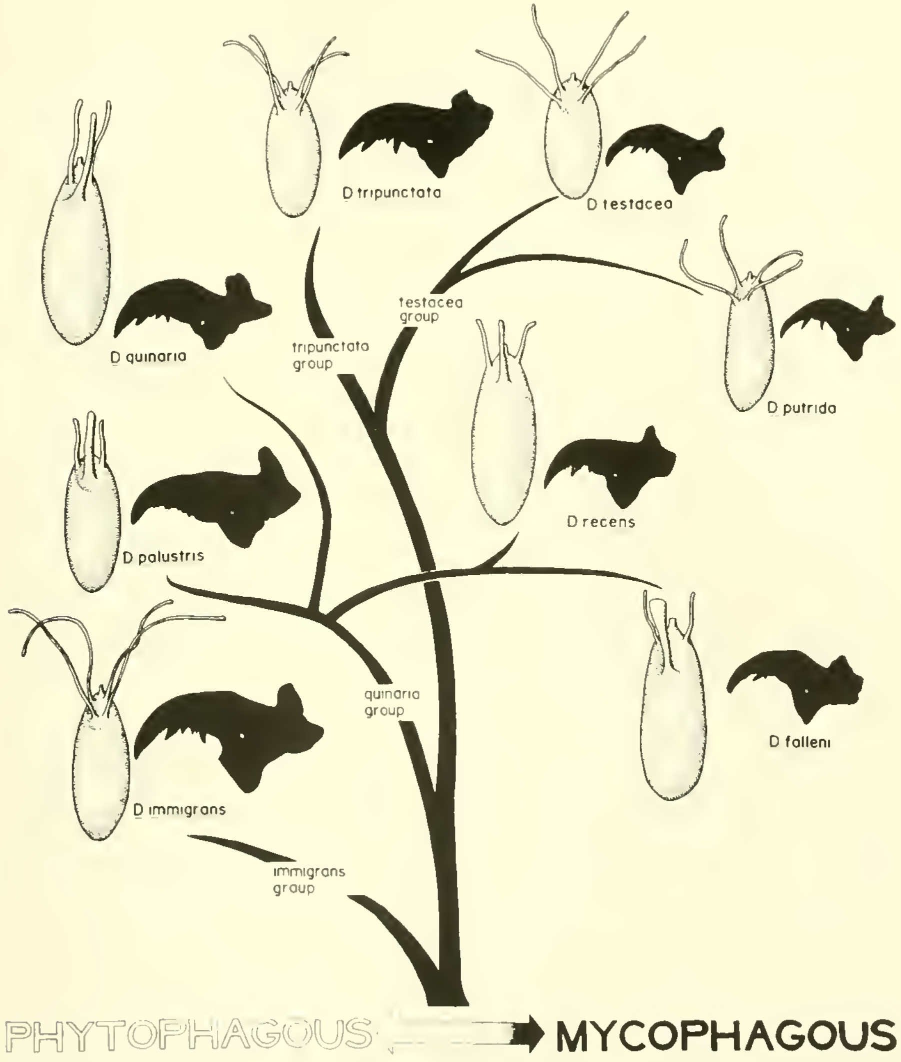

Fig. 2. Eggs and third instar larval mouthparts of 8 *Drosophila* species arranged according to breeding sites (position along the horizontal axis) and phylogenetic relationships. Phylogeny is from Throckmorton (1975).

the flies bred from mushrooms and from skunk cabbage, *D. recens* was least host restricted (Table 2). Data on *Scaptomyza graminum* (Fallén) (Drosophilidae), the most common fly on *Symplocarpus*, is presented for comparison. The stem and leaf breeding species, such as *D. quinaria* and *D. palustris* (Spencer, 1942) had heavy mouthparts with little curvature and seems to reflect the condition found in several Hawaiian leaf-breeding species (Mangan, 1978). Mycophages, however, had strongly curved, thin mouthparts (Fig. 2). Fruit breeders (*D. immigrans*) resemble mycophages more than leaf breeders in this respect, perhaps because of a similarity in breeding site texture. *Drosophila recens* and *D. tripunctata* Loew, the latter of which has been bred from fruits (Sturtevant, 1921), many different

Table 3. *Drosophila* development time, in days.

Drosophila	Trial	Number of Replicates	Mean (± SE) Time from Egg to	
			Pupation	Eclosion
D. falleni	1	27	—	$14.2 \pm .12^{a}$
	2	12	$7.2 \pm .09^{b}$	$13.8 \pm .07$
D. recens	1	27	—	$14.2 \pm .08^{a}$
	2	11	$7.3 \pm .06^{b}$	$14.1 \pm .05$
D. putrida	1	27	—	$15.8 \pm .23$
	2	7	$8.9 \pm .33^{c}$	$15.8 \pm .26$
D. testacea	1	—	—	—
	2	4	$8.6 \pm .26^{c}$	$15.4 \pm .19$

Superscript letters denote values which are not significantly different ($P > .1$, ANOVA). Comparisons are within trials only.

mushrooms (Lacy, 1984), and even slug carcasses (Kneidel, 1983), had intermediately-shaped mouthparts.

Although the chorion and filaments of eggs function in respiration (Hinton, 1981), there was no obvious relation between egg size, egg shape, filament number or length and the type of breeding site. Variations in egg morphology among these species reflected phylogenetic relationships (cf. Throckmorton, 1962, 1966), not ecological habits.

Table 4. Effects of temperature and mushroom on *Drosophila* sizes. Size is thorax length measured in ocular units (1.0 ocular unit = .38 mm).

Species	Sex	Source of Variation	F	Variables Mean Sizes†					
				15°	21°	27°	*Amanita*	*Russula*	*Polyporus*
D. falleni	M	Temperature	34.25***	2.86	2.91	2.59			
		Mushroom	28.92***				2.94	2.75	2.65
		Temp × Mush	4.14**						
	F	Temperature	56.86***	3.25	3.25	2.80			
		Mushroom	29.88***				3.32	2.99	3.08
		Temp × Mush	12.12***						
D. recens	M	Temperature	69.07***	2.94	2.96	2.69			
		Mushroom	27.16***				2.95	2.84	2.74
		Temp × Mush	5.44***						
	F	Temperature	20.14***	3.20	3.18	2.96			
		Mushroom	2.72*				3.22	3.12	3.08
		Temp × Mush	.66						
D. putrida	M	Temperature	50.74***	2.20	2.33	2.02			
		Mushroom	8.13***				2.24	2.19	2.12
		Temp × Mush	6.79***						
	F	Temperature	50.10***	2.58	2.72	2.40			
		Mushroom	15.51***				2.67	2.49	2.55
		Temp × Mush	.73						

† Values underlined are not significantly different ($P > .05$, Duncans' multiple range test). Comparisons are within treatment groups only for each species.

* $P \le .05$; ** $P \le .01$; *** $P \le .001$; df for treatment = 2.

Table 5. Habitat occurrence in coexisting *Drosophila*.

Location, Species	Number of Flies High Elevations Coniferous Forests	 Low Elevations Deciduous Forests
Deer Isle, Maine		
Drosophila falleni	247	183
D. recens	139	53
D. putrida	68	48
D. testacea	83	188
East Charleston, Vermont: Mad Brook Farm		
D. recens	15	0
D. testacea	32	11
East Charleston, Vermont: Bald Mountain		
D. testacea	9	25
Great Smoky Mountains National Park, Tennessee		
D. testacea	18	14
D. recens	57	5

Larval development.—In the lab, *D. falleni* and *D. recens* had egg to adult development times about one day shorter than either *D. testacea* or *D. putrida* (Table 3). Closely related species pairs were not significantly different in this respect ($P > .10$, ANOVA).

Drosophila falleni, D. recens and *D. putrida* are easily raised on commercial mushroom in the lab, in contrast to the difficulty I had rearing them on standard *Drosophila* media. Different mushroom species were not equally suitable for each species and temperature differences accentuated the effects. Flies of each species reared as larvae on *Amanita muscaria* were always largest (Table 4). Suitability of *Russula compacta* and *Polyporus squamosus* varied between species and sexes. For each species, larval development at 27°C resulted in adult stunting, but the temperature which maximized fly size varied. *Drosophila falleni* and *D. recens* did equally well at 15°C and 21°C, but *D. putrida* grew largest at 21°C. The combined effects of temperature and substrate were important for four of the six species-sex groups. *Drosophila falleni* and *D. recens* males, for instance, were smallest when raised on *Polyporus* at 27°C than any other treatment.

Species abundance.—*Drosophila* were not abundant at all of the locations that were sampled, even though the trapping periods coincided (Table 5). However, *D. recens* and *D. testacea* were abundant enough at each location to show that the former occurred most at high elevations and in coniferous forests. *Drosophila testacea* showed no consistent distribution. At the Deer Isle location, however, closely related species pairs had separate distributions: *D. falleni* had no obvious habitat association, but 72% of the *D. recens* were captured in a fir forest ($\chi^2 = 24.02$, $P < .01$). Also, *D. putrida* was relatively more abundant than *D. testacea* in the fir forest ($\chi^2 = 22.06$, $P < .01$). In the Great Smoky Mountains, Lacy (1984) too found *D. recens* to be more abundant at higher elevations.

In New York, populations of the two *quinaria*-group species and two *testacea*-group species separated somewhat by season (Fig. 3). *Drosophila testacea* and *D. putrida* were more common in the fall, but the other two species were equally

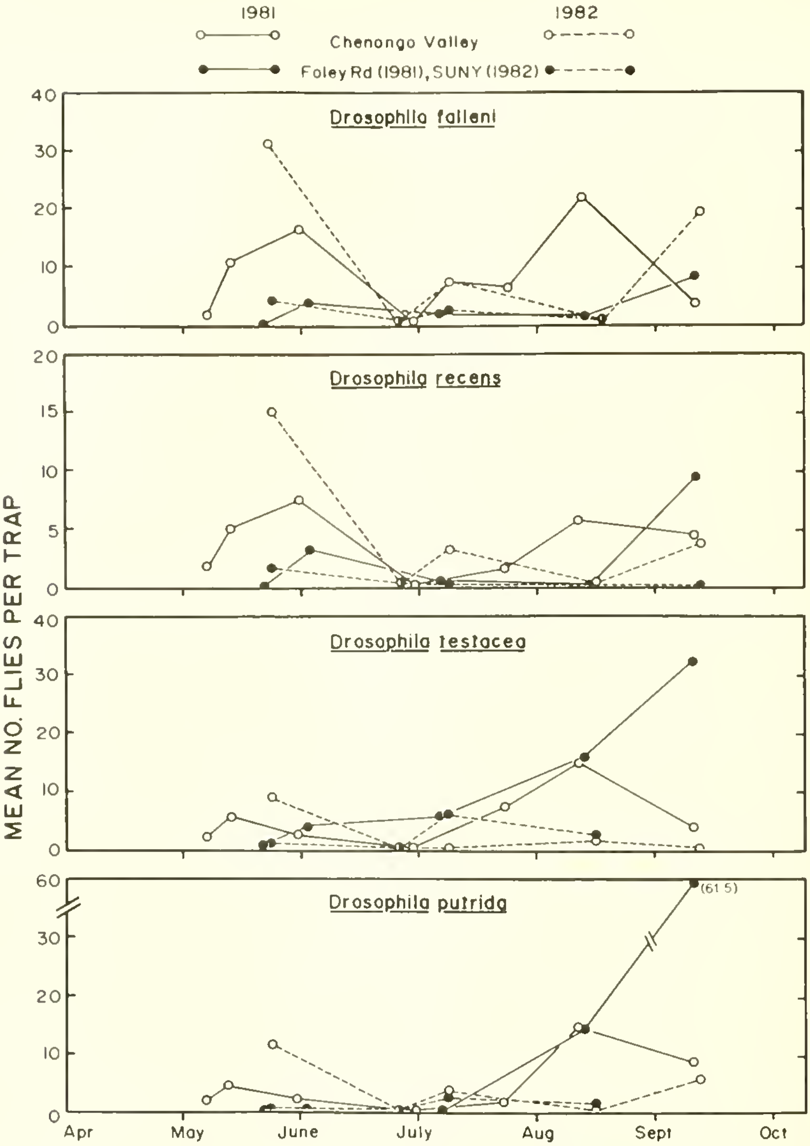

Fig. 3. Relative seasonal abundance of 4 coexisting *Drosophila* species based on constant-effort trapping during 2 years.

abundant in the spring and fall. A striking similarity to each was the simultaneous population crash in late June. This suggests that probably two generations occurred per year: a spring generation that used early mushrooms (i.e. *Polyporus squamosus* and *Tricholomopsis platyphylla*) and a late summer-early fall generation that bred in the more abundant, diverse flora found then (Grimaldi, 1983).

Oviposition site preference.—Based on the lab OSP tests, the mycophagous species preferred mushrooms over plant substrates and the fruit breeder, *D. immigrans,* preferred plant substrates (Fig. 4). Results were highly repeatable between

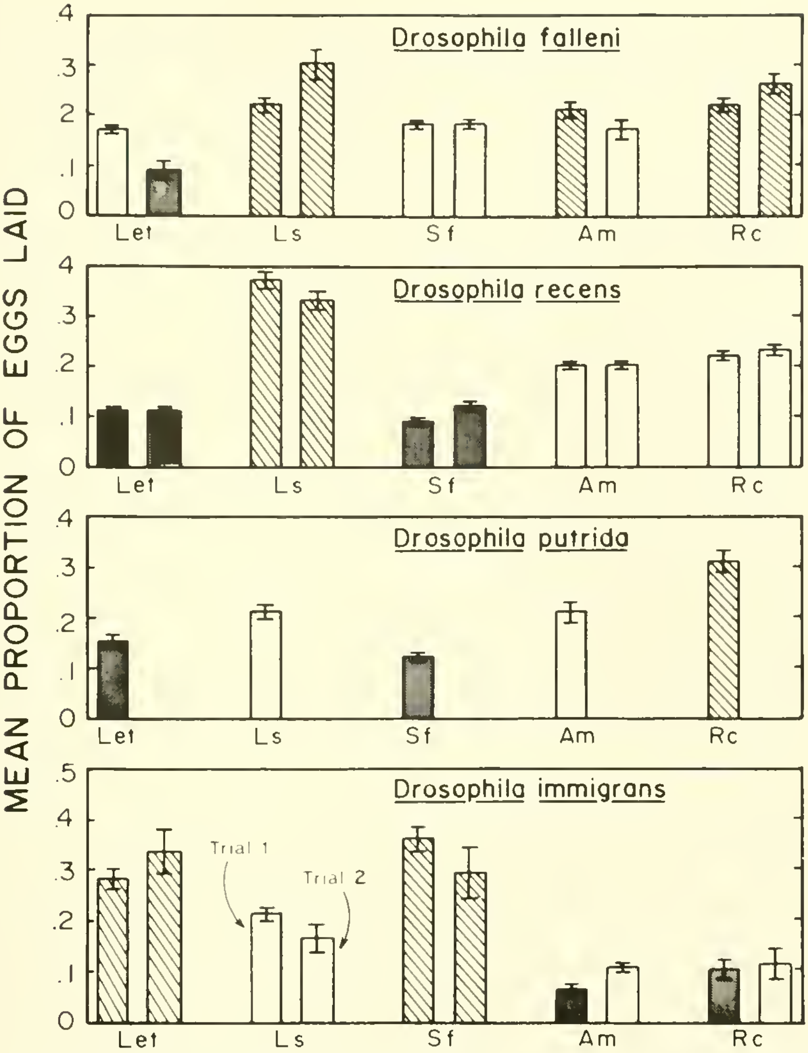

Fig. 4. Oviposition site preferences of 4 *Drosophila* species for 5 substrates. Substrates are lettuce (Let), *Leccinum scabrum* (Ls), *Symplocarpus foetidus* (Sf), *Amanita muscaria* (Am), and *Russula compacta* (Rc). The left bar of each pair represents trial 1. Bars with the same shading, within a trial and species only, denote hosts which were equally preferred (Newman-Keuls test, $P \leq .05$).

trials, with a mean of 380 eggs laid per oviposition dish. However, the OSP for particular mushrooms varied among the mycophagous species: *D. falleni* preferred *Leccinum* and *Russula, D. recens* preferred *Leccinum,* and *D. putrida* preferred *Russula. Drosophila recens* did not have a preference for *Symplocarpus* greater than the other mycophagous species. Also, *Amanita* was consistently the least preferred mushroom for each species.

The *Drosophila* netted over rotted and fresh *Amanita* at SUNY preferred the rotted ones (Table 6). This preference was accentuated in *D. testacea* and *D. putrida* ($\chi^2 = 37$, $P < .01$). Kimura (1980) noted *D. testacea* in Japan also preferred ovipositing on decaying versus fresh mushrooms.

Table 6. Numbers of *Drosophila* caught on rotted and fresh *Amanita* mushrooms.

Drosophila Species	Rotted (N = 7)	Fresh (N = 9)
D. falleni	81 (57%)	62 (43%)
D. recens	33 (67%)	16 (33%)
D. putrida	25 (96%)	1 (4%)
D. testacea	48 (98%)	1 (2%)
Total	187 (70%)	80 (30%)

DISCUSSION

Drosophila were the most abundant Diptera in mushrooms and are, therefore, likely to compete most with each other. Other flies, such as *Sylvicola* and *Limonia*, probably also compete with *Drosophila* for mushroom food, but only in some of the mushrooms used by *Drosophila*. Accordingly, there is substantial ecological separation between the four *Drosophila* species commonly found together in mushrooms.

Several facts implicate that the food for which these mycophagous *Drosophila* larvae probably compete is mushroom tissue, not just the yeasts and bacteria growing in it. First, mushroom tissue is a complete and generally nutritious insect diet (Martin, 1979). Also, several mycophagous *Drosophila* species are tolerant to naturally high levels of the mushroom toxin, α-amanitin (Jaenike et al., 1983). Thus, unlike for a cactiphilic species (Fogelman et al., 1981), these larvae are unlikely to partition their food by selective foraging on patches of certain microorganisms.

Drosophila recens is facultatively mycophagous; the other three species are strictly mushroom breeders. In addition, species-group differences were apparent: *D. testacea* and *D. putrida* had development times longer than those of *D. falleni* and *D. recens* and adults are attracted to older, decaying mushrooms. It has been inferred from electrophoresis that for *D. falleni*, but not the other three species, up to 60 sibs, the progeny of one female, can be found in a single *Amanita* (Grimaldi, 1983). This evidence strongly suggests that female *D. testacea* and *D. putrida* oviposit on mushrooms already inhabited by larvae and thus put their offspring at a disadvantage in scramble competition with the *quinaria*-group flies.

The field experiment mentioned earlier corroborates that *D. putrida*, but not *D. testacea*, is under harsh competitive pressure (Grimaldi and Jaenike, 1984). In that experiment, the reduction of "fitness" (a function of survivorship and female fecundity) due to competition for mushroom food was approximately 60% for *D. putrida*, 25 and 30% for *D. testacea* and *D. falleni*, and only 15% for *D. recens*. This is opposite of what one might expect based on the assumption that competition should affect resource use. *Drosophila recens* is the most polyphagous species, but probably not because of competitive pressure. *D. putrida*, on the other hand, was affected most by competition but shows little evidence of niche separation from the other *Drosophila*.

What prevents poor competitors like *D. putrida* from being excluded from the mycophagous niche? My results suggest that at least six factors can explain this competitive coexistence.

1.—Mushrooms are a heterogeneous insect diet. Their texture ranges from woody to almost liquid and many species are known to contain a variety of toxins. Depending on the host mushroom, slight develomental advantages can be conferred on a particular *Drosophila* species that make it less susceptible to the effects of competition. The effects of different breeding substrates on competitive outcomes in lab populations of *Drosophila* has been shown elsewhere (Merrell, 1951; Fellows and Heed, 1972; Mangan, 1982).

2.—Fluctuating competitive asymmetries resulting from different hosts can be enhanced by microclimatic variations such as temperature. For example, *D. putrida* would probably not compete well with *D. falleni* at 15°C since it develops slowly at this temperature. Three species of *Drosophila* in the *affinis* subgroup have competitive abilities affected by temperature (Fogelman and Wallace, 1980).

3.—Closely related species of mycophagous *Drosophila* can segregate by association with particular habitats. Since altitude and forest type influence species abundance, separation of the four species by habitat can be particularly important at northern latitudes and along the Appalachian Mountains.

4.—*Drosophila putrida* (and probably also *D. testacea*) are not as cold-adapted as *D. falleni* and *D. recens*. This is one reason why *D. putrida* and *D. testacea* are relatively more abundant in the late summer and early fall when temperatures are generally warmer. Seasonal separation is also known to occur in several other mycophagous *Drosophila* in England (Shorrocks and Charlesworth, 1980).

5.—Close populational tracking of resources is prevented by patchy mushroom distribution. The resulting population fluctuations, although reflecting resource supply, do not allow population size to equilibrate at high levels, which might favor only competitive ability.

6.—Although three of the four *Drosophila* are obligately mycophagous, differences in host preference that were observed in the lab can become apparent during periods when the standing mushroom crop is diverse and abundant, as in the early fall. Such periods of mushroom "bloom" should also provide the resources for a major proportion of the yearly *Drosophila* population. Differences in breeding records among some sympatric mycophagous *Drosophila* have been investigated for several faunas (Kimura, 1980; Shorrocks and Charlesworth, 1980; Lacy, 1984).

The saturated niche packing often seen in insect communities associated with ephemeral, unpredictable resources such as carrion (Beaver, 1977; Anderson, 1982), dung (Hanski and Koskela, 1977; Peck and Forsyth, 1982), and fungi (Buxton, 1960; Hackman and Meinander, 1979) is explainable even if competition is severe. Exclusion by a dominant competitor usually is prevented by seasonal, habitat, and successional separation of species, but probably also by fluctuations in competitive ability concomitant with diet and microclimatic variations.

All being equal, it is possible that just a sufficiently high variance in the distribution of "fugitive" competitors on the limiting resource can explain coexistence. However, as one model shows (Atkinson and Shorrocks, 1981), the idea suffers from some assumptions that are unrealistic. For example, identical competitors would coexist if they are not contagiously distributed and if individual breeding sites support only a few flies. Almost all work on flies that utilize transient breeding sites, including this study, shows these assumptions not to be the case. Hymenopterous parasitoids account for up to 3% of the larval mortality in mycophagous *Drosophila* (Grimaldi, 1983), and *Howardula aoronymphium* (Allantonematidae: Nematoda) can infest and kill up to 20% of the adults (Montague and Jaenike, 1985). Predation, relative resource separation, and competitive asymmetries that constantly fluctuate are thus major factors maintaining the coexistence of insect competitors.

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LITERATURE CITED

Anderson, R. S. 1982. Resource partitioning in the carrion beetle (Coleoptera: Silphidae) fauna of southern Ontario: Ecological and evolutionary considerations. Can. J. Zool. 60: 1314–1325.

Atkinson, W. D. and B. Shorrocks. 1981. Competition on a divided and ephermeral resource: A simulation model. J. Anim. Ecol. 50: 461–471.

Beaver, R. A. 1977. Non-equilibrium 'island' communities: Diptera breeding in dead snails. J. Anim. Ecol. 46: 783–798.

Buxton, P. A. 1960. British Diptera associated with fungi. III. Flies of all families reared from about 150 species of fungi. Entomol. Mon. Mag. 96: 61–94.

Fellows, D. P. and W. B. Heed. 1972. Factors affecting host plant selection in desert-adapted cactiphilic *Drosophila*. Ecology 53: 850–858.

Fogelman, J. C. and B. Wallace. 1980. Temperature-dependent development and competitive ability of three species in the *Drosophila affinis* subgroup. Am. Midl. Nat. 104: 341–351.

Fogelman, J. C., W. T. Starmer, and W. B. Heed. 1981. Larval selectivity for yeast species by *Drosophila mojavensis* in natural substrates. Proc. Nat. Acad. Sci. 78: 4435–4439.

Grimaldi, D. A. 1983. Ecology and competitive interactions of four coexisting species of mycophagous *Drosophila*. M.A. thesis, State University of New York at Binghamton.

Grimaldi, D. A. and J. Jaenike. 1984. Competition in natural populations of mycophagous *Drosophila*. Ecology 65: 1113–1120.

Hackman, W. and M. Meinander. 1979. Diptera feeding as larvae on macrofungi in Finland. Ann. Zool. Fenn. 16: 50–83.

Hanski, I. and H. Koskela. 1977. Niche relations among dung-inhabiting beetles. Oecologia 28: 203–231.

Hinton, H. E. 1981. Biology of insect eggs. 3 volumes, Pergamon Press, Oxford.

Horn, H. S. and R. H. MacArthur. 1972. Competition among fugitive species in a harlequin environment. Ecology 53: 749–752.

Jaenike, J. and D. Grimaldi. 1983. Genetic variation for host preference within and among populations of *Drosophila tripunctata*. Evolution 37: 1023–1033.

Jaenike, J., D. Grimaldi, A. E. Sluder, and A. L. Greenleaf. 1983. Alpha-amanitin tolerance in mycophagous *Drosophila*. Science 221: 165–167.

Kambysellis, M. P. and W. B. Heed. 1971. Studies of oogenesis in natural populations of Drosophilidae. I. Relation of ovarian development and ecological habitats of the Hawaiian species. Am. Nat. 105: 31–49.

Kearney, J. N. 1982. Selection and utilization of natural substrates as breeding sites by woodland *Drosophila* spp. Entomol. Exp. Appl. 33: 31–38.

Kimura, M. T. 1980. Evolution of food preferences in fungus-feeding *Drosophila*: An ecological study. Evolution 34: 1009–1018.

Kneidel, K. 1983. Fugitive species and priority during colonization in carrion-breeding Diptera communities. Ecol. Entomol. 8: 163–169.

Lacy, R. C. 1984. Ecological and genetic responses to mycophagy in Drosophilidae (Diptera). *In* Wheeler, Q. and M. Blackwell, eds., Fungus/insect relationships: Perspectives in ecology and evolution. Columbia U. Press.

Mangan, R. L. 1978. Competitive interactions among host plant specific *Drosophila* species. Ph.D. dissertation, University of Arizona, Tucson.

———. 1982. Adaptations to competition in cactus breeding *Drosophila*, pp. 257–272. *In* Barker, J. S. F. and W. T. Starmer, eds., Ecological genetics and evolution: The cactus-yeast-*Drosophila* model system. Academic Press, N.Y.

Martin, M. M. 1979. Biochemical implications of insect mycophagy. Biol. Rev. 54: 1–21.

Merrell, D. 1951. Interspecific competition between *Drosophila funebris* and *D. melanogaster*. Am. Nat. 85: 159–169.

Montague, J. R. and J. Jaenike. 1985. Nematode parasitism in natural populations of mycophagous drosophilids. Ecology 66: 624–626.

Okada, T. 1963. Caenogenetic differentiation of mouth hooks in drosophilid larvae. Evolution 17: 84–98.

Peck, S. B. and A. Forsyth. 1982. Composition, structure, and competitive behaviour in a guild of Ecuadorian rain forest dung beetles (Coleoptera: Scarabaeidae). Can. J. Zool. 60: 1624–1634.

Shorrocks, B. and P. Charlesworth. 1980. The distribution and abundance of the British fungal-breeding *Drosophila*. Ecol. Entomol. 5: 61–78.

———. 1982. A field study of the association between the stinkhorn *Phallus impudicus* Pers. and the British fungal-breeding *Drosophila*. Biol. J. Linn. Soc. 17: 307–318.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman, San Francisco.

Spencer, W. P. 1942. New species in the quinaria group of the subgenus *Drosophila*. Univ. Tex. Publ. 4213: 55–66.

Sturtevant, A. H. 1921. The North American Species of *Drosophila*. Carnegie Inst. Wash. Publ. 301, 150 pp.

Throckmorton, L. H. 1962. The problem of phylogeny in the genus *Drosophila*. Univ. Tex. Publ. 6205: 207–343.

———. 1966. The relationships of the endemic Hawaiian Drosophilidae. Univ. Tex. Publ. 6615: 335–396.

———. 1975. The phylogeny, ecology, and geography of *Drosophila*, pp. 421–469. *In* King, R. C. ed., Handbook of genetics. Vol. 3. Invertebrates of genetic interest. Plenum, N.Y.

Wieland, T. 1968. Poisonous principles of mushrooms of the genus *Amanita*. Science 159: 946–952.

Wilkens, W. H. and G. C. M. Harris. 1946. The ecology of larger fungi. V. An investigation into the influence of rainfall and temperature on the seasonal production of fungi in a beechwood and pinewood. Ann. Appl. Biol. 33: 179–188.

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RECONSTITUTION OF THE TRIBES ULOMINI AND TRIBOLIINI FOR NORTH AND CENTRAL AMERICA (TENEBRIONIDAE; COLEOPTERA)

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Abstract.—The tribes Ulomini and Triboliini are redefined, based on external and internal characters of adults and immatures. New World Ulomini include *Alegoria* Laporte, *Antimachus* Gistel, *Apteruleda* Gebien, *Apteruloma* Gebien, *Eutochia* LeConte, *Metabolocerus* Bates, *Pheres* Champion, *Uleda* Laporte and *Uloma* Latreille. *Uloma carolynae* from southern Mexico is newly described. Triboliini include *Aesymnus* Champion, *Latheticus* Waterhouse, *Lyphia* Mulsant and Rey, *Metulosonia* Bates, *Mycotrogus* Horn, *Palorus* Mulsant, *Tharsus* LeConte, *Tribolium* Macleay and *Ulosonia* Laporte.

As constituted in present catalogues the tribe Ulomini is strongly composite, containing taxa representing at least four distinct lineages. From the North American fauna Doyen (1984) removed *Adelina* Dejean, *Sitophagus* Mulsant, *Gnatocerus* Thunberg, *Doliopines* Horn, *Doliodesmus* Spilman, *Mophis* Champion, and *Cynaeus* LeConte to Diaperini, as the subtribe Adelinina. *Alphitobius* Stephens and *Metaclisa* Jaquelin du Val properly belong to Tenebrionini (Doyen and Tschinkel, 1982; Tschinkel and Doyen, 1980). *Adelonia* Laporte (= *Merotemnus* Horn; Spilman, 1961a), sometimes included in Ulomini should be placed in Belopini (Doyen and Tschinkel, 1982). Most of the remaining "ulomine" genera, related to *Tribolium* and *Palorus*, should be placed in a separate tribe, Triboliini, as detailed below. Ulomini is then restricted to a relatively small group of genera related to *Uloma*. In this sense Ulomini comprises a rather uniform assemblage, characterized by several distinctive synapomorphies (see Doyen and Tschinkel, 1982, and below). This arrangement corresponds to that of Reitter (1917), who restricted the European Ulomini to *Uloma*.

Ulomini and Triboliini are included in the tenebrionoid lineage of Doyen and Tschinkel. This lineage is defined principally by the presence of a spermatheca derived from the bursa copulatrix, and is variable in most other features.

Most characters shared by Ulomini and Triboliini are generalized features distributed widely in the tenebrionoid lineage. These include: lacinia with uncus; epipharynx symmetrical or nearly so; tentorium with bridge posterior, not arched; wing with large recurrent cell, short apical membrane; aedeagus not inverted; ovipositor with subequal coxite and paraproct, coxite with four subequal lobes; defensive reservoirs with nonannulate walls, collecting ducts arranged in a basal line.

Possible synapomorphies linking Ulomini and Triboliini include enlargement of the defensive reservoirs with a distinct basomedial pouch and closure of the mesocoxal cavities by the apposed mesosternum and metasternum. Reservoir enlargement is, however, an exceedingly common feature, which has occurred independently many times, judging from differences in details of configuration (Tschinkel and Doyen, 1980). More specifically, elongate reservoirs with basomedial pouches occur in Helopini and Cnodalonini as well as Ulomini and Triboliini. It may also be pointed out that relatively small reservoirs with broad openings occur in both Ulomini (*Antimachus*) and Triboliini (*Palorus*). Presumably this is a plesiomorphic condition, which admits the possibility that gland enlargement occurred independently. The other potential synapomorphy, closure of the mesocoxal cavities by the sterna, also occurs more widely, most notably in Hypophloeini and some genera of Diaperini.

Opposed to these few similarities are numerous differences between both adult and larval Ulomini and Triboliini. In adult Ulomini the preapical antennal segments bear large placoid sensoriae, with compound (tenebrionoid) sensoriae on only the apical segment. The ligula is sclerotized, the labroclypeal membrane is often exposed, and the seventh abdominal tergite usually forms a pygidium. In larval Ulomini the mandibular incisor is trilobed, the mala apically incised, the hypopharyngeal sclerome produced anteriorly as a flat process, and the second antennal segment bears a C-shaped sensorium. The abdominal pleura are reduced and the ninth tergite is parabolic, concealing the anus and ninth sternite.

In adult Triboliini placoid sensoriae are never present on the antennae, and compound sensoriae are present only in *Ulosonia* and related genera. The ligula is membranous and the labroclypeal membrane and the seventh tergite are concealed. In larvae the mandibular incisor is bilobed, the mala entire, the hypopharyngeal sclerome simple, U-shaped (absent in some *Tribolium*; Hayashi, 1966: 16), and the second antennal segment bears a lens-shaped sensorium at its apex. Abdominal pleura are evident, and the ninth tergite is only moderately larger than the sternite, and bears a pair of short, pointed urogomphi.

Most of these differences result from apomorphous conditions in Ulomini. When these features occur elsewhere, it is in such remote groups that convergence is almost certain. For example, placoid sensoriae occur outside Ulomini in Scotobiini and *Ammophorus* (Medvedev, 1977). The unusual larval hypopharyngeal sclerome, lack of pleural membranes and paraboloid 9th tergite have counterparts in Alleculinae (Hayashi, 1966; Watt, 1974). Most other features of Ulomini are plesiomorphic, and more precise phylogenetic affinities cannot be specified, though some characteristics of the ovipositor and defensive reservoirs suggest relationship to Helopini and Opatrini (Doyen and Tschinkel, 1982).

In contrast, most Triboliini are clearly similar to Tenebrionini. Important shared characters include: configuration of the internal female reproductive tract and ovipositor; similar wing venation; similar mouthparts (lacinia with uncus; mandibular molas simple or carinate) (adults); ninth abdominal tergite with short, pointed urogomphi (larvae). However, most of these features are probably plesiomorphic.

The most significant differences between Triboliini and Tenebrionini appear to be: 1) the enlargement of the defensive reservoirs (very short, eversible pouches in Tenebrionini); 2) closure of the mesocoxal cavities by the apposed sterna (closed by epimeron in most Tenebrionini); 3) larval antenna with a lens-shaped sensoria

(C-shaped in Tenebrionini); 4) 9th abdominal tergite produced as paired urogomphi (single, medial spine-like process or unmodified in Tenebrionini, except *Tenebrio*).

Most North American Ulomini (s.s.) have the labroclypeal membrane exposed, making it impossible to identify them in existing keys. The following changes in Arnett's (1960) key will assist with identification, until a new key can be devised.

2(1). Epistoma without a membranous margin or a membranous band between it and labrum 3
Epistoma with a membranous margin or a membranous band between it and labrum 2a
2a(2). Middle and hind tibiae bearing a longitudinal, finely crenulate carina on the outer (dorsal) margin .... Diaperini
Middle and hind tibiae lacking carina on outer margin 2b
2b(2a). Seventh abdominal tergite partially exposed as pygidium; mesocoxal cavities closed laterally by sternites; fore tibiae usually with serrate outer (dorsal) margins .... Ulomini, new sense
Seventh tergite concealed by elytra; mesocoxal cavities closed by epimeron; fore tibiae with nonserrate outer (dorsal) margins 21
10(9). Scutellum small; elytra without scutellar stria; anterior striae nonparallel .... Phrenapatini
Scutellum large; elytra with scutellar stria; anterior striae parallel .... Triboliini

Tribe Ulomini, New Sense

Ulomiens Mulsant, 1854, 1856.
Alegorides Lacordaire, 1859.
Ulomides vrai Lacordaire, 1859 (in part).
Ulomini Reitter, 1917; Gebien, 1938–42 (in part); Skopin, 1978; Kwieton, 1982.
Ulomimorpha Skopin, 1964.

Adult.—Small to large (3–25 mm), elongate to broadly oval, flattened to subcylindrical. Eyes moderately large, anteriorly emarginate or absent (*Typhuloma*); antennae gradually clavate, apical 5–8 segments bearing large placoid sensoriae (exception, *Aphtora*); apical segment with compound (tenebrionoid) sensoriae; labrum transverse, constricted at base; labroclypeal membrane exposed or concealed; mandibles with molas nonstriate, coarsely ridged in *Aphtora*; right mola weakly convex, surface simple or bluntly lobed; left mola concave, complexly lobed; lacinia with 1–2 enlarged apical unci (exception, *Aphtora*); mentum often sexually dimorphic, subtrapezoidal to cordate or oval, flat or weakly convex in females, broadly oval, enlarged and concave, frequently setose in males; ligula sclerotized; labial palp subcylindrical or enlarged, flattened in some males; tentorium with bridge posterior, not arched. Apical membrane 0.20–0.35 wing length. Procoxal cavities closed internally; protibia usually modified in males; mesocoxal cavities closed laterally by sterna or barely open (some *Uloma*); 7th abdominal tergite usually exposed as heavily sclerotized pygidium. Ovipositor with gonostyles lateral, small or moderate in size; coxite about as long as paraproct, with 4 subequal lobes. Internal female reproductive tract with long, thin, branched and tightly coiled spermatheca at base of accessory gland. Defensive reservoirs short, saccate, with common volume (*Antimachus*) or long tubular, with basomedial pouches and without common volume; reservoir walls without annular folding; secretory tissue drained by basal line of ducts. Aedeagus with tegmen dorsal; median lobe adnate.

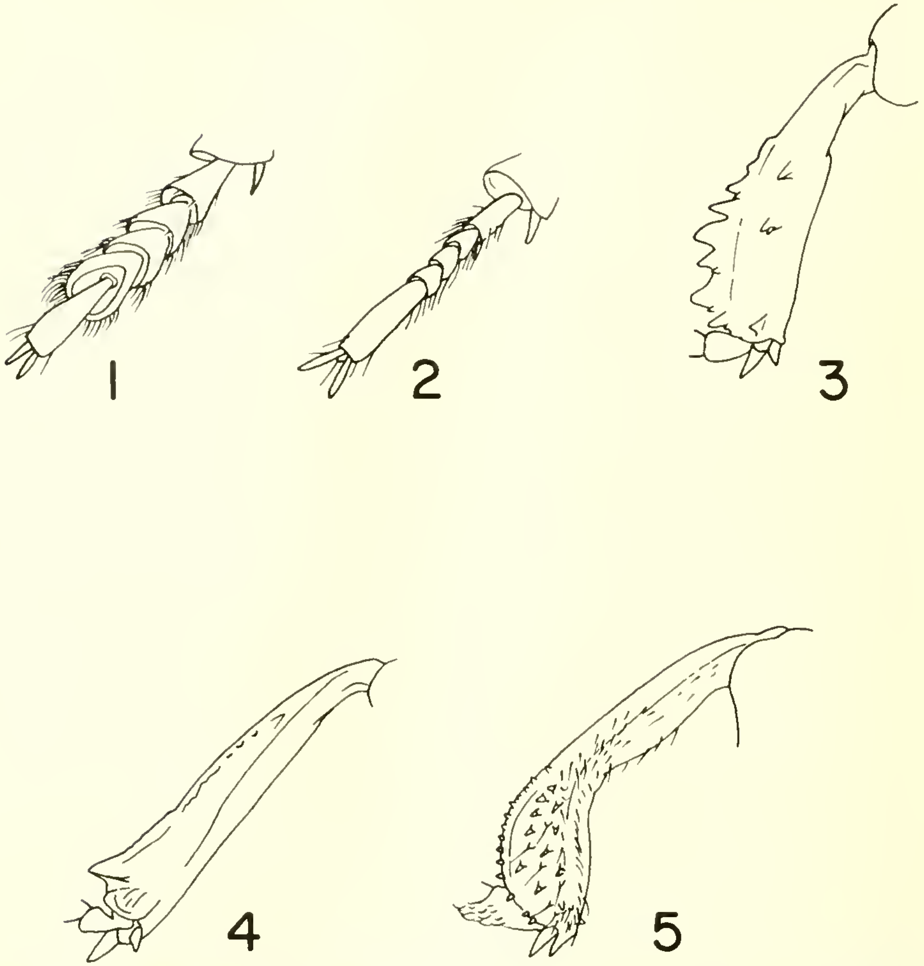
Larva.—Subcylindrical, sides subparallel; moderately to strongly sclerotized and pigmented.

Antenna with second segment about 2.0–2.5 × length of basal, bearing C-shaped sensoria near apex; third segment a digitate process, about ¼ length of second. Labrum transversely ovate; epipharyngeal masticatory processes simple single teeth, slightly asymmetrical. Mandibles with trilobed incisors or left bilobed with subapical tooth; right mola with two coarse, transverse grooves; left mola concave, with strongly prominent anterior margin. Maxilla with mola incised apically, bearing 2 rows of spines. Hypopharyngeal sclerome with base projecting anterad as stout, flattened process or unmodified (*Aphtora*); thoracic legs slender, similar in structure, sparsely set with short, stout spinose setae. Abdomen with pleural sutures obscure, indicated by folds on segments 1–7; greatly reduced or absent on segment 8; ninth tergite large, parabolic, weakly bilobed (*Oligocara*; Cekalovich & Morales, 1974) or produced as single apical and several subapical processes (*Alegoria*; Spilman, 1978); ninth sternite reduced, anus concealed beneath 8th sternite; pygopods absent. Spiracles annular.

KEY TO THE GENERA OF ULOMINI OF NORTH AND CENTRAL AMERICA

1. Tarsi with penultimate segment flattened, expanded, with last segment inserted dorso-basally (Fig. 1) .... *Alegoria* Laporte
– Tarsi with penultimate segment subcylindrical, not expanded beneath last segment, which is articulated apically (Fig. 2) 2
2. Protibia with outer (dorsal) apical margin coarsely serrate (Fig. 3) .... *Uloma* Latreille (in part)
– Protibia with outer (dorsal) margin straight or simply curved, sometimes bearing coarse spines (Figs. 4, 5) never serrate 3
3. Clypeus separated from frons by visible strip of membrane; head without horns 4
– Clypeofrontal membrane concealed beneath frons; males with large medial horn on head .... *Antimachus* Gistel
4. Metasternal length about one half mesocoxal diameter or less; protibia of males abruptly bent at apical third (Figs. 5, 7) 5
– Metasternal length subequal to mesocoxal diameter; protibia straight or arcuate (as in Fig. 4) 6
5. Eighth interval produced apically as a rounded crest supertending the enlarged punctures of the epipleural stria .... *Eutochia* LeConte
– Eighth interval not produced as a crest; epipleural punctures subequal to those of other striae .... *Uloma* Latreille (in part)
6. Epipleuron narrowing gradually to elytral apex (as in Fig. 10); anterior margin of clypeus convex .... *Pheres* Champion
– Epipleuron terminating abruptly well before elytral apex (as in Fig. 11); clypeus straight or concave .... *Uleda* Laporte

Besides the North and Central American genera included in the key above, the



Figs. 1–5. Generic characters, Ulomini. 1, 2, Tarsi, dorsal. 1, *Alegoria*. 2, *Uloma*. 3–5, Forelegs, posterior. 3, *Uloma longula* LeConte. 4, *Antimachus* species. 5, *Eutochia picea* Melsheimer.

Ulomini should include *Oligocara* Solier, *Apteruleda* Gebien, *Metabolocerus* Bates, *Apteruloma* Gebien (South America); *Achthosus* Pascoe; *Cneocnemis* Gebien (Oriental); and *Typhuloma* Lea (Australia). Probably such genera as *Macruloma* Pic, *Pycnuloma* Fairmaire, etc., belong in Ulomini in the restricted sense, but I have not made examinations.

Phtora (Palearctic) Mulsant (=*Cataphronetis* Lucas; see Spilman, 1966) strongly resembles *Uloma* in external appearance, but differs markedly in mouthpart configuration. The mandibles have undifferentiated, flattened molas, the lacinia lacks an uncus and the labrum is transverse, without a marked basal constriction. In *Phtora* the tentorial bridge is moderately arched, the antennae bear stellate sensoriae, and the wing venation differs from that of Ulomini (s.s.). Finally, *Phtora* inhabits loose, sandy soil substrates, while most Ulomini are confined to well-rotted wood. Several important internal structures of *Phtora* are undescribed, and its phyletic relationships are unclear. I have not examined *Erelus* Mulsant & Rey, but from Lacordaire's description it may be close to *Phtora.*

Aphtora rufipes Sharp and *Ulomotypus laevigatus* Brown are likewise of uncertain taxonomic position. While their larvae have the 9th tergite paraboloid, the pleurosternal sutures are distinct. The hypopharyngeal sclerome lacks the anterior process of other Ulomini (Watt, 1974). Adults superficially resemble *Uloma,* and, like Ulomini, have the labrum constricted at the base and, in *Aphtora,* have the ligula sclerotized. However, they lack placoid antennal sensoriae, have the mandibular molas coarsely ridged, and lack an uncus on the lacinia. *Ulomotypus* is further distinguished by having the procoxal cavities open internally, by lacking the transverse bridge of the tentorium and by the inverted aedeagus.

If true Ulomini, these genera would be the most primitive members of the tribe. More likely the similarity to Ulomini in adult body shape and in configuration of the larval abdominal apex represent convergences deriving from similar rotting wood habitats. The coarsely ridged mandibles occur otherwise only in Phrenapatini, but that tribe differs in numerous other adult and larval characters. Most of the other features of *Ulomotypus* and *Aphtora* are generalized and their taxonomic relationships are unclear.

Several genera deviate in one or more characters. *Typhuloma* lacks eyes, while in *Alegoria* and *Antimachus* the elytra conceal the 7th abdominal tergite and the labroclypeal membrane is concealed. In *Alegoria* the penultimate tarsal segments are enlarged beneath the terminal segment. In *Antimachus* the defensive reservoirs are small relative to body size, with broad exits. This configuration occurs in distantly related members of various tribes (see Tschinkel and Doyen, 1980, Fig. 10), and is probably a retained primitive characteristic in *Antimachus.* In other features these genera are unremarkable.

Considerable variation exists among species of *Eutochia.* In *E. picea* LeConte the metasternal length is subequal to the mesocoxal diameter, the 9th elytral intervals are prominently crested above a row of very large punctures just before the apex, and the enlarged mentum of males is broadly oval, slightly concave and covered with flattened setae. This last modification is similar to that of many species of *Uloma.* In *E. pulla* Erichson, *E. atra* Pic and *E. lateralis* Boheman the metasternal length is subequal to the mesocoxal diameter and the elytral apices are unmodified. The mentum of males is small and subtrapezoidal, but the apical segment of the labial palp is enlarged and securiform. These differences suggest that *Eutochia* should be restricted to the New World species. *Cenoscelis* Wollaston, (1867) is then the appropriate name for the Old World species.

The large genus *Uloma* is variable in several features that would be considered diagnostic of the smaller ulomine genera. For example, in most of the New World species the mentum is enlarged in males and modified as described above. In *U. longula* LeConte and *U. impressa* Melsheimer these modifications are absent. Similarly, in most *Uloma* the anterior tibiae are gradually enlarged to the apex, with the outer (dorsal) margin coarsely serrate. In *U. spinipes* Champion and *U. carolynae* Doyen the fore tibiae are apically hooked, with the outer margin weakly serrate or entire. Possibly *Uloma* is composite as now constituted, as predicted by Champion (1886). It is also likely that some of the presently recognized genera (e.g. *Achthosus*) represent specialized lineages derived from *Uloma.* A comprehensive study of the entire tribe will be required to resolve these questions. The species described below, together with *U. spinipes* will probably constitute a distinct species group of *Uloma* or a separate genus.

***Uloma carolynae*, New Species**

Fig. 6

Male.—Subcylindrical, elongate oval, shining black with piceous appendages and venter. Cranium with punctures about as large as eye facets medially, separated by ½–1 puncture diameter with an impunctate spot at the epistomal suture, becoming much finer anteriorly and laterally. Epistomum slightly emarginate in dorsal aspect, incised at epistomal suture; suture faint but entire, arcuate; labroclypeal membrane broadly exposed, labrum with disk finely, obscurely and irregularly punctate. Eye barely emarginate, ventral lobe narrower than dorsal. Mentum rugosopunctate, flat, about 1.3 times broader than long, ovate with anterior border narrowly emarginate; labial palp with terminal segment ovate, flattened, aboral surface concave.

Pronotal disk with punctures about ⅔ size eye facets, separated by about 1–2 puncture diameters; lateral borders arcuate, more strongly so in anterior ⅓, narrowly margined; anterior border nearly straight in dorsal view, anterior angles obtuse, rounded; posterior border weakly bisinuate; posterior corners nearly right angled, weakly produced, received in sockets in elytral base. Hypomera rugosopunctate; prosternum rugose, prosternal process with transverse groove posteriorly a short distance beyond coxae just before apex, then abruptly declivous.

Elytral disk at base slightly wider than pronotum with prominent humeri; broadest at about middle; strial punctures round, shallow, 1–1.5 times eye facet diameter in sutural stria, becoming larger posteriorly; about 3 times eye facet diameter in epipleural stria; connected by fine furrows except in epipleural stria; intervals convex, finely, sparsely punctate; epipleuron gradually narrowed to elytral apex.

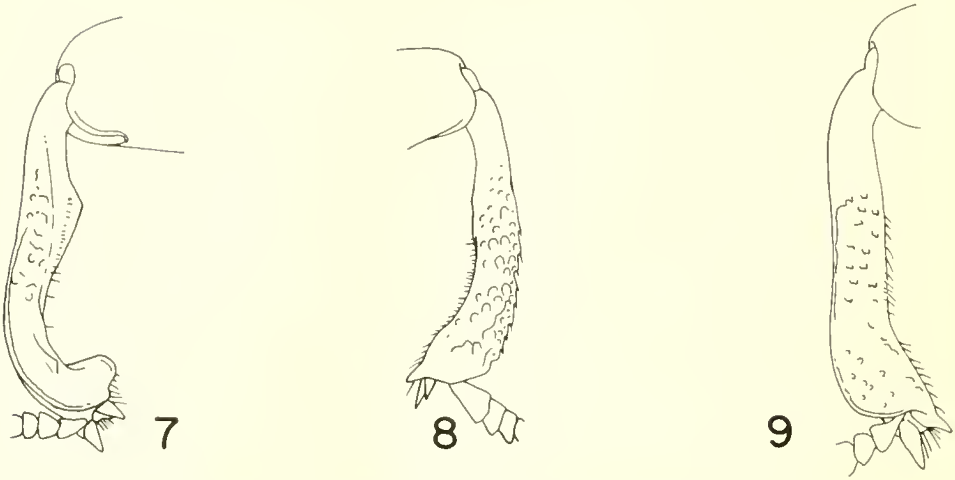
Mesosternum deeply, sharply concave; metasternal length less than ⅓ mesocoxal diameter; abdominal sternites finely rugose, with punctures about ½–1 times eye facet diameter interspersed with exceedingly fine punctures. Fore and middle femora clavate; fore tibia with blunt triangular tooth about ⅓ from base; apical third strongly curved mesally (Fig. 7), posterior surface with raised lateral margin, mesal subapical tooth and apical flattened projection subtended by row of spinose fulvous setae; middle femur with sparse strip of short stiff, fulvous setae on anteroventral surface; middle tibia (Fig. 8) arcuate, with thickened angulation ⅖ from base, row of erect, spinose setae running from angulation to apex along posteroventral surface; hind femur weakly arcuate, slightly thicker apically, with band of fulvous setae on anteroventral surface; hind tibia nearly straight with row of erect, spinose setae from just before base to apex.

Female.—Labial palp with last segment subcylindrical; fore tibia slightly thickened about ⅓ from base, apical ¼ bent slightly mesad (Fig. 9), anteroventral margin with row of erect spinose setae from near base to apex; middle tibia without angulate thickening on ventral surface.

Elytral length, 8.8–9.25 mm; greatest elytral width 6.0–6.3 mm; median pronotal length, 4.4–4.9 mm; greatest pronotal width, 5.2–5.6 mm.

Holotype male and female paratype (California Academy of Sciences) from

Fig. 6. *Uloma carolynae,* male, habitus.



Figs. 7–9. *Uloma carolynae*. 7, Fore tibia, male. 8, Middle tibia, male. 9, Fore tibia, female.

Mexico, Chiapas-Oaxaca border, 21 km W Rizo de Oro along ridge SE of Cerro Baul, altitude 1615 m, 6-IX-1972. Carolyn Mullinex. In cloud forest. One ♂ paratype, 19 km W Rizo de Oro, Cerro Baul, 1615 m, IV-28-1922. D. E. Breedlove; 1 ♀ paratype, Chiapas, SE side Cerro Tres Picos, montane rain forest, 1524–1829 m, V-28-1972. D. E. Breedlove.

Uloma carolynae is most similar to *U. spinipes* Champion, from which it differs in having the outer foretibial margin entire (denticulate in *spinipes*), in lacking the apical tooth on the middle tibia, and in lacking both the basal and apical teeth on the hind tibia. *U. carolynae* has rows of erect setae on the ventral tibial margins, while *spinipes* has brushes of hairs at the tibial apices. *U. extraordinaria* Spilman (1961b), evidently belongs in the *spinipes* species group. It is distinguished by having the basal protibial tooth very long, narrow and acute in the male, and shorter but acute in the female (Spilman, 1961: figs. 1, 2).

I take pleasure in naming this species for Carolyn Mullinex-Tibbets.

Tribe Triboliini

Triboliens Mulsant, 1854, 1856.
Triboliides (in part) Lacordaire, 1859.
Triboliini Reitter, 1917; Skopin, 1964, 1978; Kwieton, 1982.
Ulomini Gebien, 1938–42 (in part).

Adult.—Small to moderate, elongate to broadly oval, flattened to subcylindrical. Eyes moderate in size, anteriorly emarginate or entire (*Palorus*); antennae gradually clavate or with abrupt 4 segmented club (*Lyphia*), with simple, conical sensoriae, or with compound (tenebrionoid) sensoriae on inner and outer margins of apical 7–8 segments. Labrum subquadrate (*Palorus*) or broadly transverse; labroclypeal membrane concealed; mandibles with molas similar with simple or striate surface; lacinial uncus present or absent; ligula membranous; tentorium with bridge posterior, not arched, or absent (*Palorus*). Mesocoxal cavities closed laterally by sterna; apical membrane less than ⅓ wing length. Ovipositor with gonostyles lateral, small; coxite as long or longer than paraproct, with 4 subequal lobes, sometimes poorly defined. Internal female tract with long, thin, tightly coiled spermatheca at base of accessory gland, or with single diverticulum (*Palorus*). Defensive reservoirs short, saccate with broad openings (*Palorus*) or long, saccate with constricted openings; without common volume; reservoir walls without annular foldings; secretory tissue drained by basal field or basal line of ducts. Aedeagus with tegmen dorsal; median lobe free or adnate.

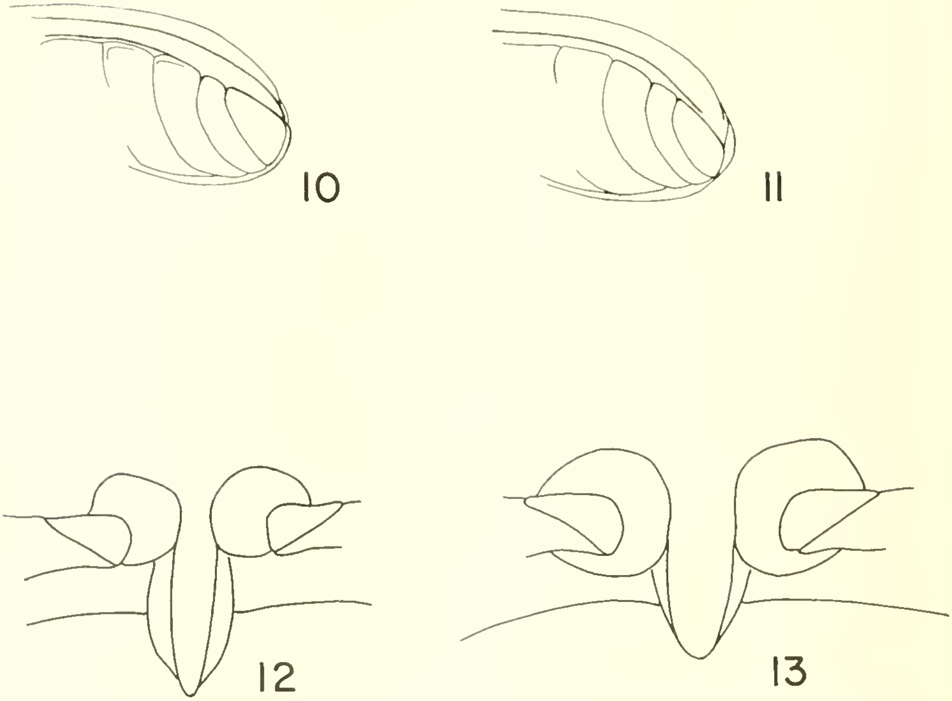
Larva (synthesized in part from Hayashi, 1966; Halstead, 1967a; Van Emden, 1947; Skopin, 1978).—Subcylindrical, slightly flattened ventrally, weakly sclerotized; caudal segments gradually tapering.

Antenna with 2nd segment about 1.25–2.0 × length of basal, bearing apicomedial lens shaped sensoria. Labrum transverse (*Tribolium*) or ovate; epipharyngeal masticatory process of small, single, slightly asymmetrical teeth or undeveloped (*Tribolium*). Mandibles with bilobed incisor; molar lobes strong, projecting, flat or nearly so, sometimes bearing few carinae. Maxilla with mala evenly convex, not incised; finely setose. Hypopharyngeal sclerome concave with base not produced, or absent (*Tribolium*; Hayashi, 1966). Thoracic legs slender, similar in structure, sparsely set with hair-like setae. Abdominal segments with pleural sutures distinct; tergite and sternite 9 subequal; tergite 9 produced as sharply pointed urogomphi; pygopods absent (*Latheticus*; Hayashi, 1966) or present. Spiracles annular.

The following key is modified in part from Spilman, 1962.

KEY TO THE GENERA OF TRIBOLIINI OF NORTH AND CENTRAL AMERICA

1\. Elytral intervals finely carinate .... *Tribolium* Macleay
– Elytral intervals flat or convex, sometimes with weak carina in eighth interval 2
2\. Elytral epipleuron tapering gradually posteriorly, attaining elytral apex (Fig. 10) 3
– Elytral epipleuron ending abruptly well before elytral apex (Fig. 11) .... *Tharsus* LeConte
3\. Antenna with last 4 segments forming distinct, capitate club .... *Lyphia* Mulsant and Rey
– Antenna gradually clavate 4
4\. Middle and hind tibiae arcuately curved .... *Aesymnus* Champion
– Middle and hind tibiae straight 5
5\. Pronotal disk with punctures of two distinct sizes 6
– Pronotal disk with punctures of a single size 8
6\. Distance between eye and cardo much less than width of cardo 7
– Distance between eye and cardo greater than width of cardo .... *Mycotrogus* Horn
7\. Prosternal process extending posteriorly beyond procoxae by nearly twice coxal length; apex acute, very narrowly rounded (Fig. 12) .... *Metulosonia* Bates
– Prosternal process extending posteriorly beyond procoxae by about one coxal length; apex broadly rounded (Fig. 13) .... *Ulosonia* Laporte
8\. Eye round, entirely ventrad of epistomal canthus .... *Palorus* Mulsant



Figs. 10–13. Generic characters, Triboliini. 10, 11, Apical region of abdomens. 10, *Ulosonia*. 11, *Tharsus*. 12, 13, Prosternal processes. 12, *Metulosonia*. 13, *Ulosonia*.

– Eye reniform, emarginated in dorsal third by epistomal canthus .... *Latheticus* Waterhouse

On the basis of adult features, Triboliini comprises two groups of genera. The *Palorus* "genus group" (Halstead, 1967b) is characterized as follows: labrum subquadrate; lacinia without uncus; eye entire; tentorial bridge absent; defensive glands small, short, saccate with broad openings; bursa copulatrix with single, thick diverticulum (accessory gland?). *Palorus* is introduced to North America; other members of the *Palorus* genus group occur in the Old World (see Halstead, 1967b).

The remaining North American Triboliini are more similar to *Tribolium*, and might be referred to as the "*Tribolium* genus group." This group is characterized as follows: labrum transverse; lacinia with uncus; eye anteriorly emarginate; tentorial bridge present, posterior, not arched; defensive glands large, elongate; female reproductive tract with both spermatheca and accessory gland.

Although they share a high level of phenetic similarity in external characters of both adults and larvae, the drastic difference between these genus groups in configuration of the female reproductive tract is unusual and suggests that the relationship between these groups deserves further consideration. Such an undertaking would require detailed study of the predominantly Old World fauna of Triboliini, which is beyond the scope of this work.

Among the *Tribolium* genus group, the genera *Ulosonia*, *Metulosonia* and *My-*

cotrogus have striate mandibular molas, the prosternal process extended far posteriorly and received in the deeply concave mesosternum, compound antennal sensoriae and relatively shorter defensive reservoirs with broad openings. In *Lyphia, Latheticus, Tribolium,* and *Tharsus* the mola is nonstriate, the prosternal process is relatively short, the antennal sensoriae are simple cones (with 2 or more sensory pegs in some *Tribolium*; Roth & Willis, 1951) and the defensive reservoirs are very elongate with constricted openings and basomedian pouches. *Tharsus* is unique among the genera considered here in having the epipleuron ending before the elytral apex, but this character is quite variable in other tribes such as Diaperini. I have been unable to dissect *Aesymnus,* but external features indicate placement in Triboliini.

Acknowledgments

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Literature Cited

Arnett, R. H., Jr. 1960. The beetles of the United States. Catholic University Press, Washington, D.C. ix + 1112 pp.

Cekalovich, T. and E. Morales. 1974. Descripcion de la larva de *Oligocara nitida* Solier, 1848 (Coleoptera, Tenebrionidae). Bol. Soc. Biol. Concepcion 48: 173–177.

Champion, G. C. 1886. Biologia Centrali-Americana, Insecta, Coleoptera (Tenebrionidae), vol. 4, pt. 1: 137–264.

Doyen, J. T. 1984. Reconstitution of the Diaperini of North America, with new species of *Adelina* and *Sitophagus* (Coleoptera: Tenebrionidae). Proc. Entomol. Soc. Wash. 86: 777–789.

Doyen, J. T. and W. R. Tschinkel. 1982. Phenetic and cladistic relationships among tenebrionid beetles (Coleoptera). Syst. Entomol. 7: 127–183.

Gebien, H. 1938–42. Katalog der Tenebrioniden, Teil II. Mitt. Muench. Entomol. Ges. 28–32: 370–744 [repaged].

Halstead, D. G. H. 1967a. Biological studies on species of *Palorus* and *Coelopalorus* with comparative notes on *Tribolium* and *Latheticus* (Coleoptera: Tenebrionidae). J. Stored Prod. Res. 2: 273–313.

———. 1967b. A revision of the genus *Palorus* (sens. lat.) (Coleoptera: Tenebrionidae). Bull. Brit. Mus. (Nat. Hist.) Entomol. 19: 5–148.

Hayashi, N. 1966. A contribution to the knowledge of the larvae of Tenebrionidae occurring in Japan (Coleoptera: Cucujoidea). Insecta Matsumarana, Suppl. 1: 1–41, 32 pls.

Kwieton, E. 1982. Revue critique des systèmes récents de la famille des Tenebrionidae (Col.). Acta Mus. Nat. Prague 38(B): 79–100.

Lacordaire, T. 1859. Histoire naturelle des insectes. Genera des Coléoptères. Tome 5. Roret, Paris. 750 pp.

Medvedev, G. S. 1977. The taxonomic significance of the antennal sensillae of the darkling beetles. Acad. Nauk SSSR, Trudi Vsesoyuznovo Entomologicheskovo Obschchestva 58: 61–86.

Mulsant, E. 1854. Histoire naturelle des Coléoptères de France, pt. 5, latigènes, pp. 1–396.[1]

———. 1856. Histoire naturelle des Coléoptères de France. Tribu des latipennes. Ann. Soc. Linn. Lyon (2)3: 305–471.[1]

Reitter, E. 1917. Bestimmungstabellen europäischer Coleoptera.—81. Unterfamilien und Tribus der palaeärtikischen Tenebrionidae. Wien. Entomol. Zeit. 36: 51–66.

Roth, L. M. and E. R. Willis. 1951. Hygroreceptors in adults of *Tribolium* (Coleoptera, Tenebrionidae). Jour. Exptl. Zool. 116: 527–570.

Skopin, N. G. 1964. Die Larven der Tenebrioniden des Tribus Pycnocerini (Coleoptera, Heteromera). Ann. Mus. R. Afr. Cent. Ser. Quart. 127: 1–35.

———. 1978. Tenebrionidae. *In* Klausnitzer, B. Ordnung Coleoptera (larven). Junk, The Hague. 378 pp.

Spilman, T. J. 1961a. Remarks on the classification and nomenclature of the American Tenebrionine genus *Adelonia*. Pan-Pac. Entomol. 37: 49–51.

———. 1961b. *Uloma extraordinaria*, a new species from Cuba (Tenebrionidae). Coleopt. Bull. 15: 113–115.

———. 1962. A few rearrangements in the Tenebrionidae, with a key to the genera of the Ulomini and Tenebrionini of America, north of Mexico. Coleopt. Bull. 16: 57–63.

———. 1966. On the generic names *Alphitobius, Phtora, Clamoris* and *Cataphronetis* (Coleoptera: Tenebrionidae). Proc. Entomol. Soc. Wash. 68: 6–10.

———. 1978. Descriptions of the larva, pupa, and adult of *Alegoria dilatata*, associated with banana plants in the Neotropics (Coleoptera: Tenebrionidae). U.S. Dep. Agr. Coop. Pl. Pest Rep. 3: 47–51.

Tschinkel, W. R. 1975. A comparative study of the chemical defensive system of tenebrionid beetles. III. Morphology of the glands. J. Morphol. 145: 355–370.

Tschinkel, W. R. and J. T. Doyen. 1980. Comparative anatomy of the defensive glands, ovipositors and female genital tubes of tenebrionid beetles (Coleoptera). Int. J. Insect Morphol. and Embryol. 9: 321–368.

Van Emden, F. I. 1947. Larvae of British beetles. VI. Tenebrionidae. Entomol. Mon. Mag. 83: 154–171.

Watt, J. C. 1974. A revised subfamily classification of Tenebrinidae (Coleoptera). N.Z. J. Zool. 1: 381–452.

Wollaston, T. V. 1867. Coleoptera Hesperidum, being an enumeration of the coleopterous insects of the Cape Verde Archipelago. London, 285 pp.

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[1] From Blackwelder, R. E. 1957. Checklist of the Coleopterous Insects of Mexico, Central America, the West Indies, and South America. U.S. Nat. Mus. Bull. 185: 927–1492.

PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 525–529

THE NYMPH OF *BISANCORA RUTRIFORMIS* SURDICK (PLECOPTERA: CHLOROPERLIDAE)[1]

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Abstract.—The previously unknown nymph of the stonefly *Bisancora rutriformis* was collected at its type locality, reared, and is described and illustrated herein. Preliminary comparisons, based on similarities of pronotal setation and mouthparts between it and nymphs of the other seven genera of the subfamily Chloroperlinae indicate that *rutriformis* is most closely allied with *Alloperla*. This corroborates relationship of these two genera based on adult genitalia.

In 1978, K. W. Stewart and B. P. Stark began a program to rear and comparatively describe and illustrate the unknown and poorly known nymphs of North American stonefly genera to enable: (1) construction of the first complete generic-level nymph key, and (2) acquisition of new nymphal characters that could be used as additional lines of evidence for phylogenetic analyses of Plecoptera. Since then, they and colleagues have described and illustrated for the first time nymphs in the genera *Calliperla* (Perlodidae) (Szczytko and Stewart, 1984), *Cascadoperla* (Perlodidae) (Szczytko and Stewart, 1979), *Chernokrilus* (Perlodidae) (Stewart and Stark, 1984), *Lednia* (Nemouridae) (Baumann and Stewart, 1980), *Oconoperla* (Perlodidae) (Stark and Stewart, 1982b), *Viehoperla* (Peltoperlidae) (Stark and Stewart, 1982a), representative nymphs for all genera in the Peltoperlidae (Stark and Stewart, 1981) and Perlodinae (Stewart and Stark, 1984), and nymphs of the species of *Taeniopteryx* (Fullington and Stewart, 1980).

The only remaining nearctic genera with unknown nymphs are *Hansonoperla* Nelson (Perlidae) (Nelson, 1979) and *Bisancora* Surdick (Chloroperlidae) (Surdick, 1981b). On May 13, 14, 1984, K. W. Stewart and B. Poulton visited Little Rock Crk., Los Angeles Co., Calif., the type locality of *Bisancora rutriformis* Surdick, and adjacent streams in the San Gabriel Mts. They collected the following *B. rutriformis* specimens: (1) 1 mature ♂ nymph, 13 ♂ and 6 ♀, Little Rock Crk., 6.3 mi. S. Hwy. 138 (Pearblossom Hwy.) on Cheeseboro Rd. (2.4 mi. S. Little Rock Dam) 13-IV-1984, and (2) 1 ♀ nymph, 4 ♂ and 2 ♀, Little Rock Crk. between Basin and Sycamore campgrounds, 14-IV-1984. The female nymph was field-reared in a styrofoam ice chest. The following description and figures were prepared from the single male nymph, and nymphal exuvium from the reared female.

With B. P. Stark we are currently engaged in a comparative study of chloro-

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[1] Study supported in part by National Science Foundation Grants DEB78-12565, BSR 8308422 and the Faculty Research Fund of North Texas State University.

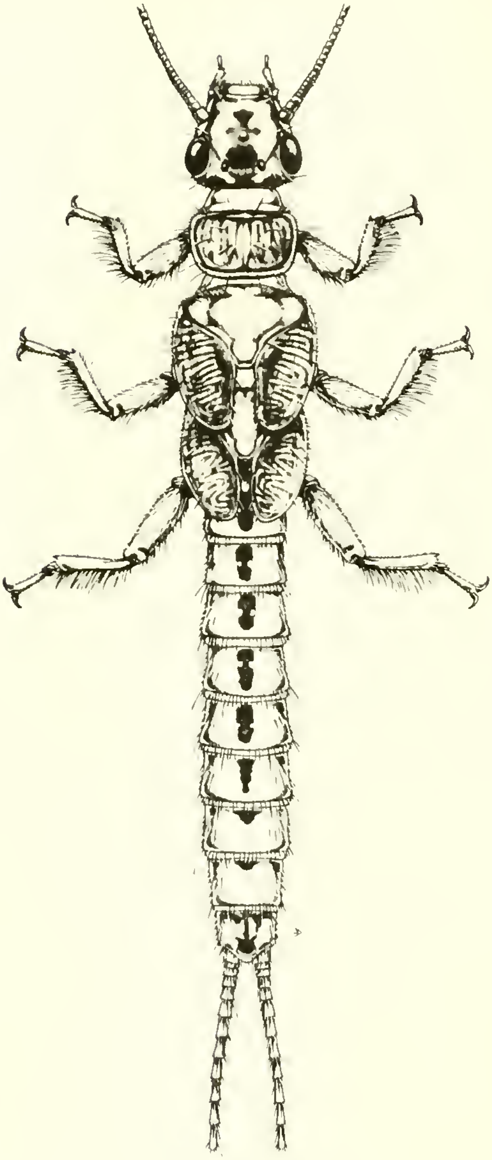

Fig. 1. Nymph habitus of *Bisancora rutriformus*; scale line = 2 mm.

perlinae nymphs, which should help to further elucidate generic relationships in this group. Morphological gaps between several genera are relatively small in all life stages; for example, the epiproct differences (which should carry heavy weight in character analysis) between species of *Bisancora, Alloperla* and some *Sweltsa* seem sufficiently subtle to raise questions about their placement in separate genera. A careful comparative study of all life stages is needed for acquisition of additional characters in the group.

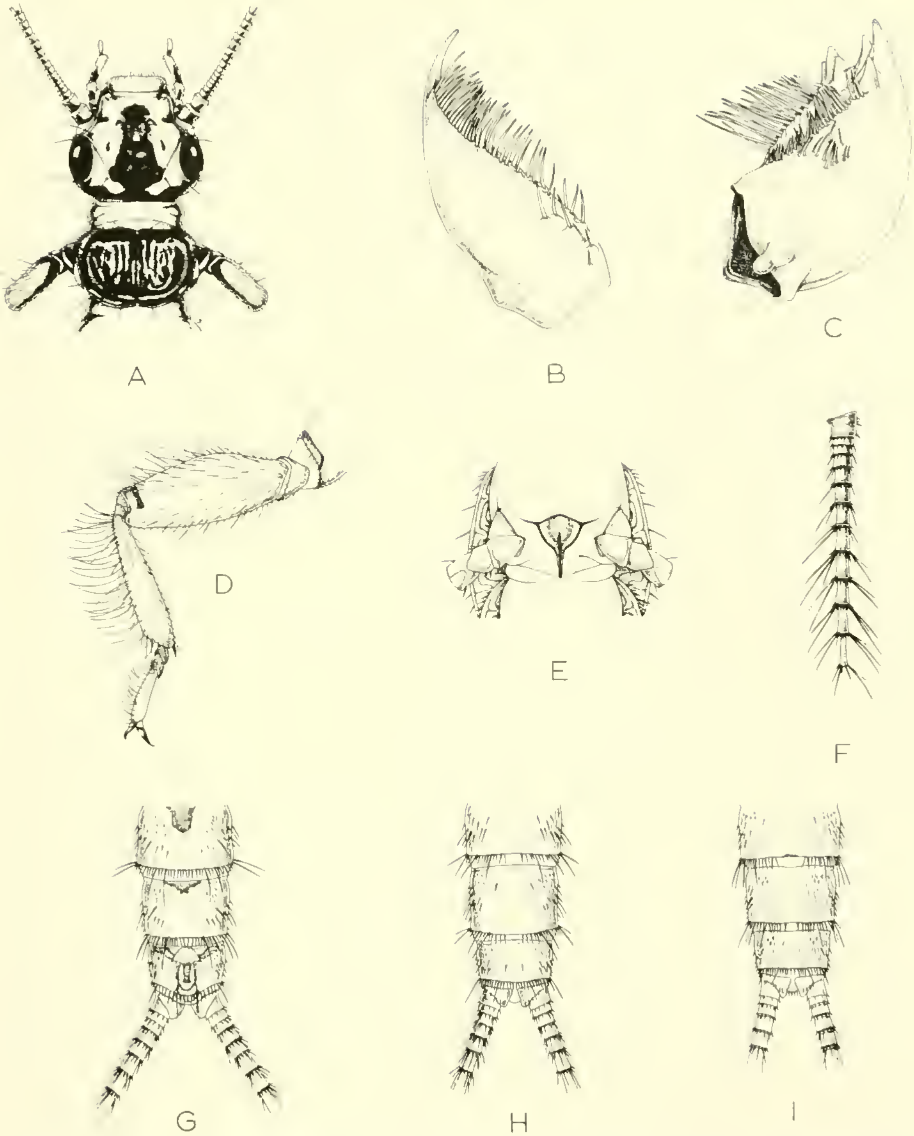

Fig. 2. Nymph characters of *Bisancora rutriformis*. A, Head-pronotum. B, Right lacinia (ventral). C, Right mandible. D, Right front leg (anterior). E, Mesosternum with Y-pattern. F, Right cercus (lateral). G, ♂ abdomen (dorsal). H, ♂ abdomen (ventral). I, ♀ abdomen (ventral).

***Bisancora rutriformis* nymph**

Mature male nymph (Fig. 1).—Length 5.0 mm; general color yellow with light brown markings; body covered with long clothing hairs. Dorsum of head yellow with light brown patch enclosed within ocellar triangle, extending forward medially on frons; occiput with posterior light brown transverse band; antennae yellow; 2

long setae anterior and posterior to eye, and single, long seta at anterior corners of frons and outside each lateral ocellus (Fig. 1). Ventral and dorsal cusps of left mandible each with 3 unserrated teeth and median ventral patch of 12–14 stout hairs (Fig. 2C). Laciniae with single terminal tooth, about 0.25 the total lacinial length; thickset row of long, stout setae below tooth and continuous row of stout, marginal setae; submarginal basal row of 6–8 stout setae (Fig. 2B). Pronotum light brown with darker rugosities (Fig. 1); lateral pronotal setae absent; setae on corners, and a medial pair on anterior and posterior margins (Fig. 1). Meso- and metanota yellow; wingpads brown, with irregular short to medium length lateral, marginal setae; a few long setae on posterior and inner wingpad margins, and dorsally. Legs yellow, with partial transverse dorsal brown band distal end of femur; femorae and tibiae with scattered medium to long surface setae and sparse dorsal fringe of long, fine hairs (Fig. 2D). Y-arms of mesosternum meeting posterior corners of furcal pits; transverse ridge distinct (Fig. 2E). Abdominal tergae 1–9 with dark median stripe (Fig. 1); lateral stripe present on segments 1–4; posterior margins with row of median to long setae; a few mostly lateral short to long intercalary setae (Fig. 2G); sternae 8–9 with medially-interrupted posterior setal row; sternum 10 posterior setal row complete (Fig. 2H). Cerci 12-segmented, with posterior circlets of hairs and 2–3 long dorsal and ventral posterior setae on each segment (Fig. 2F); no dorsal fringe of silky hairs.

Female nymphal exuvium.—Length 6.0 mm. Abdominal sternae similar to ♂, with medially-interrupted posterior setal row or segments 8–9 (Fig. 2I).

Diagnosis and discussion.—There is little basis for a definitive diagnosis of *Bisancora*'s relationship to the other seven Chloroperlinae genera, based on nymph characters. Surdick (1981a) and Fiance (1977) have provided the only recent generic-level comparisons and keys to the other nymphs of this subfamily. There are ambiguities between some key characters and referred illustrations in the Surdick (1981a) paper, and she gave no indication of which species were examined for generation of nymph characters, or whether there was interspecific variation in generic characters used in the key and written nymph descriptions.

We have made a preliminary comparison of *Bisancora* nymphs with those of the type species of all seven other genera in the subfamily, and nymphs of several species of *Sweltsa, Alloperla* and *Triznaka*. It appears that they are most closely allied to *Alloperla*, based on the following similarities: (1) pronotal setation of *Alloperla* is exclusively on the corners; *Bisancora* has setation primarily on the corners with only a pair of setae on the anterior and posterior margins (Figs. 1, 2A), (2) *Alloperla* and *Bisancora* both have a close-set comb of socketed teeth just below the major terminal lacinial tooth (Fig. 2B). Nymphs of the other seven genera have numerous fringe hairs at least on the posterior pronotal margin, and no close-set comb of socketed teeth immediately below the major terminal lacinial tooth.

LITERATURE CITED

Baumann, R. W. and K. W. Stewart. 1980. The nymphs of *Lednia tumana* (Ricker) (Plecoptera: Nemouridae). Proc. Entomol. Soc. Wash. 72: 655–659.

Fiance, S. B. 1977. The genera of eastern North American Chloroperlidae (Plecoptera): Key to larval stages. Psyche 83: 308–316.

Fullington, K. E. and K. W. Stewart. 1980. Nymphs of the stonefly genus *Taeniopteryx* (Plecoptera: Taeniopterygidae) of North America. J. Kans. Entomol. Soc. 53: 237–259.

Nelson, C. H. 1979. *Hansonoperla appalachia*, a new genus and a new species of eastern nearctic Acroneuriini (Plecoptera: Perlidae), with a phenetic analysis of the genera of the tribe. Ann. Entomol. Soc. Am. 72: 735–739.

Stark, B. P. and K. W. Stewart. 1981. The nearctic genera of Peltoperlidae (Plecoptera). J. Kans. Entomol. Soc. 54: 285–311.

———. 1982a. The nymph of *Viehoperla ada* (Plecoptera: Peltoperlidae). J. Kans. Entomol. Soc. 55: 494–498.

———. 1982b. *Oconoperla*, a new genus of North American Perlodinae (Plecoptera: Perlodidae). Proc. Entomol. Soc. Wash. 84: 746–752.

Stewart, K. W. and B. P. Stark. 1984. Nymphs of North American Perlodinae genera. Great Basin Natur. 44: 373–415.

Surdick, R. F. 1981a. Nearctic genera of Chloroperlinae (Plecoptera: Chloroperlidae). Ph.D. Thesis, Univ. of Utah, Univ. Microfilms #DA8208937.

———. 1981b. New nearctic Chloroperlidae (Plecoptera) Great Basin Natur. 41: 349–359.

Szczytko, S. W. and K. W. Stewart. 1979. The genus *Isoperla* (Plecoptera) of western North America; holomorphology and systematics, and a new stonefly genus *Cascadoperla*. Mem. Am. Entomol. Soc. 32: 1–120.

———. 1984. Descriptions of *Calliperla* Banks, *Rickera* Jewett, and two new western nearctic *Isoperla* species. Ann. Entomol. Soc. Am. 77: 251–263.

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BRACHYDERES INCANUS (COLEOPTERA: CURCULIONIDAE): NEW RECORDS AND CONFIRMATION OF ITS ESTABLISHMENT IN NORTH AMERICA

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Abstract.—*Brachyderes incanus* (L.), a brachyderine weevil considered a conifer pest in Europe, has been recorded in the curculionid literature from Missouri and Canada, but the validity of these records and the establishment of North American populations have been questioned. Records of this species from Massachusetts and New York and its injury to ornamental conifers, published in the economic literature but largely overlooked, are reviewed; new state records are given for Connecticut and Pennsylvania; and additional localities are cited for Massachusetts, New Jersey, and New York. The life history and economic importance in Europe are summarized, and an adult diagnosis is provided.

Brachyderes incanus (L.) is an Old World brachyderine weevil that ranges throughout much of northern and middle Europe south to Italy and France and east to the Balkan Peninsula. Known in the German economic literature as "Graue Kiefernnadelrüssler" or "Gemeine Graurüssler," this conifer pest usually is important only in established plantations, although larval injury may threaten the existence of seedling nurseries. Scotch pine, *Pinus sylvestris* L., is a common host plant, with other pines and genera of conifers also serving as hosts.

My interest in *Brachyderes incanus* was prompted by Anne T. Howden. In preparing a petition to the International Commission on Zoological Nomenclature concerning the weevil generic names *Brachyderes*, *Cycloderes*, and *Thylacites*, she was interested in knowing whether this Palearctic species is established in the Western Hemisphere. She considered published records from Missouri and Canada as possibly spurious, or at least as inconclusive regarding the establishment of New World populations. No voucher material has been located for an early Missouri record (1880's) that may be based on a misidentification (see discussion under History and Distribution in North America). Because D. R. Whitehead (Systematic Entomology Laboratory, Agricultural Research Service, Washington, DC) had told her I collected a specimen of *B. incanus* at the Longwood Gardens (Chester Co.), Pennsylvania in 1974 (identified by R. E. Warner), she encouraged me to try to determine if this species is still present in the arboretum. Having collected 12 specimens there in August 1984, I can confirm the establishment of *B. incanus* in North America.

Here, I summarize information on the biology and economic importance of *B. incanus* in Europe, review its history and distribution in North America, call attention to authentic but largely overlooked records published in the U.S. Department of Agriculture's *Insect Pest Survey Bulletin* in 1928 and 1934 and an unverified record from a USDA list of important insects for 1942, and provide a diagnosis of the adult.

LIFE HISTORY AND IMPORTANCE IN EUROPE

The following outline of phenology and habits of *B. incanus* in Europe was drawn from Butovitsch (1932), de Fluiter and Blijdorp (1933a, b; 1935), Schwerdtfeger (1936), Adlung (1964), Schindler (1974), Dieckmann (1980), and Harde (1984). The most detailed treatment of biology, with photographs of life stages and injury to conifers, is that of de Fluiter and Blijdorp (1935).

Overwintered adults become active in early spring, and females deposit groups of 30–125 eggs in the soil. A maximum fecundity of 1200–1300 has been recorded. Eggs hatch in about three weeks, and larvae begin to bore into and strip bark from roots of their hosts, especially at the junction of a large and small root. Roots up to 3 mm in diameter may be killed. Pupation occurs during July and August, adults emerge after 3–4 weeks, and females begin to oviposit after about two weeks.

Some authors state that only adults of this univoltine species overwinter, but it appears that eggs and larvae also overwinter. Some summer females apparently do not complete oviposition before hibernating; during summer, overwintered adults may overlap with those developing from eggs or larvae that passed the winter. The seasonal history of populations probably varies according to locality and length of the growing season.

Adults feed on conifer needles, producing a characteristic serrated appearance and dripping resin, and occasionally attack the bark. Heavily infested trees may be detected by a resinous odor and a whitish cast to the shoots that results from the copious deposits of resin. Injury is said to be more severe in dry seasons or under conditions of poor soil fertility.

HISTORY AND DISTRIBUTION IN NORTH AMERICA

The first mention of *B. incanus* in the New World appears to have been published by LeConte and Horn (1883: 439), who noted that this introduced species "has occurred at St. Louis." The citing of a locality suggests that they had seen material from that city, but no specimens of *B. incanus* are present in the Le Conte or Horn collections, which are housed at the Museum of Comparative Zoology at Harvard University (A. F. Newton, Jr., pers. comm.). Because the length given for their weevil (36 mm) is more than three times that of *B. incanus* (7.0–11.5 mm), it seems unlikely that this was the species present at St. Louis.

Brachyderes also has been recorded from Canada (O'Brien and Wibmer, 1982). The basis for this record is a specimen (now in the possession of C. W. O'Brien) from the Warren Knaus collection, labeled "Can." (A. T. Howden, pers. comm.). Two similarly labeled specimens from the Knaus Collection, determined by C. W. O'Brien, are in the Kansas State University collection (H. D. Blocker, pers. comm.). Another specimen bearing a "Can." label, part of the F. Knab collection, is housed at the National Museum of Natural History (NMNH) (D. R. Whitehead, pers. comm.). The origin of these specimens may actually have been Canada, although no Canadian specimens of *B. incanus* have been located in the Canadian

National Collection or the Royal Ontario Museum (Howden, pers. comm.). It also is possible that the specimens were collected at Canada, *Kansas*, a small town situated about 30 miles east of McPherson where Knaus published the local newspaper (Dean, 1938).

Two records published more than 50 years ago in the economic literature and overlooked by weevil specialists represent the only reliable information available on *B. incanus* in North America. Bourne (1928) reported that in early June 1928 large numbers of this weevil caused "considerable injury to blue spruce" (*Picea pungens* Engelm.) in eastern Massachusetts. Further examination revealed that nearly all spruces and most of the pines, except white pine (*Pinus strobus* L.), had been attacked. It was noted that H. S. Barber identified the specimens, but Bourne did not mention an exact locality; there is material in the NMNH collection from Abington, Massachusetts, June 8, 1928, on Koster blue spruce from Holland and June 9, from Bay State Nursery, Abington, on spruce. Schaffner (1934) stated that specimens of *B.* (= *Thylacites*) *incanus*, determined by L. L. Buchanan, had been collected on blue spruce, October 11, 1934, at North Roslyn, New York, and that control suggestions were needed. The NMNH has voucher specimens from that Long Island, New York collection. The U.S. Department of Agriculture (1942) reported New Jersey as a new state record, noting this weevil was injuring conifers in a nursery, but no New Jersey specimens collected before 1945 have been found.

The following new records of *B. incanus*, obtained from the insect collections of Cornell University (CU), Museum of Comparative Zoology (MCZ), Pennsylvania Department of Agriculture (PDA), and NMNH, confirm the establishment of this Palearctic weevil in eastern North America.

CONNECTICUT: Westport, 4 Aug. 1953, on white pine (NMNH); Hartford (? loc.), Liebeck Collection (MCZ). MASSACHUSETTS: Rockland, 22 Aug. 1940, E. W. King (NMNH). NEW JERSEY: Passaic Co., Wanaque Res., 9 Sept. 1966, E. E. Simons, on red pine (PDA); Washington Crossing, 18 June 1945 (submittal date), H. B. Girth, on red pine, and 13 Oct. 1964, J. Beach, on larch (NMNH). NEW YORK: Glen Head, 11 May 1937; Hempstead, 22 Sept. 1935, on pine needles (CU); Jericho, 25 Oct. 1944, Tuthill, on red pine; Patchogue, 25 Sept. 1933, L. A. Gilbert, in nursery on pine; Roslyn, Sept. 1937, Mrs. P. S. Allen, in house, and 8 Dec. 1943, Plummer, with fallen Austrian pine needles (NMNH); Saratoga State Nursery, 9 Oct. 1958, R. H. Everitt (CU). PENNSYLVANIA: Chester Co., Longwood Gardens, 20 Aug. 1974, A. G. Wheeler, Jr., on Scotch pine, and 23 Aug. 1984, A. G. W., on Japanese larch (PDA).

With little doubt, the New World origin of *B. incanus* can be attributed to importation with European nursery stock. Label data on Abington, Massachusetts specimens indicate its collection from spruces that originated in Holland (NMNH, MCZ). The considerable numbers already present then at Abington (Bourne, 1928) suggest an established population and its earlier introduction. Because millions of conifers and other plants were imported to northeastern United States in the early twentieth century (e.g. Atwood, 1910; Felt, 1910), multiple introductions of this pest seem probable. A separate introduction may explain the occurrence of *B. incanus* on Long Island, New York during the 1930's, or shipments of conifers from infested nurseries in eastern Massachusetts may have been responsible for the New York populations. Once established on Long Island, *B. incanus* was spread through plant shipments. A Patchogue specimen collected in 1933 can be traced to a shipment of stock from a Roslyn nursery (NMNH).

Recognition of Adult *Brachyderes incanus*

The principal morphological characters allowing *B. incanus* to be placed in the subfamily Brachyderinae are: scrobe lateral, sharply defined, strongly deflexed so that scape usually rests below eye when retracted next to head, and prothorax with anterior margin truncated, margin not produced into rounded lobe behind eye (van Emden, 1944; Kissinger, 1964).

Adults of *B. incanus*, the sole member of *Brachyderes* occurring in North America, can readily be distinguished from other brachyderine weevils by the following combination of characters: tarsal claws connate at base, hind tibia with corbel open, head not constricted dorsally behind eyes, elytral humeri absent, and ascending comb of hind tibia longer than width of hind tibia at base. The adult habitus is figured in Schindler (1974: 257); Amann (1961: 14) and Harde (1984: 291) provide a color illustration of the adult.

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Literature Cited

Adlung, K. G. 1964. Zum Auftreten einiger Laus-und Käferarten an Jungkiefern. Anz. Schädlingskd. 37: 90–91.

Amann, G. 1961. Kerfe der Waldes. J. Neumann, Neudamm & Melsungen. 284 pp.

Atwood, G. G. 1910. Brown-tail moth on imported nursery stock. J. Econ. Entomol. 3: 71–76.

Bourne, A. I. 1928. A curculionid (*Thylacites incanus* L.). Insect Pest Surv. Bull. 8(5): 185.

Butovitsch, V. 1932. Der Larvenfrass von *Brachyderes incanus*. Allg. Forst-u. Jagd-Zgt. 108: 91–94.

Dean, G. A. 1938. Warren Knaus. J. Kans. Entomol. Soc. 11: 1–3.

Dieckmann, L. 1980. Beiträge zur Insektenfauna der DDR: Coleoptera-Curculionidae (Brachycerinae, Otiorhynchinae, Brachyderinae). Beitr. Entomol. 30: 145–310.

van Emden, F. I. 1944. A key to the genera of Brachyderinae of the world. Ann. Mag. Nat. Hist. (11) 11: 503–532; 559–586.

Felt, E. P. 1910. Recent observations upon European insects in America. J. Econ. Entomol. 3: 340–343.

de Fluiter, H. J. and P. A. Blijdorp. 1933a. De "grauwe dennensnuitkever," *Brachyderes incanus* L., als ernstige vijand onzer naaldhoutboomen. Tijdschr. Plantenziek. 39: 95–96.

———. 1933b. Voorloopige mededeeling omtrent de beschadiging door de larve (1ste stadium) van den grauwen dennensnuitkever *Brachyderes incanus* L. aangericht aan de wortels van de grove den. Tijdschr. Plantenziek. 39: 212–213.

———. 1935. De grauwe dennensnuitkever *Brachyderes incanus* L. Tijdschr. Plantenziek. 41: 141–211.

Harde, K. W. 1984. A field guide in colour to beetles. Octopus Books Ltd., London. 334 pp.

Kissinger, D. G. 1964. Curculionidae of America north of Mexico: a key to the genera. Taxonomic Publications, South Lancaster, Massachusetts. 143 pp.

LeConte, J. L. and G. H. Horn. 1883. Classification of the Coleoptera of North America. Smithsonian Misc. Coll. 26(507): 1–567.

O'Brien, C. W. and G. J. Wibmer. 1982. Annotated checklist of the weevils (Curculionidae *sensu lato*) of North America, Central America, and the West Indies (Coleoptera: Curculionoidea). Mem. Am. Entomol. Inst., Ann Arbor, Michigan. No. 34. 382 pp.

Schaffner, J. V., Jr. 1934. A curculionid (*Thylacites incanus* L.). Insect Pest Surv. Bull. 14(8): 295.

Schindler, U. 1974. Fam.-Reihe: Rhynchophora-Adelognathi, Kurzrüssler, pp. 252–271. *In* Schwenke, W., ed., Die Forstschädlinge Europas. Vol. 2. Paul Parey, Hamburg & Berlin.

Schwerdtfeger, F. 1936. Kulturschädlinge nach Forleulenfrass. Z. Forst-u. Jagdwes. 68: 653–660.

U.S. Dep. Agric. 1942. The more important insect records for August 1942. USDA Bur. Entomol. Plant Quar. Mimeogr. 2 pp.

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PUPIFORM LARVAE IN THE PHYLLOXERIDAE (HOMOPTERA: APHIDOIDEA)

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Abstract.—The existence of an unusual developmental form, here named a pupiform larva, in the life cycle of sexual males and females (sexuales) of the Phylloxeridae (Homoptera: Aphidoidea) is demonstrated for the first time to occur in five species of phylloxerans and is confirmed in a sixth species. Attention is called to erroneous reports on the development of the sexuales in the Phylloxeridae and to the total lack of information in textbooks on the existence of this unusual developmental form.

The Phylloxeridae, Aphididae, and Adelgidae constitute the superfamily Aphidoidea (Homoptera). In the Phylloxeridae the characteristic development of stem mothers (fundatrices) and apterous and alate females is hemimetabolous with progression through five instars, all of which feed and move about. The development of the sexual males and females (sexuales), however, is holometabolous rather than hemimetabolous; but they also go through five instars. Unusual development in the larval instars of the sexuales was reported in 1875 by Balbiani who worked on the grape phylloxera, *Daktulosphaira vitifoliae* (Fitch), in Europe; and Maillet (1957) gave an excellent review of the early publications on the sexuales of the grape phylloxera. Nevertheless, the report of this unusual developmental form subsequently has gone unnoticed in texts on morphology, physiology, and phylogeny. Detailed studies of the biological development of phylloxerans have been conducted in the United States by Pergande (1904), Whitehead and Eastep (1937), and Caldwell and Schuder (1979); however, they have all incorrectly stated that the sexually mature males and females hatch directly from eggs. This report is being presented to demonstrate for the first time the occurrence of holometabolous development in sexuales of five species in the Phylloxeridae and to confirm the occurrence in a sixth species.

In 1978 I began a detailed study of the biology and morphology of the species of *Phylloxera* on pecan, *Carya illinoensis* (Wangenheim) C. Koch (Stoetzel, 1981). This study was soon expanded to include observations on field populations of six species of gall-forming *Phylloxera* (*P. caryaecaulis* Fitch, *P. caryaevenae* (Fitch), *P. deplanata* Pergande, *P. devastatrix* Pergande, *P. notabilis* Pergande, and *P. russellae* Stoetzel). I noticed the unusual larval development while observing molts of the various stages within the galls. Sexuparae were collected and isolated in small stender dishes where most readily laid eggs. The color (white, yellow, or yellowish green) and number (up to 25) of eggs depended on the species involved.

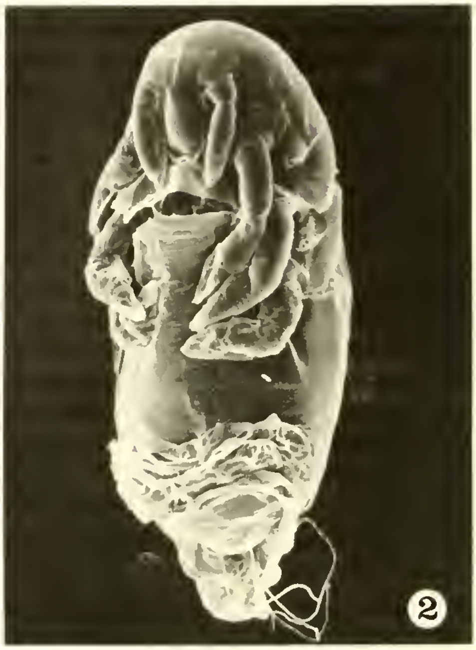

Fig. 1. Scanning electronmicrograph of a pupiform larva (*Phylloxera notabilis*) that has just hatched.

Fig. 2. Scanning electronmicrograph showing the layered exuviae that have accumulated at the posterior end of the pupiform larva (*Phylloxera notabilis*). The specimen has molted three times while remaining in place and "standing on end."

In three to four days a dark eclosion line between the two red eye spots was visible through the chorion. Pergande (1904), Whitehead and Eastep (1937), Maillet (1957), and Caldwell and Schuder (1979) all reported that the eggs were of two sizes with the larger eggs producing sexual females and the smaller eggs producing sexual males. However, all but Maillet reported that larger sexuparae lay only large eggs and therefore produce only females while the smaller sexuparae lay only smaller eggs and therefore produce only males. While larger sexuparae did lay more eggs than smaller sexuparae, in all of the six species studied, both sexual males and sexual females were produced by both the larger and the smaller sexuparae. By the fourth or fifth day after the eggs had been laid, they hatched into developmental forms which I call pupiform larvae (Fig. 1). They lacked mouthparts, often stood vertically on the substrate, and moved in undulating motions as they molted. Each pupiform larva molted four times, and the exuviae piled up in circular layers at the posterior end of the insect (Fig. 2). Between molts, the pupiform larvae do not feed, since they have no mouthparts; and they do not exhibit any apparent change in size or shape. At the final molt the sexuales are produced. Adult sexuales are larviform, without any indication of wingpads, and lack a rostrum; but they are quite active.

After mating, each sexual female (ovipara) produces only one overwintering egg that fills her abdominal cavity but is usually laid (*P. caryaecaulis, P. caryaevenae, P. deplanata*, and *P. notabilis*). Occasionally, the overwintering egg is only partially laid and the female's body remains attached to the egg (*P. russellae*) or the overwintering egg is retained within the female's body (*P. devastatrix*) which then shrivels around the egg. Development from an egg to a sexual male or female averages 7 to 10 days. Developmental time from the hatching of an overwintering egg to the deposition of an overwintering egg is approximately 50–60 days for those species developing in galls on species of *Carya*.

I believe that these pupiform larvae will be found in the development of the sexuales of all species in the Phylloxeridae.

In the Aphidoidea most of the sexual females (oviparae) are wingless. Sexuales of the Pemphiginae (Aphidoidea) resemble those of the Phylloxeridae in that both females and males are very small, are active, have no functional mouthparts; and the oviparae lay only one overwintering egg. But the Pemphiginae do not have pupiform larvae as far as is known. Only in the Phylloxeridae have these pupiform larvae been found, but their existence usually is unrecorded in biological studies and in texts on morphology, physiology, and phylogeny.

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LITERATURE CITED

Balbiani, E. G. 1875. Les Phylloxéras sexués et l'oeuf d'hiver. C. R. Acad. Sci. 71: 31.

Caldwell, D. L. and D. L. Schuder. 1979. The life history and description of *Phylloxera caryaecaulis* on shagbark hickory. Ann. Entomol. Soc. Am. 72: 384–390.

Maillet, P. 1957. Contribution à l'étude de la biologie du Phylloxera de la Vigne. Ann. Sci. Nat. Zool. Biol. Anim. 11: 345–349.

Pergande, T. 1904. North American Phylloxerinae affecting Hicoria (Carya) and other trees. Proc. Davenport Acad. Sci. 9: 187–273.

Stoetzel, M. B. 1981. Two new species of *Phylloxera* on pecan. J. Ga. Entomol. Soc. 16: 127–144.

Whitehead, F. E. and O. Eastep. 1937. The seasonal cycle of *Phylloxera notabilis* Pergande (Phylloxeridae, Homoptera). Ann. Entomol. Soc. Am. 30: 71–74.

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A NEW GENUS AND SPECIES OF RIFFLE BEETLE, *NEBLINAGENA PRIMA*, FROM THE VENEZUELAN TEPUI, CERRO DE LA NEBLINA (COLEOPTERA, ELMIDAE, LARINAE)

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Abstract.—A new genus and species of aquatic beetle, ***Neblinagena prima***, is described, illustrated by scanning electron micrographs and pen and ink drawings, and is distinguished from other larine genera by interpolation in the most recent key to the larine genera of elmid beetles. The specimens were collected from an area of suspected high endemicity, the tepui Cerro de la Neblina, in southern Venezuela.

The new genus described below was collected from Cerro de la Neblina, the "Mountain of the Mists" in southeastern Venezuela at the Brazilian border. Cerro de la Neblina, a 647 square kilometers sheer-sided sandstone mesa (tepui; highest peak, about 3045 meters) is one of numerous high, table-top mountains that occur in northern South America. The mesas are the eroded remains of a former large plateau, the Guiana Highland Shield, which probably dates from hundreds of millions of years ago at the time South America and Africa formed a single huge continent. The mesas rise sharply from the tropical rain forests and their tops are often obscured by a dense cloud cover. Consequently, climatic conditions on the tops of the mesas are harsh, with wide temperature fluctuations occurring between day and night. There are frequent torrential rains. The few mesas that have been visited were explored by botanists who found a high rate of endemic plants on those ancient remnants. Botanists have estimated that 98% of the plants on Cerro de la Neblina are species new to science. The animals on the mesas have been less well collected but those that have been obtained and studied suggest that many also are endemic forms. Whether the new genus *Neblinagena* (collected at altitudes ranging from 770 to 2100 meters) is endemic to Cerro de la Neblina is a question that probably will not be answered until much more fieldwork can be carried out in South America.

The specimens of this new genus and species were collected during a biological survey of Cerro de la Neblina. The expedition to Cerro de la Neblina Park was organized and directed by the Foundation for the Development of Physics, Mathematics, and Natural Sciences of Venezuela, with the patronage of the Ministry of Education, National Council of Scientific and Technological Research, and National Institute of Parks (all are Venezuelan institutions) and was coordinated by Dr. Charles Brewer-Carias. The expedition was conducted in collaboration with the National Science Foundation of the United States, the American Museum of Natural History, the Field Museum of Natural History, the Missouri Botanical Garden, the New York Botanical Garden, and the Smithsonian Institution; biologists from several universities and other institutions have also participated.

***Neblinagena*, New Genus**

Body elongate, subparallel, and moderately convex (Figs. 1, 2). Integument clothed for the most part with dense, moderately long, usually recumbent hydrofuge pubescence.

Head partly retracted into pronotum but not beyond the basal portion of the submentum. Mouthparts visible. Maxillary palpus, 4 segmented. Labial palpus, 3 segmented. Antenna, 11 segmented. Clypeus transversely subrectangular; clypeal suture raised, ridgelike between bases of antennae; anterolateral angles broadly rounded. Labrum transversely rectangular; anterior margin moderately emarginate at middle; anterolateral angles broadly rounded.

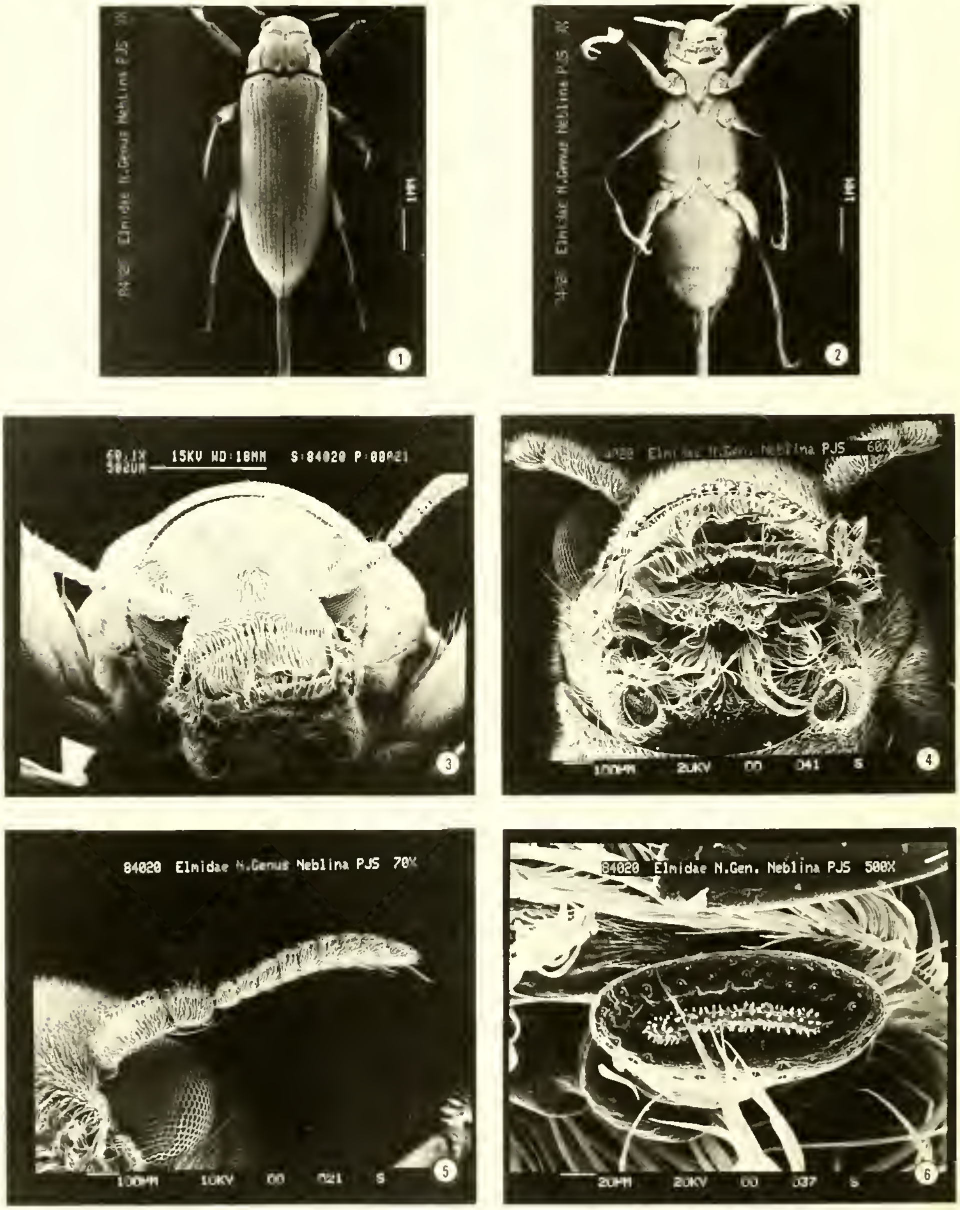
Pronotum widest at base then sinuately narrowing anteriorly, becoming evenly arcuate over head; base trisinuate, broadly sinuate on each side and much more narrowly so in front of scutellum; posterolateral angles acute and broadly depressed; middle of base with 2 short prescutellar carinae, each carina with distinct lateral depression. Pronotum with Y-shaped discal groove; lateral branches shallowly, broadly depressed, short, not confluent with sublateral arcuate-sinuate groove; stem of Y-shaped groove moderately deep; sublateral carina short, evident at base then merging with sublateral arcuate-sinuate groove. Scutellum flat, obovate. Elytron with 10 rows of punctures; without accessory row of punctures; without carinae; apex slender and prolonged. Prosternum long in front of procoxae, about 4 times the length of third antennal segment; moderately reflexed along anterior margin. Prosternal process broadly triangular between procoxae; apex subacute. Mesosternum with a deep V-shaped depression on midline for the reception of apex of prosternal process. Metasternum with disc shallowly, broadly depressed on posterior two-thirds; with longitudinal groove on posterior two-thirds of midline. Legs with visible portion of procoxae transverse and trochantin visible. Claws without teeth.

Abdomen with 6 sterna visible. Sternum 1 with carina behind each metacoxa extending to hind margin of sternum.

Type species of the genus.—*Neblinagena prima,* new species.

Etymology.—*Neblinagena* from Cerro de la Neblina, the name of the type-locality which means mountain of the mists; plus gena, L. = born in or living in, in reference to its relationship to its habitat. The gender is feminine.

Comparative notes.—Although this new genus keys to *Phanocerus* in Brown's (1981) key to the world genera of the elmid subfamily Larinae, its morphological affinities are with the South American genus *Pseudodisersus.* However, from *Pseudodisersus* which it resembles in habitus, *Neblinagena* differs as follows: with only a short, shallow remnant of the deep and complete transverse groove across the pronotum near the apex; without the bidentate posterolateral angles of the pronotum found on *Pseudodisersus*; without mammilliform tubercles on the base of the pronotum in front of the scutellum; and the prosternum in front of the procoxae is 4 times the length of the third antennal segment instead of one-half the length of the third antennal segment as it is in *Pseudodisersus.*



Figs. 1–6. *Neblinagena prima.* 1, Habitus, dorsal view, 9 ×. 2, Habitus, ventral view, 9 ×. 3, Head, face view, 60 ×. 4, Head, adoral view, 60 ×. 5, Eye and antenna, 70 ×. 6, Labial palpus, apical segment with sensilla, 500 ×.

The genus *Neblinagena* may be distinguished from *Phanocerus* by replacing 4a in Brown's (1981) key with the following couplet.

Length, 6.0 mm. Clypeus fused to frons and slightly raised where fused. First visible abdominal sternum with distinct carinae extending from metacoxae to posterior margin of sternum. Elytral apices prolonged and terminating in narrowed but rounded apices .... *Neblinagena*, new genus

– Length, 2.5–4.0 mm. Clypeus separated from frons by a distinct groove. First abdominal sternum without carinae. Elytral apices rounded, not prolonged .... *Phanocerus* Sharp

Neblinagena prima, New Species

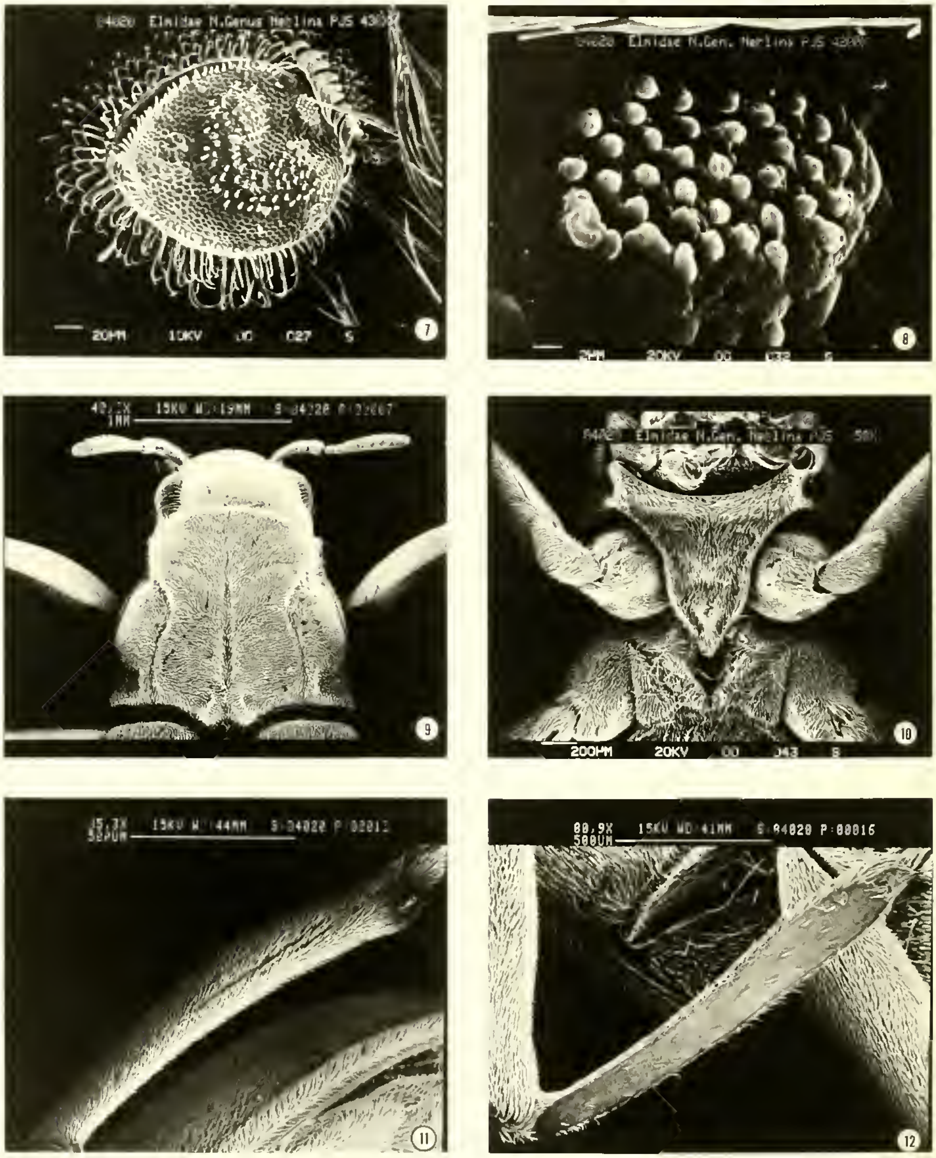
Figs. 1–15

Holotype male.—Body form and size: Elongate, subparallel, moderately convex dorsally (Figs. 1, 2). Length, 6.0 mm; width, 2.1 mm.

Coloration: Black dorsally. Antennal segments 1 and 2 reddish brown; antennal segments 3–11 black. Venter black except maxillary palpal segments 1, 2, and 3, labial palpi, labium, maxillae, coxae, trochanters, medial (posterior) surfaces of femora, tarsal claws, and narrow posterior margins of metasternum between metacoxae reddish brown.

Head: Finely, densely punctate; punctures separated by about half their diameter. Eyes large, hemispherical (Figs. 3, 4, 5). Antenna (Fig. 5) with basal two segments moderately densely pubescent on anterior and posterior margins. Clypeus shallowly arcuately emarginate anteriorly. Labrum rectangular; surface, especially on anterior half, finely densely punctate; anterior margin feebly, shallowly emarginate apicomedially and densely fringed with long, fine, golden, hairlike setae; anterolateral angles rounded but not expanded laterally; lateral margins not expanded but a long, dense, tuft of black setae curled over margin. Labium with long, dense setae on surface (Fig. 4). Last segment of labial palpus (Fig. 6) and maxillary palpus broad and bearing sensilla on flattened apex (Figs. 7, 8).

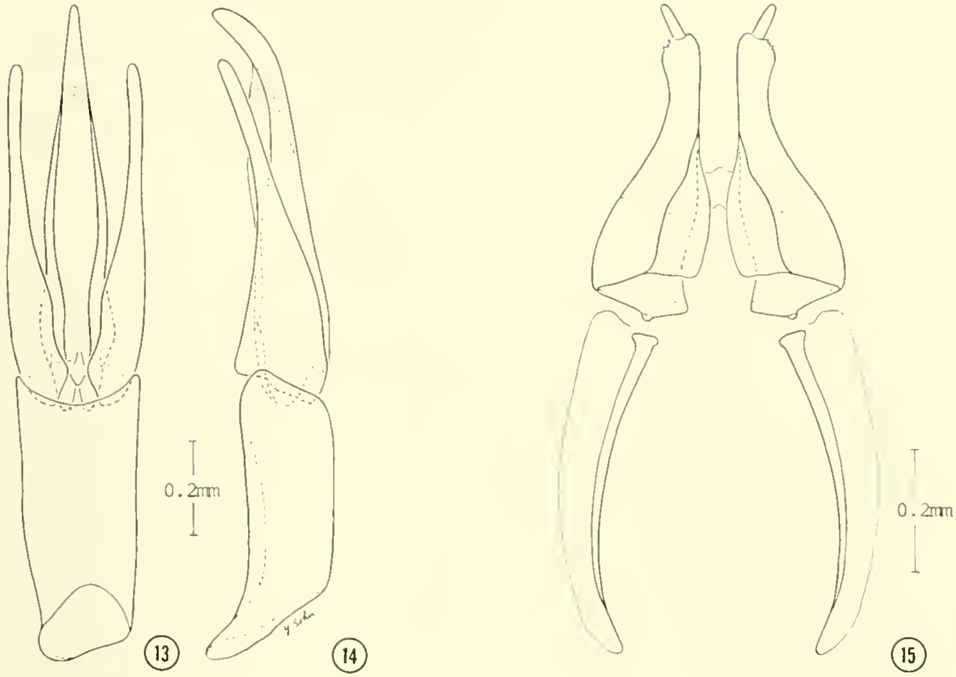
Thorax: Pronotum 1.6 mm long, 1.90 mm wide; widest at base; sides sinuate; anterolateral angles obtuse, with distinct constriction behind each angle resulting from deep arcuate-sinuate sublateral groove which extends from apical third of pronotum to base; apex arcuate; base strongly trisinuate; with a shallow depression on each side of short prescutellar carinae; posterolateral angles obtuse, with a deep, broad depression adjacent to each angle (Fig. 9); discal surface with Y-shaped groove; lateral branches of groove shallowly, broadly depressed and not confluent with arcuate-sinuate sublateral groove; stem of Y-shaped groove moderately deep and terminating at anterior end of prescutellar carinae; sublateral carina short but evident at base then merging with sublateral arcuate-sinuate groove; discal area finely densely punctate, punctures separated by a distance equal to or less than their diameter. Prosternum long in front of procoxae. Prosternal process (Fig. 10) triangular, broad at base and tapering to apex; lateral margins reflexed; middle moderately longitudinally cariniform; apex subacute. Mesosternum with a deep depression for reception of apex of prosternal process. Metasternum with disc depressed on posterior three-fourths with a deep, narrow, shining, longitudinal groove on posterior two-thirds of midline; surface finely microreticulate and punctate; punctures on lateral surface coarse and sparse, separated by a distance about 2 times their diameter. Procoxae and metacoxae moderately widely separated, mesocoxae slightly more widely separated. Legs long and slender. Protibiae and metatibiae (Fig. 11) with hydrofuge pubescence laterally. Mesotibiae with lateral surface finely alutaceous; without dense hydrofuge pubescence except a very short area on apex (Fig. 12). Tarsal claws long and stout. Elytron with 10 rows of coarse



Figs. 7–12. *Neblinagena prima.* 7, Maxillary palpus, last segment, apex with sensilla, 430×. 8, Sensilla, last segment, maxillary palpus, 4200×. 9, Head and pronotum, 41×. 10, Prosternum, 50×. 11, Metatibia, lateral view, 85×. 12, Mesotibia, lateral view, 81×.

punctures; discal punctures separated by a distance equal to their diameter or slightly less; intervals finely densely punctate, punctures separated by about their width and obscured by dense pubescence; humeral area strongly tumid; sides of elytra distinctly margined and almost parallel; apex not dehiscent but prolonged and terminating in rounded apex.

Abdomen: First sternum with intercoxal process broadly, shallowly depressed and carinate adjacent to metacoxae; carinae extending longitudinally behind meta-



Figs. 13–15. *Neblinagena prima.* 13, Male genitalia, dorsal view. 14, Male genitalia, lateral view. 15, Female genitalia, ventral view.

coxae for entire length of sternum. Last sternum with a small tuft of longer, golden, hairlike setae on an acute apex.

Male genitalia.—As illustrated (Figs. 13, 14).

Female.—Similar to male. Genitalia as illustrated (Fig. 15).

Variations.—The few specimens available are very similar. The only minor variations noted are the length, which ranges from 6.0 to 6.3 mm, and the reddish-brown instead of black mesosternum and inner surface of the protibiae, mesotibiae, and metatibiae of some specimens.

Type-data.—Holotype male: VENEZUELA: TERRITORIO FEDERAL AMAZONAS: Cerro de la Neblina, Camp XI (1 km W), 00°52′N 65°58′W, 1450 m (at stream), 25–28 February 1985, P. and P. Spangler, R. Faitoute; USNM type number 100124; deposited in the National Museum of Natural History, Smithsonian Institution. Allotype and 6 paratypes (2 males, 4 females): Same locality data as holotype. Additional paratypes with the same data except as follows. Camp VII, 00°51′N 65°58′W, 1730 m, 1 February 1985, P. and P. Spangler, R. Faitoute, 1 male; Camp II, 00°50′N 65°58′W, 2100 m, 13 February 1985, W. Steiner, 1 female; Camp X, 00°54′N 66°2′W, 1690 m, 12–13 February 1985, W. Steiner, 23 males, 10 females; Camp IV, 00°56′N 65°57′W, 770 m, 15–18 March 1984, O. S. Flint, Jr., 2 males, 5 females, at blacklight.

Paratypes will be deposited in the collections of the Instituto de Zoologia Agricola, Facultad de Agronomia, Maracay, Venezuela; American Museum of Natural History, New York; California Academy of Sciences, San Francisco; Canadian

National Collection, Ottawa; Institut Royal de Histoire Naturelle de Belgique, Bruxelles; Museum National de Histoire Naturelle, Paris; Museo Argentina de Ciencias Naturales, Buenos Aires; Zoologische Sammlung Bayerischen Staates, Munchen; and the collection of Harley P. Brown, Norman, Oklahoma.

Etymology.—The specific epithet, *prima* is from the Latin *primus* meaning first, because this is the first aquatic beetle species to be described from the survey of the flora and fauna of the Cerro de la Neblina.

Habitat.—The type-material was collected from 5 camps on Cerro de la Neblina at altitudes ranging from 770 to 2100 meters. Specimens from Camp IV were collected at blacklight operated beside the Rio Baria. All other adult specimens and numerous larvae were collected by hand from small, partially shaded tributaries feeding the Rio Baria. The small blackwater tributary streams varied from about 1 to 5 meters in width with cascades, riffles, and occasional pools usually less than 1 meter deep. The substratum was bedrock, boulders, cobbles, and occasional small sandy deposits. Flooding occurs frequently in these small streams and leaf packs, where most of our specimens were found, were moderately abundant. The Rio Baria, also a blackwater stream, clear of suspended material is about 15 to 25 meters wide and 1 or more meters deep. The river flows through a series of riffles and pools and has a substratum of sand, boulders, and bedrock, and is a tumbling river given to flash-flooding.

Colorimetric water chemistry analyses at Camp XI provided the following data; pH–4, hardness–O, oxygen–9 ppm. The water temperature was 17°C.

ACKNOWLEDGMENTS

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LITERATURE CITED

Brown, H. P. 1981. Key to the world genera of Larinae (Coleoptera, Dryopoidea, Elmidae), with descriptions of new genera from Hispaniola, Colombia, Australia, and New Guinea. Pan-Pac. Entomol. 57: 76–104.

PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 545–553

IDENTIFICATION, HOSTS AND DISTRIBUTION OF *PSEUDAULACASPIS PENTAGONA* (TARGIONI-TOZZETTI) AND *P. PRUNICOLA* (MASKELL) IN VIRGINIA (HOMOPTERA: DIASPIDIDAE)

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Abstract.—A comparison is made between host records, distribution and selected key morphological characters of *Pseudaulacaspis pentagona* and *P. prunicola* in Virginia. *P. pentagona* was recorded from 17 host genera and *P. prunicola* from five, all five of which were shared with *P. pentagona*. Both species occur throughout most of Virginia, but are more frequent in the warmer lowlands and have been recorded from only three counties in the western highlands. Significant differences were found between the species in three numerical morphological characters when using a standard *t*-test. Discriminant function analysis showed that there is a 16 percent probability of error in species determinations of *Pseudaulacaspis prunicola* collected in Virginia. Canonical discriminant analysis revealed *P. prunicola* is extremely variable in its morphology whereas *P. pentagona* is not. Two characters, number of gland spines in the third space of the pygidial margin and whether spines were forked or simple, were found to be most useful when identifying specimens.

The white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti), is a common insect pest of a wide range of ornamental plants and fruit trees. Although it can occur in any county of Virginia, at present it is a serious pest only from the Piedmont eastward. What has been known up until now in the U.S. as *P. pentagona* was recently found to consistof two cryptic species, *P. pentagona* (PE) and *P. prunicola* (Maskell) (PR), both of which are cosmopolitan and polyphagous (Davidson et al., 1983). In their summary, they state that PE tends to be more southern in distribution and occurs commonly on *Prunus, Morus, Callicarpa, Diospyros* and *Melia,* whereas PR tends to occur farther north and often occurs on *Prunus, Ligustrum* and *Syringa.* They found that ranges of the two overlap in the U.S. and that there are exceptions to the trends mentioned above.

Five morphological characters were used by Davidson et al. (1983) to distinguish PE from PR: number of gland spines in the third space on the pygidial margin; presence of forked versus unforked spines in the second, third, or fourth spaces; number of perivulvar pores; number of large macroducts; and number of small macroducts on the metathorax and first abdominal segment. Significant differences between the two species were found for all four of the numerical characters when they were compared using a standard *t*-test.

On a practical basis, identification laboratories usually only receive short series of specimens that are often poorly mounted. In the case of scales, many characters are not visible in poor mounts, and poorly visible in all but the best mounts. When identifications are made, they are made with a certain probability of error due to the suboptimal condition of the specimens, or misinterpretation by the taxonomist. Another source of error is the inappropriateness of the literature used as the basis of the identification, e.g. use of a key prepared for European species to identify specimens from the United States. Many keys and descriptions of insect species may be based on specimens from either certain geographical areas or from world populations. These descriptions can be misleading for local specimens for two reasons: 1) Many morphological characters are variable even within a single species. If these characters are correlated with some other variable such as geographic distribution or host preference, then comparing locally collected specimens with those from another location may involve extreme ends of naturally occurring morphological distributions; 2) If descriptions are based on population samples from many different parts of the world, the morphological description would tend to reflect the center of any distribution. If the locally collected specimens represent extremes in the distribution of any morphological character, there is a possibility that they will be misidentified.

The purpose of this paper is to use the criteria of Davidson et al. (1983) to separate specimens of PR and PE from Virginia, give the current distribution and host records of each species, describe the shortcomings of the criteria when working on local populations, and describe the error associated with identifications using this method.

Materials and Methods

Information for this study was taken from the 378 Virginia specimens of slide-mounted adult female *Pseudaulacaspis* in the VPI&SU collection. Four morphological characters were used for comparisons among Virginia specimens: number of gland spines in the third space (spines), presence or absence of forked spines (forks), number of large dorsal macroducts (ducts), and total number of perivulvar pores (pores). The number of small macroducts was not considered in this study because they are much more difficult to see than large macroducts and consequently would not be of much use to inexperienced persons trying to key out a specimen of *Pseudaulacaspis*.

The two characters we used were number of gland spines in the third space and whether spines were forked or simple to assign specimens to either PE or PR. Then, for each species, we found the mean, range and variance for spines, ducts, and pores. We chose to record only the presence or absence of at least one forked spine as the fourth character (non-numeric) and did not consider the number of spines which were forked or the degree of forking because this would be difficult to quantify.

To compare values for spines, pores and ducts of our Virginia material with values obtained by Davidson et al. (1983) we used the same statistical analysis they did, a standard *t*-test to determine significant differences between the two species.

Because specimens are sometimes encountered for which either pores or ducts cannot be counted, or spines are broken off, we also calculated Spearman's cor-

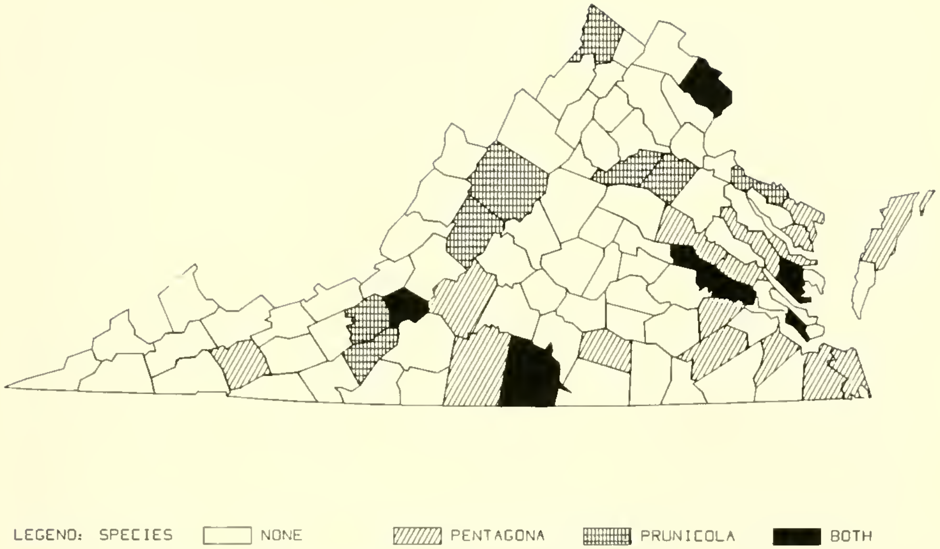

Fig. 1. Known distribution of *Pseudaulacaspis* species in Virginia.

relation coefficient within each species for each combination of characters to find if any correlations existed.

In addition, variation of characters with different hosts was explored using a one-way analysis of variance. Samples of PE (ranging from 10 to 26 specimens each) collected from *Catalpa*, *Morus*, *Prunus*, *Salix*, and *Syringa* were compared. Each sample represented several separate collections from each host. Not enough specimens of PR were available from different hosts to conduct a similar comparison for it.

To describe the error in classification due to using the criteria of Davidson et al. (1983) on the Virginia material, we employed a discriminant function analysis and canonical discriminant analysis. Whereas the *t*-test analysis compared spines, pores and ducts between species one at a time, the discriminant analyses compared those three variables plus a fourth variable (forks) simultaneously. Information from these analyses allowed us to estimate misclassification probabilities and the importance of each morphological character in making species determinations.

The discriminant function analysis computes a distance function that can be used to classify two or more groups on the basis of one or more numerical variables. Each observation is placed in the class from which it has the smallest generalized squared distance (Harris, 1975). The canonical discriminant analysis is a dimension reduction technique. Canonical variables (linear combinations of quantitative variables) are derived that summarize between-class variation by creating the linear combination of variables that has the highest possible multiple correlation with the groups. The frequency of species is then plotted along the canonical axis to show the degree of overlap between the species (Harris, 1975).

RESULTS

Determination of species.—Of 81 collections (comprising 378 specimens) of *Pseudaulacaspis* from Virginia, 44 were identified as PE, 34 as PR, and 3 as

Table 1. Recorded hosts of *Pseudaulacaspis* in Virginia.

Plant Family	Genus	Number of Collections *pentagona*	Number of Collections *prunicola*
Bignoniaceae	*Catalpa*	5	1
Buxaceae	*Buxus*	2	
Brassicaceae	*Iberis*	4	
Ericaceae	*Rhododendron*	1	
Juglandaceae	*Carya*	1	
	Juglans	1	
Fabaceae	*Glycine*	1	
Lythraceae	*Lagerstroemia*	1	
Magnoliaceae	*Magnolia*	1	
Moraceae	*Broussonetia*	2	
	Morus	4	
Oleaceae	*Fraxinus*	1	
	Ligustrum	2	5
	Osmanthus	2	
	Syringa	5	4
Rosaceae	*Prunus*	5	23
Salicaceae	*Salix*	6	1
	Total =	44	34

intermediate. Specimens classified as intermediate either had one side of the pygidium resembling PE and the other side PR, or the gland spines were truly a blend on both sides, i.e. two spines were present but one was forked, or one spine was present but it was not forked. Ten of the collections were initially called intermediate, but a re-examination of specimens left only three collections in this category. Those which were moved out of the intermediate group usually had one or more specimens which were hard to classify, but had the majority of specimens fitting PR. Those which were left in the intermediate group had the majority of specimens with a blend of characters or an equal number of specimens resembling each species.

The earliest collection of PR in Virginia was from Richmond in 1937 on *Li-*

Table 2. Comparison between a world population sample and a Virginia population sample for three morphological characters of *Pseudaulacaspis pentagona* and *P. prunicola*.

Character	Species	Mean Va	Mean World[1]	±Stand. Error Va	±Stand. Error World	Range Va	Range World	Sample Size Va.	Sample Size World	*t*-test Value[2] Va.	*t*-test Value[2] World
No. of large macroducts	*pent.*	52.74	67.66	0.84	2.28	28–77	40–106	123	50	5.60	3.57
	prun.	46.41	57.64	0.75	1.59	24–78	38–86	158	47		
No. of perivulvar pores	*pent.*	65.88	76.04	0.91	2.21	43–104	51–124	141	65	2.83	3.92
	prun.	62.71	65.39	0.68	1.60	37–85	35–99	162	67		
No. of gland spines in 3rd space	*pent.*	1.06	1.05	0.01	0.03	1.0–2.0	—	194	65	22.60	12.56
	prun.	1.92	2.07	0.04	0.08	1.0–3.0	—	181	58		

[1] Values for the world population sample are from Davidson et al., 1983.

[2] All values significant at $\alpha = .01$ or less.

Table 3. Correlation between no. of gland spines in third space, no. of perivulvar pores and no. of large macroducts for all samples of *Pseudaulacaspis pentagona* and *P. prunicola* collected in Virginia.

Characters Compared*	*P pentagona* Spearman Correlation Coefficient	*P pentagona* Probability	*P prunicola* Spearman Correlation Coefficient	*P prunicola* Probability
Spines/Pores	0.0279	0.7435	−0.0110	0.8914
Spines/Ducts	−0.1360	0.1353	0.1712	0.0350
Pores/Ducts	0.6365	0.0001	0.0843	0.3083

* In each case N = 100.

gustrum. The earliest for PE was from Roanoke in 1940 on *Catalpa.* For the intermediate group, the oldest specimen was from Fairfax in 1968 on *Prunus.*

Distribution.—Both PE and PR occur throughout Virginia. Current records indicate PE in 23 counties and PR in 15 (see Fig. 1). Although *Pseudaulacaspis* has been collected from only three counties in the mountainous western region of Virginia, this probably reflects its lack of pest status there rather than its lack of occurrence. The three collections of intermediates were from Fairfax, Fredericksburg, and Henry County.

Hosts.—In Virginia, PE has a much wider range of host plants than PR, the former attacking 17 genera in 12 different plant families, whereas the latter occurs on five plant genera in only four families (see Table 1). All five plant genera that serve as hosts for PR are also known as hosts for PE. Common hosts of PE in Virginia are *Catalpa, Morus, Prunus, Salix,* and *Syringa.* Sixty-eight percent of all PR collections were from *Prunus.*

Character comparison.—A comparison between Virginia specimens and those in the world sample for three morphological characters is given in Table 2. The mean number of ducts for PE from Virginia was 52.74, for PR 46.41. The difference was highly significant. Both values are well below the means derived from the world population sample. The range of values in number of ducts for Virginia specimens of PE overlapped completely with those of PR. The mean number of

Table 4. Influence of host on two morphological characters of *Pseudaulacaspis pentagona.* Comparison of mean no. of large macroducts and perivulvar pores using a one-way analysis of variance.

Host Genus	Morphological Character	Least Squares Mean	±Standard Error
Catalpa	ducts	50.85	2.35
n = 13	pores	69.23	2.76
Morus	ducts	50.45	2.55
n = 11	pores	64.55	3.00
Prunus	ducts	49.90	2.68
n = 10	pores	65.60	3.15
Salix	ducts	52.50	1.66
n = 26	pores	65.35	1.95
Syringa	ducts	59.50*	2.68
n = 10	pores	72.50	3.15

* Significantly different at the 5% level.

Table 5. Results of using discriminant function analysis based on four morphological characters to identify specimens of *Pseudaulacaspis* in Virginia.

From Species		Number of Observations and Percentages Classified into Species		
		pentagona	*prunicola*	Total
pent.	no.	115	0	115
	%	100.00	0.00	100.00
prun.	no.	23	118	141
	%	16.31	83.69	100.00
Total	no.	138	118	256*
	%	53.91	46.09	100.00

* Only specimens with values for all four characters were used in this analysis.

perivulvar pores was 65.88 for Virginia PE and 62.71 for PR. As in the case of ducts, the difference was highly significant. Values for the world population sample were higher than for the Virginia sample for both species, and there was a greater separation of means. The range of values for pores in the Virginia sample showed a great deal of overlap between species.

The mean number of gland spines in the third space for PE was 1.06, for PR 1.92. The difference was highly significant for this character also (Table 2). Values for the world population sample were almost identical for PE but substantially higher for PR.

The range in number of pores and ducts within one population was found for each species by choosing one collection of each from which we had mounted a large number of specimens. Values were: for PE (n = 20, host = *Salix*)—pores 45–84, ducts 44–70 and for PR (n = 21, host = *Prunus*)—pores 49–80, ducts 36–60. Although ranges were narrower for individual populations than for the entire Virginia sample, there was still considerable variation present.

Correlation among characters.—A highly significant correlation was found in PE between number of pores and number of ducts (Table 3). There were no other strong correlations.

Variation among individuals from different hosts.—It is apparent that the specimens collected from *Syringa* (Table 4) possessed the highest number of both pores and ducts. Mean number of ducts ranged from 49.9 for PE on *Prunus* to 59.5 for PE on *Syringa*. Number of ducts for specimens on *Syringa* were significantly different from all others. Mean number of pores ranged from a low of 64.5 for specimens on *Morus* to a high of 72.5 for those on *Syringa*. There was no significant difference among means for pores.

Table 6. Canonical scores or weights for four morphological variables of *Pseudaulacaspis* specimens from Virginia.

Character	Within Class Canonical Structure	Normalized Canonical Coefficients	Raw Canonical Coefficients
Forks	0.7486	0.9369	1.8984
Spines	−0.7417	−1.0026	−1.6979
Ducts	0.2100	0.3073	0.0306
Pores	0.1180	−0.0544	−0.0056

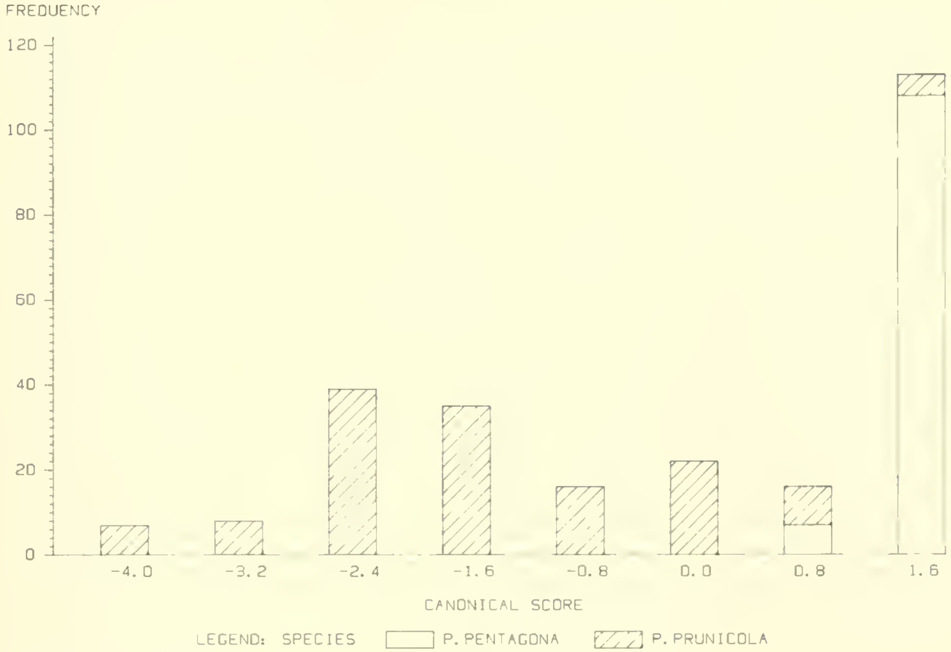

Fig. 2. Frequency of each species along canonical axis.

Discriminant function analysis and canonical discriminant analysis.—The discriminant analysis revealed that when using all four characters—forks, spines, ducts and pores—there were no errors in species determinations of PE, but 16 percent of PR were wrongly identified (Table 5).

Also, as indicated by the canonical discriminant analysis, each of the four characters was of different importance in identifying the specimens. The relative importance or canonical weight of each character is displayed in Table 6. In all three cases, the within class canonical structure, the normalized canonical coefficients and the raw canonical coefficients, the same pattern is seen. The canonical weights are high and inversely related for forks and spines and low for ducts and pores. Obviously, forks and spines contribute the most to discriminating between species and ducts and pores do not contribute much at all. The first canonical variate is pictured in Fig. 2. PR has a wider distribution over the canonical axis representing its extremely variable morphology. PE has a much tighter distribution indicating less morphological variability among specimens. At the zero point on the axis PR overlaps into the PE region and therefore these specimens may be misidentified as PE. PE does not overlap at all into the PR region indicating that none of PE would be misclassified.

SUMMARY

Our results support the conclusion of Davidson et al. (1983) that *P. pentagona* and *P. prunicola* are two distinct species. However, their species concept, derived from samples from around the world, presents some problems for a small geographical area (Virginia) where both species have been present for at least forty years. The mean number of large macroducts and perivulvar pores for the two species in Virginia are quite different from those for both species in the world sample. This indicates that values may have to be determined for a particular region of the country before they can be used as an aid in distinguishing populations of the two species. A review of specimens from Pennsylvania or New York, as well as Florida or South Carolina should reveal whether numbers of pores and ducts vary significantly from one region to another. Furthermore, we found specimens with characters intermediate between the two species which were difficult to classify.

For the average species determination, when only two or three specimens are examined, counting the number of ducts and pores may not be useful because of the large variation in their values even within one population. To distinguish between the two species, we suggest relying on the number of gland spines in the third space of the pygidial margin and whether the spines are forked or not. When an intermediate specimen is encountered using these two characters, it will be necessary to examine several more specimens from the same population. Our results indicate that the number of large macroducts will be more reliable to use in distinguishing differences than the number of perivulvar pores because there was a greater difference between means for the two species in number of ducts than number of pores, and greater differences were found among means for ducts than pores when specimens of *P. pentagona* from different hosts were compared.

According to our discriminant analyses, there is a 16 percent probability of error in species determinations of Virginia collected PR based on the criteria of Davidson et al. (1983). This may be an acceptable error rate depending on the use to which the determinations will be put. If high value decisions will be based on these determinations the 16 percent probability of error may be translated into a substantial monetary loss. For instance, if PE is a highly destructive species and PR is not, then misidentification may cause expensive and unnecessary pest management costs if the species truly is not PE but is identified as such, or misidentification can cause preventable destruction if the species truly is PE but is identified as PR. The discriminant analysis can help in this situation also. The prior probabilities can be adjusted to reflect the consequences of making erroneous decisions and therefore bias the analysis based on the "cost" of the erroneous decision.

It appears that *P. pentagona* is somewhat more firmly established than *P. prunicola* in Virginia because it was collected more often and it occurs in more counties. The exact pest status of each species requires further investigation.

Data from previous works on *P. pentagona* in the U.S. must be re-evaluated in light of the fact that both it and *P. prunicola* are present in the U.S. If voucher specimens were kept, they should be re-examined. Although there are records of *P. pentagona* from as far north as Indiana and records of *P. prunicola* from as far south as Florida, we cannot delineate the range of either species from present records because we do not know whether these specimens came from established populations or not. The fact that *P. prunicola* has been collected in Florida and probably in Sri Lanka (latter unconfirmed, see Maskell, 1898) seems to indicate it is not restricted to more northerly regions than *P. pentagona*. Conversely, records of *P. pentagona* from New York and Indiana suggest the possibility that it ranges as far north as *P. prunicola*.

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LITERATURE CITED

Davidson, J. A., D. R. Miller, and S. Nakahara. 1983. The white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Homoptera:Diaspididae): Evidence that current concepts include two species. Proc. Entomol. Soc. Wash. 85: 753–761.

Harris, R. J. 1975. A Primer of Multivariate Statistics. Academic Press, New York. 332 pp.

Maskell, W. M. 1898(1897). Art. XXVI. Further coccid notes: With description of new species, and discussion of points of interest. Trans. Proc. N.Z. Inst. 30: 219–252.

PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 554–563

DESCRIPTION AND KEY TO LARVAE OF *CURCULIO* SPP. OF EASTERN UNITED STATES AND CANADA (COLEOPTERA: CURCULIONIDAE)

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Abstract.—A general description of *Curculio* larvae is given. Key characters are presented to separate 15 of the 16 described species of eastern North America. A brief key for separating *Curculio* larvae from *Conotrachelus* and lepidopterous larvae is presented.

This paper provides a general description and key for the larvae of 15 of the 16 *Curculio* species of eastern United States and Canada. *Curculio confusor* (Hamilton) is not included in the key because no larvae are known for this species.

Several of the species occur only in southern United States: *Curculio humeralis* (Casey) and *C. longidens* Chittenden from Missouri south through Texas east to Florida and north up the coast to New Jersey; *C. fulvus* Chittenden from coastal South Carolina south to Florida and westward along the coast to coastal east Texas; *C. victoriensis* Chittenden from Louisiana west to Arizona and north to southern Kansas. One other species, a western species, *C. nanulus* (Casey), is not included in the key. It may be found rarely in Texas (Gibson, 1969).

No previous taxonomic key to the larvae of *Curculio* has been published, but Scherf (1964) published a key to European *Curculio* by host plant. Several papers have described various larvae of Curculionidae (Boving & Craighead, 1930; Emden, 1938, 1952; Scherf, 1964). Larval characters of a few American species of *Curculio* have been briefly described and/or depicted by several authors (McClenahan, 1904; Chittenden, 1904, 1908; Leiby, 1925; Brooks and Cotton, 1929; and Peterson, 1960).

The larvae used in this paper were from several sources. Larvae of *C. sayi* (Gyllenhal), *C. proboscideus* Fabricius, *C. sulcatulus* (Casey), *C. pardalis* Chittenden, and *C. strictus* (Casey) were reared from identified parents. Larvae of *C. caryatrypes* (Boheman), *C. caryae* (Horn), and *C. obtusus* (Blanchard) were obtained from host material. Larvae of *C. fulvus*, *C. humeralis* (Casey), *C. iowensis* (Casey), and *C. nasicus* (Say) were obtained from host acorns (from individual trees) that were found through laboratory rearing of adults to contain only one species of *Curculio* larvae. The larvae of *C. victoriensis*, *C. orthorhynchus* (Chittenden), and *C. longidens* were isolated by removing identified larvae from among preserved larvae from acorn collections that contained one of these three in addition to identifiable larvae.

For study, larvae were positioned in a pocket cut into a styrofoam block and

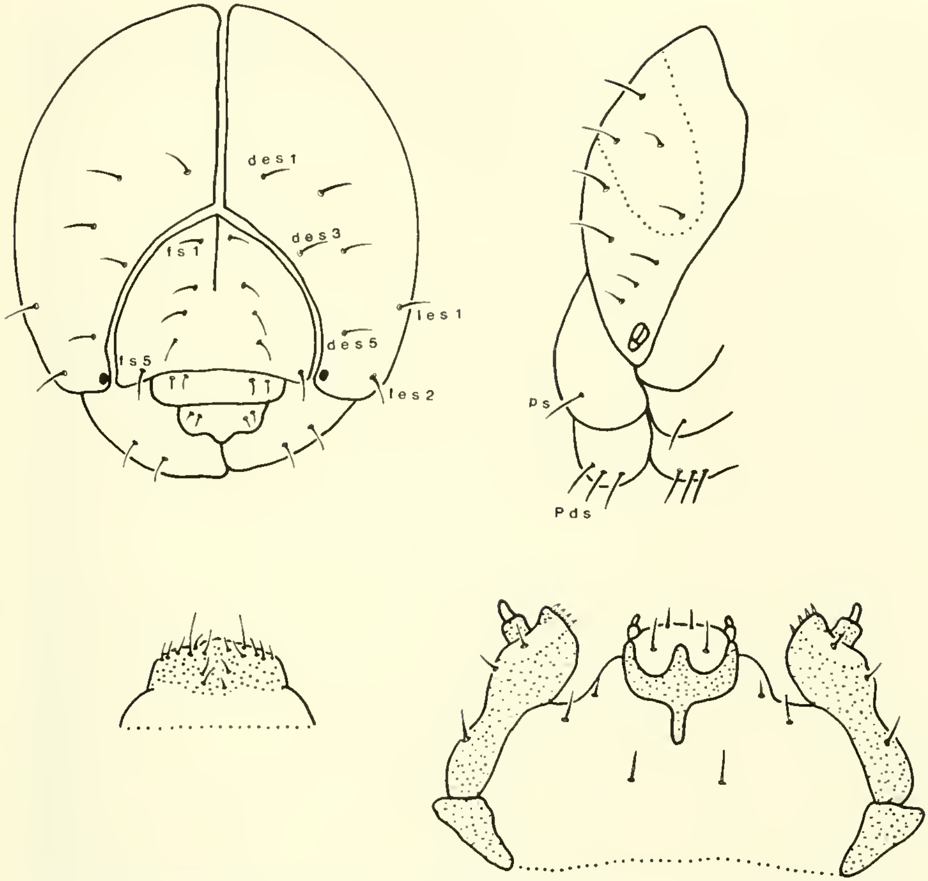


Fig. 1. Hypothetical *Curculio* larva head and mouthparts. a, Head capsule, des—dorsal epicranial setae, fs—frontal setae, les—lateral epicranial setae. b, Epipharynx. c, Maxillae and labium. d, Prothoracic segment, Pds—pedal setae, ps—pleural setae.

viewed under a stereomicroscope. Fourteen or more larvae of each species were studied except for *C. iowensis* and *C. caryatrypes* for which only three and two larvae, respectively, were available for study. The terminology used in this paper is that of Anderson (1947).

Curculio spp. larvae are found in nuts of *Carya* spp., *Castanea* spp., *Corylus* spp., and *Quercus* spp. of eastern North America. They can be separated from other larvae infesting these nuts by the following brief key:

1. Larva with legs .... Lepidoptera
– Larva legless, 6 to 20 mm long 2
2. Abdominal segments II to VII each with 3 dorsal plicae, prothorax without a pigmented sclerotized pronotal shield .... *Curculio* spp.
– Abdominal segments II to VII each with 4 dorsal plicae, prothorax with a pigmented sclerotized pronotal shield .... *Conotrachelus* spp.

Curculio larvae have typical characteristics of Curculionidae: they lack legs; the

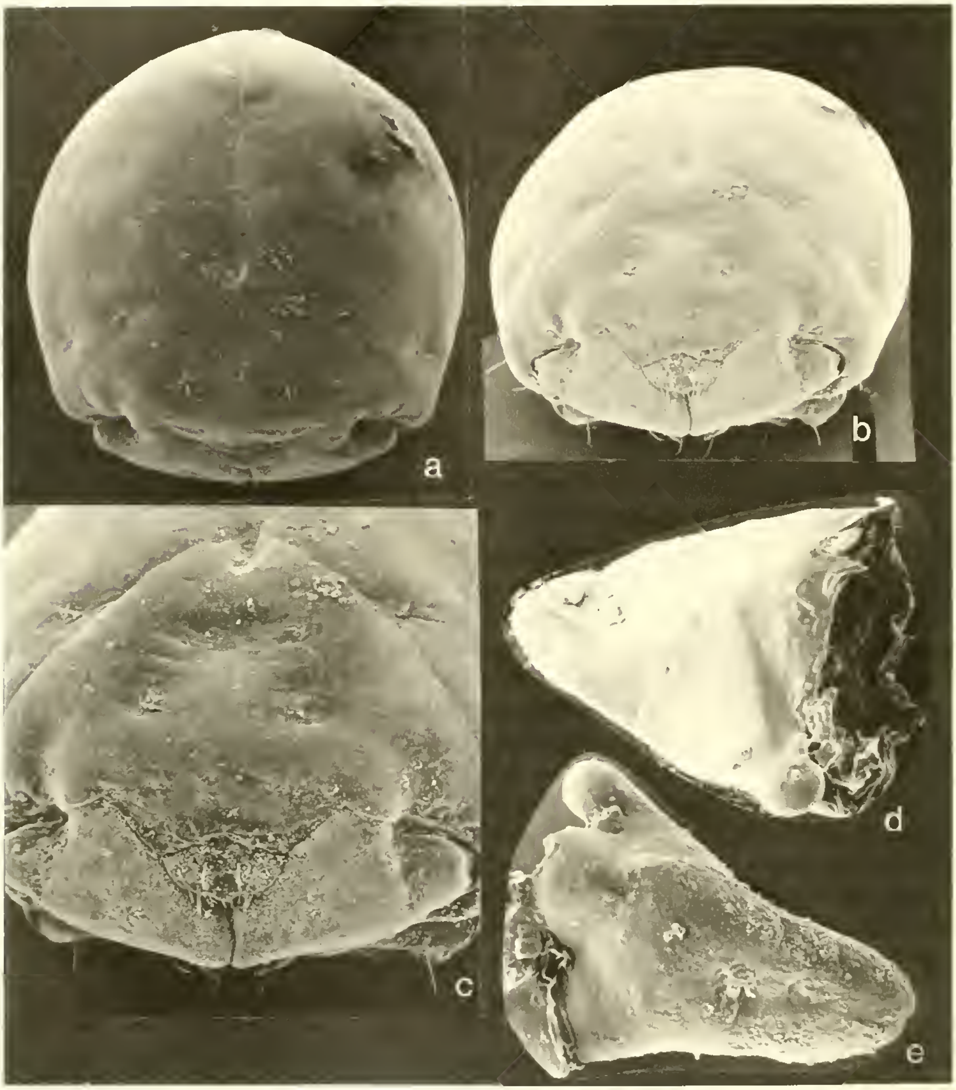


Fig. 2. Scanning electron micrographs of *Curculio sulcatulus.* a and b, Head capsule (46×). c, Frons, clypeus, labrum, and mandibles (72×). d and e, Mandibles, dorsal and ventral views (150×).

gular region and suture are absent; the mandibles are without a molar region; the hypopharyngeal sclerome is absent and the bracon is present; the 9th and 10th abdominal segments are soft and lack modifications such as cerci or soft lobes; the epicranial suture is present; the subfacial region of head and the ventral region of prothorax are contiguous. The mentum is connected laterally with the maxillary stipes.

ULTIMATE INSTAR *CURCULIO* LARVAE

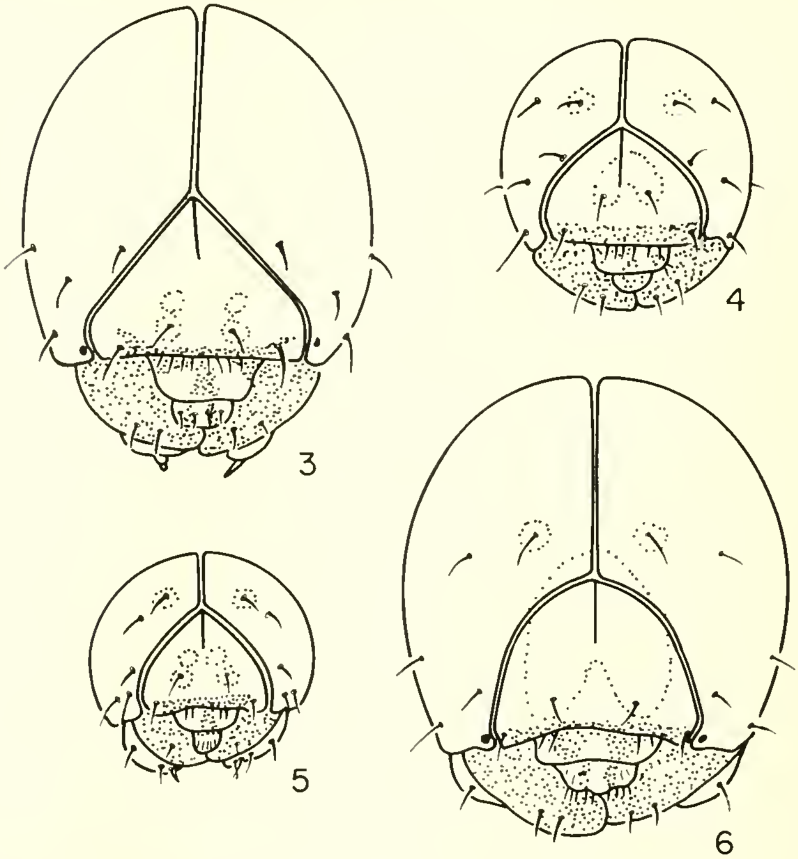
Subcylindrical, 7 to 20 mm long, legless, vary sparsely clothed with setae; moderately falciform to falciform; fleshy, white to dirty yellowish white, with a

Table 1. Selected traits for larval *Curculio* identification.

Curculio Species	Host	Setae Present			Concavity at des 3	Concavity on Frons
		des	fs	les		
						See:
caryatrypes	*Castanea*	1, 2, 5	4, 5	1, 2	No	Fig. 6
sayi	*Castanea*	1, 2, 3, 5	4, 5	2	No	Fig. 5
caryae	*Carya*	3, 5	4, 5	1, 2	No	Fig. 3
obtusus	*Corylus*	1, 2, 3, 4	3, 5	1, 2	No	Fig. 4
proboscideus	*Quercus*	1, 2, 3, 4, 5	2, 3, 4, 5	1, 2	No	Fig. 9
nasicus	*Quercus*	3, 4	none	1, 2	No	Fig. 7
longidens	*Quercus*	1, 2, 3, 4	3, 4, 5	1, 2	No	Fig. 10
orthorhynchus	*Quercus*	1, 3, 4	4	2	Yes	Fig. 8
sulcatulus	*Quercus*	1, 3, 4	3	1, 2	Yes	Fig. 12
pardalis	*Quercus*	1, 3, 4	3	1, 2	Yes	Fig. 11
strictus	*Quercus*	1, 2, 3, 4	4, 5	1, 2	No	Fig. 15
humeralis	*Quercus*	1, 3, 4	3	0	Yes	Fig. 13
fulvus	*Quercus*	1, 3, 4	3, 5	1, 2	No	Fig. 17
victoriensis	*Quercus*	1, 2, 3, 5	4	2	Yes	Fig. 16
iowensis	*Quercus*	1, 2, 3, 4	4	0	Yes	Fig. 14

yellow, red, light reddish brown, light brown, or brown head. Head capsule small, lightly sclerotized, width varying with species, e.g. ca. 1.3 mm for *C. sayi* and ca. 2.1 mm for *C. caryatrypes*; mandibles sclerotized and darker.

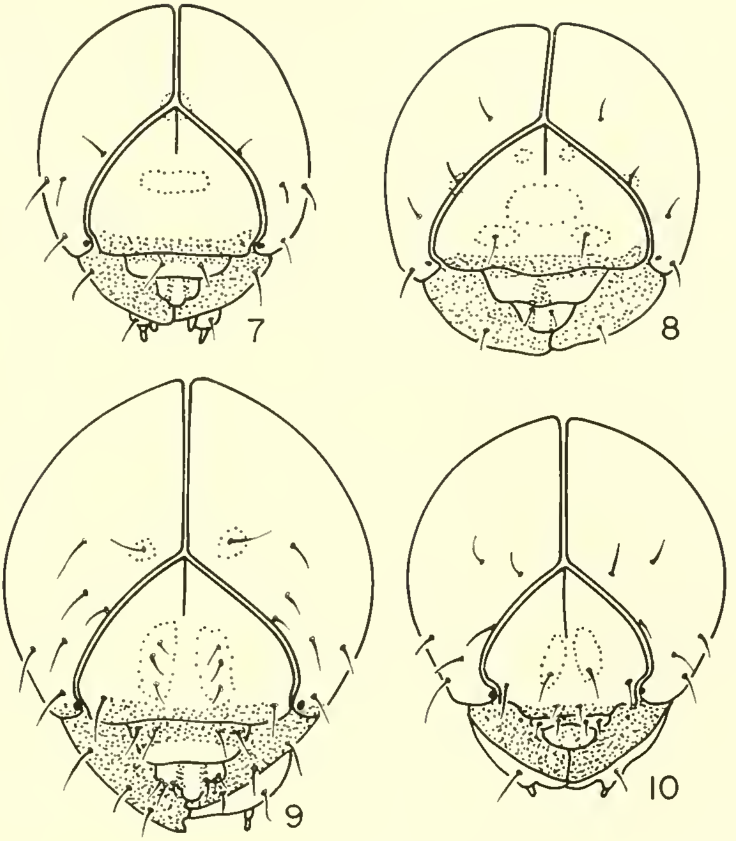
Head capsule (Figs. 1a, b, & c, 2 to 17).—Head free or only a little retracted, longer than wide or as wide as long; broadest at or near middle, rounded or narrowed anteriorly and moderately rounded posteriorly; ocelli absent; anterior ocellar spot present; antennae absent, represented only by a basal space; hypopharyngeal bracon absent; frontal suture distinguishable throughout length, epicranial suture less than ½ as long as head; endocarina distinct approximately ½ as long as frons; frons usually with 1 to 3 pairs of frontal setae (fs)—fs 1 absent in all specimens examined, fs 2 present only on *proboscideus*, fs 3 present on *obtusus, proboscideus, longidens, sulcatulus, pardalis, humeralis*, and *fulvus*, fs 4 present on all except *obtusus, nasicus, sulcatulus, pardalis, humeralis*, and *fulvus*, fs 5 present on all but *nasicus, orthorhynchus, sulcatulus, pardalis, humeralis, victoriensis*, and *iowensis*, (some setae may be absent on some specimens); dorsal epicranial setae (des) 1, 2, 3, and 4 usually present subequal and moderately long—des 1 present in all species except *nasicus*; des 2 absent in *caryae, nasicus, orthorhynchus, sulcatulus, pardalis, humeralis*, and *fulvus*; des 3 present in all species except *caryatrypes*; des 4 absent in *caryatrypes, sayi, caryae*, and *victoriensis* (in some specimens of *victoriensis* it is difficult to determine whether it is 4 or 5 that is absent); des 5 usually absent in all species except *caryatrypes, sayi, caryae*, and *proboscideus*. Lateral epicranial setae (les) 1 and 2 subequal in length moderately long—les 1 present on all species except *sayi, orthorhynchus, humeralis, victoriensis*, and *iowensis*, les 2 present on all species except *humeralis* and *iowensis*; clypeal setae 2 pair only, very short; anterior margin of frons variable, convex in center in *orthorhynchus*, straight or slightly convex in *obtusus, nasicus, proboscideus, longidens, caryae*, and *victoriensis*, concave centrally in *sayi, caryatrypes, pardalis, sulcatulus, humeralis, iowensis, strictus*, and *fulvus*.



Figs. 3 to 6. Head capsules of *Curculio* larvae. 3, *C. caryae*. 4, *C. obtusus*. 5, *C. sayi*. 6, *C. caryatrypes*.

Labrum broadly rounded with 2 to 3 (rarely 4) pair of small dorsal setae, and with 8 or 10 anterior setae of the epipharynx protruding along the front edge, slightly produced into clypeus at center of posterior edge; labral setae 1, 2, and 3 short; epipharynx (1b) with 3 pairs of anterolateral setae, 1 pair anteromedian setae, and 2 or 3 pairs median spines; mandibles triangular in outline, with 1 or 2 apical teeth, and sometimes with a poorly defined inner tooth (Fig. 2d, e); mandibular setae short or absent; labial palpus with 2 articles; premental sclerite complete, with anterior and posterior median extensions; postmentum with three pairs of setae, maxillae simple, palpus with 2 articles, without accessory process or setae (Fig. 1c). Cardo and stipes meet at right angles. Stipes fused with mala; mala armed with 10 setae on front edge. Labium is reduced and its parts consolidated (Fig. 1c).

Prothorax (Figs. 1d, 18 to 32).—Pronotum with 6 to 11 pairs of setae, prothoracic shield very lightly sclerotized and indefinite on most species (not visibly sclerotized on *C. strictus*). Spiracle bicameral. Prothorax with 1 to 7 pedal setae and 1 to 3 pleural setae.

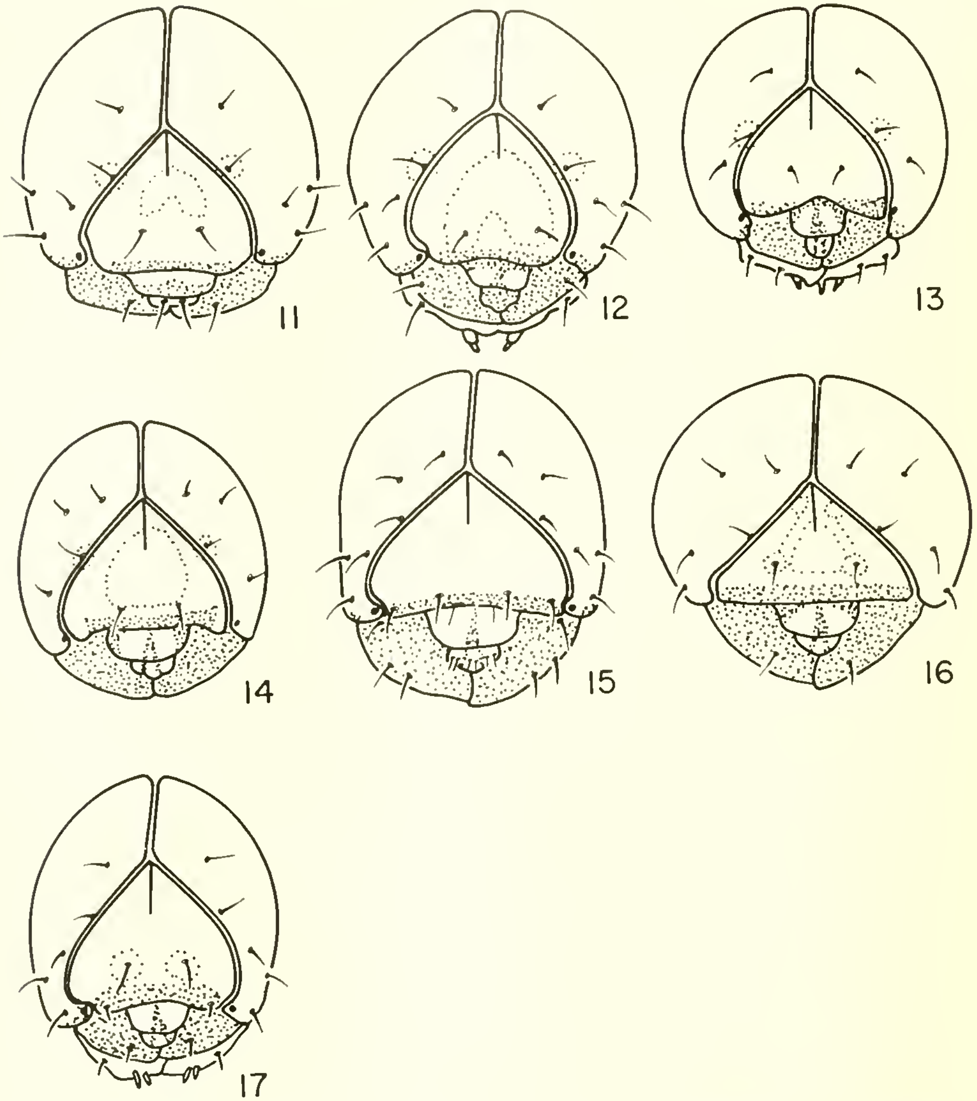


Figs. 7–10. Head capsules of *Curculio* larvae. 7, *C. nasicus*. 8, *C. orthorhynchus*. 9, *C. proboscideus*. 10, *C. longidens*.

Abdomen.—With 8 pairs of spiracles, all lateral and bicameral, similar to prothoracic pair. Typically abdominal segments I to VII with 3 transverse dorsal plicae, abdominal segment VIII with 2 dorsal plicae, and abdominal segment IX undivided. Anus X-shaped. Pedal lobes not bulging. Pleura I to VIII and epipleurum usually with 1 or 2 setae each. Eusternum with 1 seta. Pedal area with 1 to 5 setae. Ninth abdominal segment with 1 pair of moderately long setae dorsally, and epipleurum with 1 pair of setae. Epipleural seta (eps) 1 tiny, located anterio-dorsal from eps 2. Pleural seta 1 tiny, located anterio-dorsal from ps 2.

The larvae are not able to move forward when on their side or back. Forward movement on a smooth surface is difficult.

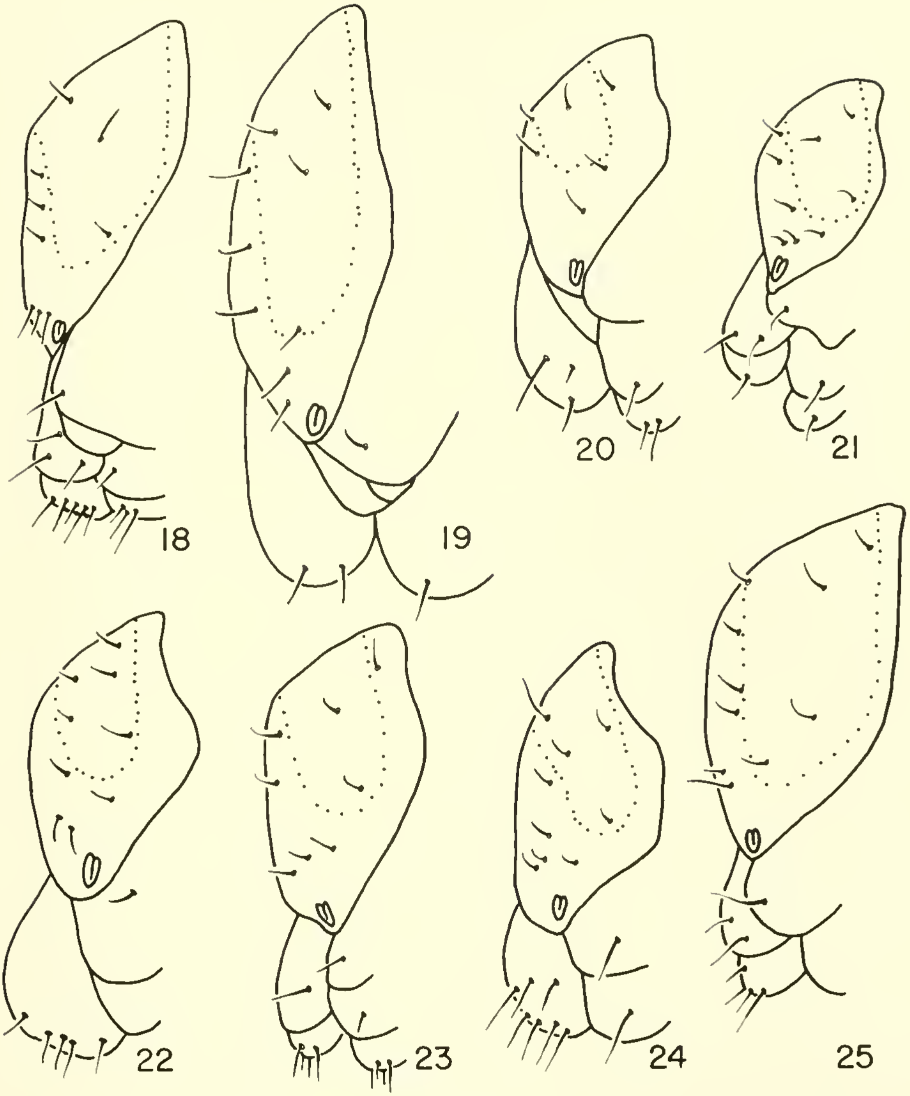
Variation in ultimate instar (mature) larvae makes it difficult to identify some larvae accurately. The larval length and head capsule size vary between specimens of some species. The number of setae on the head may vary due to breaking off or shaving off during emergence from the host nut. Usually the setae of the body are reliable but again some may be broken off. It is important to look at both sides of the head or larvae when keying. If the larvae will not key out, then other characters found in Table 1 will be of assistance.



Figs. 11–17. Head capsules of *Curculio* larvae. 11, *C. pardalus.* 12, *C. sulcatulus.* 13, *C. humeralis.* 14, *C. iowensis.* 15, *C. strictus.* 16, *C. victoriensis.* 17, *C. fulvus.*

KEY TO THE MATURE LARVAE OF *CURCULIO* SPECIES FROM EASTERN UNITED STATES AND CANADA

1. Host *Quercus* (oak acorns) 5
– Host not *Quercus* 2
2. Host *Carya* (pecan & hickory) (Figs. 3 & 19) . . . . *caryae* (Horn)
– Host *Castanea* (chestnut & chinquapin) or *Corylus* (hazelnut) 3
3. Host *Corylus* (Figs. 4 & 20) . . . . *obtusus* (Blanch.)
– Host *Castanea* 4
4. Head capsule round; 1.3 mm wide; larva ca. 10 mm long (Figs. 5 & 21) . . . . *sayi* (Gyll.)

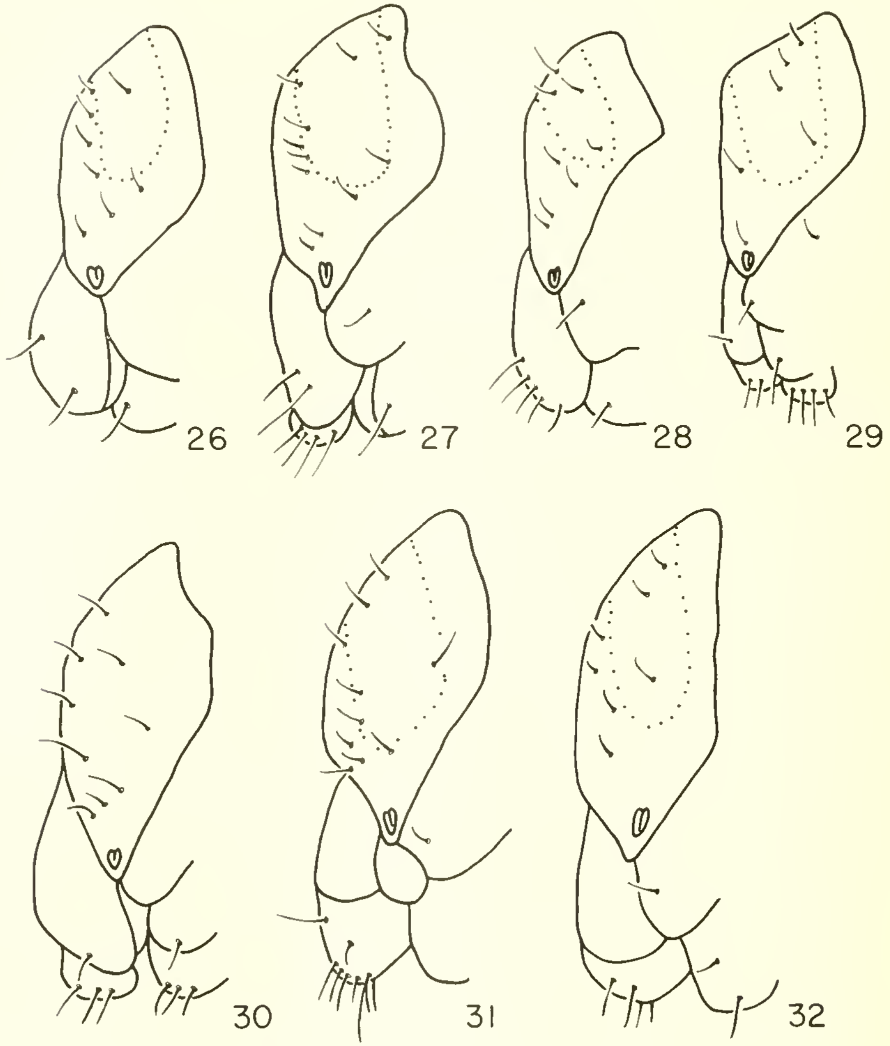


Figs. 18 to 25. Prothoracic segments of *Curculio* larvae (18 and 24 drawn ⅓ scale of others). 18, *C. caryatrypes*. 19, *C. caryae*. 20, *C. obtusus*. 21, *C. sayi*. 22, *C. nasicus*. 23, *C. orthorhynchus*. 24, *C. proboscideus*. 25, *C. longidens*.

– Head capsule higher than wide; 2.1 mm wide; larva 18 to 20 mm long (Figs. 6 & 18) .... *caryatrypes* (Boh.)

5. Head capsule height from frons apex 1.7 to 2.1 mm; concavities on frons either horizontally oval or obliquely vertical twin ovals, if apparently inverted U then there are no concavities around des 3 6

– Head capsule height from frons apex 1.3 to 1.5 mm; concavities on frons variable but never oval, if inverted U then there are always concavities around des 3 9



Figs. 26–32. Prothoracic segments of *Curculio* larvae. 26, *C. pardalis.* 27, *C. sulcatulus.* 28, *C. humeralis.* 29, *C. iowensis.* 30, *C. strictus.* 31, *C. victoriensis.* 32, *C. fulvus.*

6. No setae on frons; central concavity oval and horizontal on frons, fs 4 or its socket not in concavity; head capsule height 1.7 mm (Figs. 7 & 22) .... *nasicus* (Say)
– One to 4 pair setae on frons; central concavity oval and vertical, if horizontal on frons then fs 4 or its socket is in concavity; head capsule height 1.7 to 2.0 mm 7
7. Concavities on frons vertical twin ovals or inverted U shape 8
– Concavities on frons a central horizontal oval and 4 corner concavities at fes 1 and fes 4 positions; head capsule height 1.7 mm (Figs. 8 & 23) .... *orthorhynchus* (Chitt.)
8. Concavity on frons vertical twin ovals or two lines of 3 concavities, if twin ovals then 2 or 3 pair of setae are in the concavities; 2 to 4 pair of

setae on frons; concavity at des 1; head capsule height 2.0 mm (Figs. 9 & 24) .... *proboscideus* F.
- Concavity on frons inverted U or vertical twin ovals, if twin ovals then only 1 pair of setae is in the concavities; 3 pair setae on frons; no concavity at des 1; head capsule height 1.85 mm (Figs. 10 & 25) ... *longidens* Chitt.

9. One pair setae on frons; 3 or 4 pair epicranial setae 10
- Two pair setae on frons; 5 or 6 pair epicranial setae 13

10. Concavity on frons inverted U shape 11
- Concavity on frons absent or not an inverted U shape 12

11. Eight setae on each side of pronotum, fs 4 or its socket is not in frons concavity (Figs. 11 & 26) .... *pardalis* Chitt.
- Eleven setae on each side of pronotum, fs 4 or its socket is in frons concavity (Figs. 2, 12 & 27) .... *sulcatulus* (Casey)

12. No concavity on frons (Figs. 13 & 28) .... *humeralis* (Casey)
- Concavity on frons triangular (Figs. 14 & 29) .... *iowensis* (Casey)

13. No concavity on frons; head capsule yellow and lightly sclerotized, pronotal plate not sclerotized (Figs. 15 & 30) .... *strictus* (Casey)
- Concavity on frons at least around fs 4; head capsule light brown, pronotal plate lightly sclerotized 14

14. Concavity around des 3 and irregularly in central frons (Figs. 16 & 31) .... *victoriensis* Chitt.
- No concavity around des 3 or centrally on frons (Figs. 17 & 32) .... *fulvus* Chitt.

LITERATURE CITED

Anderson, W. H. 1947. A terminology for the anatomical characters useful in the taxonomy of weevil larvae. Proc. Entomol. Soc. Wash. 49: 123–132.

Boving, A. G. and F. C. Craighead. 1930. An illustrated synopsis of the principal larval forms of the order Coleoptera. Entomol. Am. 11: 1–351.

Brooks, F. E. and R. T. Cotton. 1929. The chestnut curculios. USDA Tech. Bull. No. 130: 1–27, 6 pls.

Chittenden, F. H. 1904. The chestnut weevils, with notes on other nut feeding species. USDA Div. Entomol. Bull. 44: 24–39, illus.

———. 1908. The nut weevils. USDA Bur. Entomol. Circ. 99: 1–15, illus. (Reprinted from USDA Yearbook 1904, pp. 299–310).

Emden, F. van 1938. On the taxonomy of Rhynchophora larvae (Coleoptera). Trans. Royal Entomol. Soc. London 87: 1–37.

———. 1952. On the taxonomy of Rhynchophora larvae: Adelognatha and Alophinae (Insecta: Coleoptera). Proc. Zool. Soc. London 122(3): 651–795.

Gibson, L. P. 1969. Monograph of the genus *Curculio* in the New World (Coleoptera:Curculionidae). Part I. United States and Canada. Entomol. Soc. Am. Misc. Publ. 6(5): 239–285.

Leiby, R. W. 1925. Insect enemies of the pecan in North Carolina. Bull. North Carolina Dep. Agric., Raleigh. 67 pp.

McClenahan, E. M. 1904. The development of the rostrum in Rhyncophorous Coleoptera. Psyche 89–102, plates VI–XX.

Peterson, A. 1960. Larvae of insects. Part II. Coleoptera, Diptera, Neuroptera, Siphonaptera, Mecoptera, Trichoptera. Alvah Peterson, Columbus, Ohio. 416 pp.

Scherf, H. 1964. Die Entwicklungsstadien der mitteleuropaischen Curculioniden (Morphologie, Bionomie, Okologie). Abh. Senckenb. Naturf. Ges. 506: 1–355, 497 figs.

PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 564–571

HOST-PLANT RELATIONS OF *TRUPANEA* SPP. (DIPTERA: TEPHRITIDAE) IN SOUTHERN CALIFORNIA

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Abstract.—Many new rearing records are reported for nine of 15 species of *Trupanea* occurring in California. The host relations of all 15 species are assessed, including two species for which hosts remain unknown, two monophagous species, five oligophagous species, and six generalist species, all restricted to Asteraceae. The numbers of flies reared from flower head samples from the different hosts of each species of *Trupanea* also varied considerably.

Five years ago I began long-term studies on the biology and ecology of flower-head infesting and gall-forming fruit flies (Diptera: Tephritidae) in southern California, that section of the state defined and treated by Munz (1974). I report here many new rearing records for several species of *Trupanea*, the most common genus of nonfrugivorous Tephritidae encountered in southern California, and briefly characterize their host affinities in light of these new records.

Materials and Methods

Mature flower heads of Asteraceae were sampled as encountered during wide-ranging field research on a variety of entomological projects throughout southern California during 1980–1984. Samples of excised heads and a few whole plants for use in identification were transported in individual, sealed, 23 × 30.5-cm, polyethylene plastic bags in a cold chest to the University of California at Riverside. The number of heads sampled varied with their availability and inversely with their size, but usually comprised a full bag of one to several hundred heads. Following temporary storage for up to 1 week in a refrigerator at 2°C, the plants were identified and the flower head samples separately caged in the insectary of the Division of Biological Control at 26 ± 1°C and a 12-h or 16-h photoperiod in glass-topped, wooden, sleeve cages described by Gilstrap and Goeden (1974). Samples were spread on the bare cage floors and held for 2 weeks to 1 month, depending on the amount and duration of fly emergence. A hygroscopic mixture of honey (five parts) : yeast hydrolyzate (two parts) narrowly streaked on the underside of the cage top provided a temporary food and moisture source for emerged flies. Bi-weekly collections of the fully colored, 2–3 day old flies were made and the number and sex of all tephritid species recovered from each sample recorded.

Results

New host-plant genus or species rearing records determined by comparison with Wasbauer (1972) for nine of 15 species of *Trupanea* reported from southern

California by Foote and Blanc (1963) are listed below. Host-plant records that are not reported in Wasbauer (1972) are labelled with a double or single asterisk for genera and species, respectively. Among multiple samples of a particular plant species, only the sample from which the most individuals of each fly species was recovered is reported. The plant nomenclature used follows Munz (1974); the insect nomenclature, Foote (1960), and Foote and Blanc (1963). Rearing records for the flies and their host plants are listed alphabetically.

Trupanea actinobola (Loew), 43 ♂ and 28 ♀, ***Acamptopappus shockleyi* Gray, SE end Kingston Range, NE San Bernardino Co., 27.v.1982; 12 ♂ and 13 ♀, ***A. sphaerocephalus* (Harvey and Gray) Gray, Phelan, SW San Bernardino Co., 27.v.1980; 1 ♂, ***Achillea millefolium* L. var. *californica* (Pollard) Jepson, Corralilos Canyon, W Santa Barbara Co., 28.vi.1983; 33 ♂ and 32 ♀, ***Baileya multiradiata* Harvey and Gray, Piute Valley, E San Bernardino Co., 24.iii.1982; 34 ♂ and 37 ♀, ***Dyssodia pentachaeta* (de Candolle) Robinson ssp. *pentachaeta* var. *belenidium* (de Candolle) Strother, S of Mountain Pass, SE of Mescal Range, NE San Bernardino Co., 20.ix.1983; 1 ♂, ***Erigeron foliosus* Nuttall, W of Tehachapi, Kern Co., 12.vii.1983; 13 ♂ and 9 ♀, ***Gutierrezia microcephala* (de Candolle) Gray, N of Mercury Mountain, NE San Bernardino Co., 20.x.1982; 1 ♀, ***Heterotheca grandiflora* Nuttall, Pine Valley, San Diego Co., 18.ix.1980; 1 ♀, ***Lepidospartum squamatum* (Gray) Gray, Cajon Junction, SW San Bernardino Co., 9.ix.1981; 1 ♂, ***Porophyllum gracile* Bentham, Turquoise Mountain, NE San Bernardino Co., 29.iv.1981; 1 ♂, **Solidago confinis* Gray, W shore of Lake Hemet, San Jacinto Mountains, San Bernardino Nat. Forest, Riverside Co., 29.ix.1982; 58 ♂ and 31 ♀, ***Trixis californica* Kellogg, Chino Canyon, Riverside Co., 9.iv.1981.

Trupanea californica Malloch, 62 ♂ and 42 ♀, **Gnaphalium beneolens* Davidson, W shore of Lake Hemet, San Jacinto Mountains, San Bernardino Nat. Forest, Riverside Co., 29.ix.1982; 21 ♂ and 15 ♀, **Gnaphalium bicolor* Biolette, Grapevine Canyon, San Diego Co., 9.ii.1984; 9 ♂ and 11 ♀, **Gnaphalium californicum*, Los Osos, San Luis Obispo Co., 29.vi.1983.

Trupanea femoralis (Thomson), 1 ♀, **Haplopappus acradenius* (Greene) Blake ssp. *eremophilus* (Greene) Hall, Mountain Springs, SW Imperial Co., 14.x.1981; 1 ♂ and 4 ♀, **Haplopappus linearifolius* de Candolle, Devil's Punchbowl, Los Angeles Co., 27.v.1980; 2 ♂ and 1 ♀, **Haplopappus pinifolius* Gray, McCain Valley, San Diego Co., 16.x.1980; 3 ♂ and 1 ♀, **Hemizonia floribunda* Gray, Lark Canyon, San Diego Co., 16.x.1980; 11 ♂ and 4 ♀, ***Lepidospartum squamatum*, Snow Creek, Riverside Co., 20.x.1981; 2 ♂, ***Peucephyllum schottii* (Gray) Gray, N side of Graham Pass, Riverside Co., 21.iii.1984.

Trupanea imperfecta (Coquillett), 1 ♀, ***Ambrosia ilicifolia* (Gray) Payne, Signal Mountain, Imperial Co., 25.ii.1981; 1 ♀, ***Coreopsis gigantea* (Kellogg) Hall, Ocean Beach, Santa Barbara Co., 18.iv.1980.

Trupanea jonesi Curran, 6 ♂ and 3 ♀, ***Agoseris heterophylla* (Nuttall) Greene, Figueroa Mountain, San Rafael Wilderness, Santa Barbara Co., 21.v.1981; 1 ♀, ***Artemisia douglasiana* Besser in Hooker, Kitchen Creek, San Diego Co., 16.ix.1981; 1 ♂ and 3 ♀, ***Artemisia dracunculus* L., Mahogany Creek, Sequoia Nat. Forest, Tulare Co., 11.vii.1984; 3 ♂ and 2 ♀, ***Artemisia ludoviciana* Nuttall, Cienaga Creek, San Bernardino Nat. Forest, SW San Bernardino Co., 18.viii.1981; 2 ♂ and 3 ♀, ***Baccharis glutinosa* Persoon, Weldon Valley, Walker Pass, Kern Co., 25.iv.1984; 1 ♂ and 1 ♀, ***Baccharis sergiloides* Gray, Howe Spring, Pinto Valley, New York Mountains, NE San Bernardino Co., 9.ix.1981; 1 ♀, ***Baileya* *multiradiata*, Mountain Pass, NE San Bernardino Co., 23.iv.1981; 10 ♂ and 12 ♀, ***Balsamorhiza deltoidea* Nuttall, N of Burnt Peak, Angeles Nat. Forest, Los Angeles Co., 8.vi.1983; 28 ♂ and 5 ♀, ***Chaenactis douglasii* (Hooker) Hooker and Arnott, Jackass Meadow, Sequoia Nat. Forest, SE Tulare Co., 26.vii.1983; 41 ♂ and 31 ♀, ***Chaenactis fremontii* Gray, Snow Creek, Riverside Co., 9.iv.1981; 1 ♂ and 3 ♀, **Chrysothamnus nauseosus* (Pallas) Britton, Landers Meadow, Sequoia Nat. Forest, Kern Co., 3.ix.1981; 1 ♀, **Chrysothamnus parryi* (Gray) Greene ssp. *vulcanicus* (Greene) Hall and Clements, Evans Flat, Greenhorn Mountains, Sequoia Nat. Forest, Kern Co., 30.viii.1983; 3 ♂ and 4 ♀, **Chrysothamnus viscidiflorus* (Hooker) Nuttall, Landers Meadow, Sequoia Nat. Forest, Kern Co., 3.ix.1981; 2 ♂ and 3 ♀, **Coreopsis douglasii* (de Candolle) Hall, S of 29 Palms, S San Bernardino Co., 27.iv.1982; 3 ♀, **Erigeron coulteri* Porter, Onion Valley, Sierra Nevada Mountains, W Inyo Co., 14.ix.1982; 32 ♂ and 22 ♀, **Erigeron peregrinus* (Pursh) Greene ssp. *callianthemus* (Greene) Cronquist, Smith Meadows, Sequoia Nat. Forest, SE Tulare Co., 3.viii.1983; 1 ♂, ***Eriophyllum confertiflorum* (de Candolle) Gray, Pioneertown, SW San Bernardino Co., 5.v.1981; 3 ♂ and 6 ♀, ***Eriophyllum pringlei* Gray, Chimney Creek, Sequoia Nat. Forest, SE Tulare Co., 25.iv.1984; 5 ♂ and 4 ♀, ***Geraea canescens* Torrey and Gray, Hidden Spring, W of Indio, Riverside Co., 14.iv.1981; 1 ♂, ***Hymenoxys cooperi* (Gray) Cockerell var. *cooperi*, Caruthers Canyon, New York Mountains, NE San Bernardino Co., 31.viii.1982; 10 ♂ and 7 ♀, ***Layia glandulosa* (Hooker) Hooker and Arnott, ssp. *glandulosa*, Pioneertown, SW San Bernardino Co., 5.v.1981; 22 ♂ and 23 ♀, ***Layia platyglossa* (Fischer and Meyer) Gray prob. ssp. *campestris* Keck, Howard Canyon, Santa Barbara Co., 17.iv.1980; 2 ♀, ***Lepidospartum squamatum*, Cajon Junction, SW San Bernardino Co., 2.ix.1981; 1 ♂, ***Lessingia lemmonii* Gray var. *lemmonii*, Cedar Canyon, NE San Bernardino Co., 9.ix.1981; 1 ♀, ***Perityle emoryi* Torrey in Emory, S of Ibis, SW side of Dead Mountains, E San Bernardino Co., 24.iii.1982; 5 ♂ and 4 ♀, ***Senecio canus* Hooker, N of Troy Meadows, Sequoia Nat. Forest, SE Tulare Co., 26.vii.1983; 11 ♂ and 5 ♀, ***Solidago occidentalis* (Nuttall) Torrey and Gray, Kennedy Meadows, Sequoia Nat. Forest, Tulare Co., 26.ix.1980; 1 ♀, ***Stephanomeria virgata* Bentham, Cuddy Valley, Los Padres Nat. Forest, SW Kern Co., 31.viii.1983; 13 ♂ and 16 ♀, ***Tetradymia spinosa* Hooker and Arnott var. *longispina* Jones, Pioneertown, SW San Bernardino Co., 5.vi.1981.

Trupanea nigricornis (Coquillett) (does not include rearing records cited by Cavender and Goeden (1983)), 16 ♂ and 5 ♀, **Acamptopappus shockleyi*, SE end Kingston Range, NE San Bernardino Co., 27.v.1982; 1 ♂, **Brickellia californica* (Torrey and Gray) Gray, S end Ivanpah Mountains, NE San Bernardino Co., 21.x.1982; 1 ♀, **Brickellia desertorum* Coville, Colton Well, NE San Bernardino Co., 21.x.1982; 3 ♂ and 4 ♀, **Brickellia incana* Gray, Sacramento Spring (S of Colton Hills and E of Mitchell Caverns), NE San Bernardino Co., 21.x.1982; 2 ♂ and 1 ♀, **Brickellia oblongifolia* Nuttall var. *linifolia* (D. C. Eaton) Robinson, Opal Canyon, Inyo Nat. Forest, NE Inyo Co., 30.vi.1982; 3 ♂ and 5 ♀, ***Chaenactis carphoclina* Gray, Sheephole Mountains, SE San Bernardino Co., 10.iv.1984; 18 ♂ and 20 ♀, **Chrysothamnus paniculatus* (Gray) Hall, N Alabama Hills, Inyo Co., 8.vi.1982; 10 ♂ and 16 ♀, ***Dyssodia cooperi* Gray, NW of Stepladder Mountains, SE San Bernardino Co., 22.x.1982; 2 ♂ and 1 ♀, ***Erigeron peregrinus* ssp. *callianthemus*, Smith Meadows, Sequoia Nat. Forest, SE Tulare Co., 3.viii.1983; 16

♂ and 24 ♀, ***Haplopappus acradenius* ssp. *acradenius*, Sacramento Spring, NE San Bernardino Co., 21.x.1982; 3 ♂ and 2 ♀, **Haplopappus cuneatus* Gray, S end of Ivanpah Mountains, NE San Bernardino Co., 21.x.1982; 18 ♂ and 20 ♀, **Haplopappus paniculatus* (Gray) Hall, N Alabama Hills, Inyo Co., 8.vi.1982; 2 ♂ and 4 ♀, **Haplopappus parishii* (Greene) Blake, Garnet Mountain, San Diego Co., 9.ix.1980; 5 ♂ and 9 ♀, **Haplopappus pinifolius* Gray, McCain Valley, San Diego Co., 16.x.1980; 3 ♂ and 2 ♀, ***Hymenoxys cooperi*, Caruthers Canyon, New York Mountains, NE San Bernardino Co., 31.viii.1982; 2 ♀, ***Leucelene ericoides* (Torrey) Greene, Death Valley Road above Eureka Valley, NE Inyo Co., 5.vi.1984; 1 ♂ and 1 ♀, ***Pleurocoronis pluriseta* (Gray) King and Robinson, NW of Coxcomb Mountains, SE San Bernardino Co., 20.iii.1984; 4 ♂ and 5 ♀, ***Senecio canus*, N of Troy Meadows, Sequoia Nat. Forest, SE Tulare Co., 26.vii.1983; 1 ♀, **Solidago confinis* Gray, Antelope Spring, NE Inyo Co., 15.ix.1982; 5 ♂ and 4 ♀, ***Tetradymia axillaris* A. Nelson, Marble Canyon, Inyo Nat. Forest, Inyo Co., 30.vi.1982; 6 ♂ and 6 ♀, ***Tetradymia canescens* de Candolle, 1 km E of Aspen Grove, San Bernardino Nat. Forest, SW San Bernardino Co., 19.viii.1982; 1 ♂, ***Tetradymia spinosa* Hooker and Arnott var. *longispina* Jones, Weldon Valley, Walker Pass, Kern Co., 25.iv.1984; 15 ♂ and 3 ♀, **Viguiera multiflora* (Nuttall) Blake var. *nevadensis* (A. Nelson) Blake, S of Mountain Pass, SE side of Mescal Range, NE San Bernardino Co., 20.ix.1983.

Trupanea radifera (Coquillett), 1 ♂ and 1 ♀, ***Aster scopulorum* Gray, Cowhorn Valley, N Inyo Nat. Forest, NE Inyo Co., 30.vi.1982; 1 ♂, ***Baileya pauciradiata* Harvey and Gray, sand dunes near Hidden Springs (W of Indio), Riverside Co., 14.iv.1981; 1 ♂, ***Chrysothamnus viscidiflorus*, Antelope Spring, NE Inyo Co., 15.ix.1982; 3 ♂ and 6 ♀, ***Eriophyllum wallacei* Gray, Sheephole Mountains, SE San Bernardino Co., 10.iv.1984; 31 ♂ and 26 ♀, ***Machaeranthera tortifolia* (Gray) Cronquist and Keck, S of former site of Fort Piute, Piute Range, NE San Bernardino Co., 18.iii.1982; 44 ♂ and 43 ♀, ***Malacothrix coulteri* Gray, Rainbow Basin (N of Barstow), NW San Bernardino Co., 16.iv.1983; 102 ♂ and 93 ♀, ***Malacothrix glabrata* Gray, Sheephole Mountains, SE San Bernardino Co., 10.iv.1984; 4 ♂ and 6 ♀, ***Microseris linearifolia* (de Candolle) Schultz-Bipontinus, 5 km W of Aguanga, SW Riverside Co., 11.v.1982; 2 ♂ and 10 ♀, ***Monoptilon bellioides* (Gray) Hall, 7 km NW of Manix, NW San Bernardino Co., 5.v.1982; 44 ♂ and 71 ♀, ***Nicolletia occidentalis* Gray, Alvord Mountain (between Baker and Barstow), NW San Bernardino Co., 23.iv.1982; 33 ♂ and 26 ♀, ***Palafoxia linearis* (Cavanilles) Lagasca y Segura var. *gigantea* Jones, Sand Hills (W of Glamis), Imperial Co., 28.i.1982; 37 ♂ and 26 ♀, ***Palafoxia linearis* var. *linearis*, Big Morongo Canyon, Riverside Co., 15.iv.1984; 33 ♂ and 30 ♀, ***Perityle emoryi*, Chemhuevi Wash (at West Well S of Needles), E San Bernardino Co., 16.iii.1982; 1 ♀, ***Pleurocoronis pluriseta*, N slope of Graham Pass, E Riverside Co., 21.iii.1984; 7 ♂ and 1 ♀, ***Rafinesquia neomexicana* Gray, Rainbow Basin, NW San Bernardino Co., 29.iv.1982.

Trupanea vicinia (van der Wulp), 3 ♀, ***Coreopsis douglasii*, S of 29 Palms, S San Bernardino Co., 27.iv.1982; 1 ♀, ***Dyssodia porophylloides* Gray, Grapevine Canyon, San Diego Co., 30.iv.1982; 1 ♀, ***Nicolletia occidentalis*, SE of Alvord Mountain (between Barstow and Baker), NW San Bernardino Co., 23.iv.1982.

Trupanea wheeleri Curran, 1 ♀, ***Acamptopappus shockleyi* Gray, Aguerreberry Point, Panamint Range, Inyo Co., 9.vi.1982; 2 ♂ and 2 ♀, ***Brickellia californica*, Quatal Canyon, Los Padres Nat. Forest, S Kern Co., 31.viii.1983; 1 ♀, ***Chrysopsis villosa*, Cuddy Valley, Los Padres Nat. Forest, S Kern Co., 31.viii.1983; 2 ♀, ***Chrysothamnus nauseosus*, atop Mt. Pinos, Los Padres Nat. Forest, Ventura Co., 7.ix.1982; 1 ♂ and 1 ♀, ***Chrysothamnus parryi* ssp. *asper* (Greene) Hall and Clements, Squirrel Meadow, Sequoia Nat. Forest, Kern Co., 2.ix.1981; 5 ♂ and 2 ♀, **Encelia farinosa* Gray ex Torrey, Chino Canyon, Riverside Co., 3.iv.1980; 9 ♂ and 3 ♀, **Encelia virginensis*, Cactus Canyon, Riverside Co., 29.iv.1980; 4 ♂ and 6 ♀, ***Eriophyllum confertiflorum*, S side of Refugio Pass, Santa Barbara Co., 17.vi.1980; 1 ♂ and 3 ♀, **Haplopappus cuneatus*, Lark Canyon, San Diego Co., 16.x.1980; 6 ♂ and 7 ♀, **Haplopappus ericoides* (Lessing) Hooker and Arnott ssp. *blakei* C. B. Wolf, Orcutt, Santa Barbara Co., 7.xii.1982; 11 ♂ and 7 ♀, **Haplopappus parishii*, Descanso Junction, San Diego Co., 16.x.1980; 1 ♂ and 4 ♀, **Haplopappus pinifolius*, McCain Valley, San Diego Co., 16.x.1980; 24 ♂ and 19 ♀, **Haplopappus propinquus* Blake, Kitchen Creek, Cleveland Nat. Forest, San Diego Co., 14.x.1981; 1 ♂ and 2 ♀, **Haplopappus venetus* ssp. *furfuraceus* (Greene) Hall, Proctor Valley, SW San Diego Co., 28.x.1981; 1 ♂ and 3 ♀, ***Hemizonia floribunda*, Lark Canyon, San Diego Co., 16.x.1980; 1 ♀, ***Perityle emoryi*, Travertine Rocks, Imperial Co., 15.iv.1980.

Discussion

In his revision of the genus *Trupanea*, Foote (1960) noted that no concerted effort had been made to evaluate the host specificity of this worldwide, largely non-economic taxon or to study the biology of any species. Foote and Blanc (1963) listed collection and rearing records for *Trupanea* from California, which include 15 of 20 species known from North America north of Mexico. They remarked that the host specificities of the California species of *Trupanea* remained largely undefined. Wasbauer (1972) cataloged both published and unpublished host records for North American Tephritidae, including *Trupanea*. Stegmaier (1968) studied the biology of *T. actinobola* in Florida and discussed its known host relationships. Cavender and Goeden (1982, 1983) described the life history of *T. bisetosa* (Coquillett) and discussed how its host specificity helped to distinguish this species from *T. nigricornis*. These references contain most published knowledge of the host relations of North American *Trupanea*.

The many rearing records reported herein allow an initial analysis to be made of the host specificity of *Trupanea* species in California. It is readily apparent that considerable differences exist in the host specificity of the various species. Degrees of specificity represented vary from the narrow monophagy of *T. conjuncta* (Adams), which only reproduces on *Trixis californica* (Goeden, 1983; Goeden and Ricker, unpublished data); to oligophagous species like *T. californica*, which infests heads of several species each of the closely related genera, *Anaphalis* and *Gnaphalium* (Wasbauer, 1972), in the tribe Inulae (Munz and Keck, 1959); to generalist species like *T. jonesi*, which is now known from 29 genera and 41 species of Asteraceae (Wasbauer, 1972, and in the present work). Between the extremes in host specificity represented by *T. conjuncta* and *T. jonesi* lie the 11 other species of *Trupanea* from California for which at least some host data are available.

I have not yet reared *T. arizonensis* Malloch or *T. maculigera* Foote, for which Wasbauer (1972) also listed "no host information." These two species were represented by records for only five and nine individuals, respectively, all collected by sweeping (Foote and Blanc, 1963). Both species presumably have very restricted host ranges in California. The distributional data for *T. arizonensis* in Foote and Blanc (1963) and my sweeping samples suggest that this fly infests the heads of a fairly widespread host, and for *T. maculigera,* that its unknown host is of extreme southern distribution in California.

Trupanea pseudovicina Hering has only been reported from *Bebbia juncea* and *Porophyllum gracile* (Wasbauer, 1972). I have confirmed the latter rearing record three times, but never the former record, even after many weekly samplings of *B. juncea* heads with D. W. Ricker during our ongoing, life history study of *T. imperfecta.* Therefore, the published, "unpublished" record for *Bebbia juncea* in Wasbauer (1972) was probably erroneous or atypical and rare (see discussion below), and *T. pseudovicina* normally is monophagous in heads of *Porophyllum gracile.*

Besides *T. californica,* four additional, oligophagous species of *Trupanea* in California include: *T. bisetosa,* associated with *Helianthus* spp. and other Heliantheae (Cavender and Goeden, 1982, 1983); *T. imperfecta,* principally reproducing in flower heads of *Bebbia juncea* (Bentham) Greene (Wasbauer, 1972; Goeden and Ricker, unpublished data), though rarely also transferring to and limitedly reproducing in other desert Asteraceae, e.g. *Ambrosia ilicifolia,* and related Heliantheae, e.g. *Coreopsis gigantea*; *T. signata* Foote, like *T. californica,* apparently principally infesting heads of *Anaphalis* and *Gnaphalium* spp. (Wasbauer, 1972); and *T. vicina* (van der Wulp), reported from flower heads of marigold, *Tagetes* sp. (Wasbauer, 1972), a garden ornamental widely planted and commonly infested by this fly in southern California (Goeden and Ricker, unpublished data), and also reared in small numbers, as noted above, from native hosts sampled at isolated desert locations in 1982, a year of exceptionally high rainfall.

Like *T. jonesi,* the five other generalist species have wide host ranges within the family Asteraceae in southern California: *A. femoralis,* now known from seven genera and 13 species; *A. radifera,* now known from 16 genera and 18 species; *A. actinobola,* now known from 16 genera and 26 species; *T. wheeleri,* now known from 17 genera and 24 species; and *T. nigricornis,* now known from 20 genera and 42 species (Wasbauer, 1972, and in the present work).

These rearing records represented the maximum number of flies recovered from each of one to five samples of flower heads of each plant species at different locations. The maximum numbers of each species of *Trupanea* reared varied considerably among the different host plants. The fly recoveries presumably were proportional to the nutritional suitability of the different hosts for progeny development or to the attractiveness of their flower heads for oviposition. Samples from which no flies were reared, though fairly common, are not reported here; however, some of these records probably accurately reflected complete plant resistance to tephritid attack. Four of seven new host records reported here for *T. femoralis* involved only one to four reared flies; as did nine of 16 new records for *T. wheeleri*; 13 of 29 new records for *T. jonesi*; five of 12 new records for *T. actinobola*; seven of 23 new records for *T. nigricornis*; and four of 15 new records for *T. radifera* (Wasbauer, 1972). Parasitism also reduced to an undetermined degree the numbers of flies reared. The number of heads sampled was not so limited as to account for the rearings of so few flies. Multiple infestation of individual flower heads by single species of *Trupanea* spp. is common (Stegmaier, 1968; Cavender and Goeden, 1982; Goeden and Ricker, unpublished data). Then, too, some samples when collected may have contained larvae too young to complete their development in the excised flower heads. However, as mature flower heads mainly were sampled, this explanation might better apply to certain Tephritidae other than *Trupanea* that apparently have longer developmental periods, e.g. *Neaspilota* and *Urophora* (Goeden, unpublished data). All species of *Trupanea* that my coworkers and I have studied to date pupariate in heads and emerge as adults from mature heads. Another factor probably involved in limiting numbers of emerged flies of individual species was interspecific competition by *Trupanea* spp. and other Tephritidae for flower heads of the same host species at a particular location (synphagy) (Goeden, unpublished data).

Zwölfer (1983) noted that nonfrugivorous tephritids either are generalists with broad host ranges or specialists with narrow host ranges. Among *Trupanea* species in California, specialists are either monophagous or oligophagous. The six generalist species of *Trupanea* in California show considerable differences in their host ranges and their abilities to reproduce in the flower heads of different host species. Exploitation of less suitable hosts may be a survival mechanism for "spreading the risk" against local, catastrophic annihilation or the result of "competition for enemy-free space from specialized natural enemies," as suggested by Zwölfer (1983). Alternatively, the low numbers of flies reared from samples of certain species of plants may result from oviposition fostered by juxtaposition with a preferred host, especially at high fly densities. This "spillover" effect sometimes is observed in cage studies of host-plant specificity (Zwölfer and Harris, 1971). Whatever their cause(s), limited host-plant transfers apparently are normal occurrences in all generalist species, at least some oligophagous species, and, perhaps, even monophagous species of *Trupanea* in California.

The host relations of *Trupanea* will be further defined as additional rearing records are published. My samplings will continue, working towards a personal goal of defining the tephritid associates of all Asteraceae known from southern California.

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LITERATURE CITED

Cavender, G. L. and R. D. Goeden. 1982. Life history of *Trupanea bisetosa* (Diptera: Tephritidae) on wild sunflower in southern California. Ann. Entomol. Soc. Am. 75: 400–406.

———. 1983. On distinguishing *Trupanea bisetosa* (Coquillett) from *T. nigricornis* (Coquillett) (Diptera: Tephritidae). Proc. Entomol. Soc. Wash. 85: 275–281.

Foote, R. H. 1960. A revision of the genus *Trupanea* in America north of Mexico. U.S. Dep. Agric. Tech. Bull. 1214, 29 pp.

Foote, R. H. and F. L. Blanc. 1963. The fruit flies or Tephritidae of California. Bull. Calif. Insect Surv. 7, 115 pp.

Gilstrap, F. E. and R. D. Goeden. 1974. Biology of *Tarachidia candefacta*, a Nearctic noctuid introduced into the U.S.S.R. for ragweed control. Ann. Entomol. Soc. Am. 67: 265–270.

Goeden, R. D. 1983. Initial host-plant records for five species of fruit flies from southern California (Diptera: Tephritidae). Proc. Entomol. Soc. Wash. 85: 399–400.

Munz, P. A. 1974. A flora of Southern California. Univ. Calif. Press, Berkeley, Los Angeles, London, 1086 pp.

Munz, P. A. and D. D. Keck. 1959. A California flora. Univ. Calif. Press, Berkeley and Los Angeles, 1681 pp.

Stegmaier, C. E. 1968. Notes on the biology of *Trupanea actinobola*. Fla. Entomol. 51: 95–99.

Wasbauer, M. W. 1972. An annotated host catalog of the fruit flies of America north of Mexico (Diptera: Tephritidae). Calif. Dep. Agric. Bur. Entomol. Occas. Pap. 19, 172 pp.

Zwölfer, H. 1983. Life systems and strategies of resource exploitation in tephritids, pp. 16–30. *In* Cavalloro, R., ed., Fruit flies of economic importance. Proc. CEC/IOBC Int. Sym., Athens, Greece, Nov. 1982, A. A. Balkema, Rotterdam.

Zwölfer, H. and P. Harris. 1971. Host specificity determination of insects for biological control of weeds. Ann. Rev. Entomol. 16: 159–178.

PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 572–577

THE SIZE AND SEASONAL DISTRIBUTION OF THE SIBLING SPECIES *TABANUS NIGROVITTATUS* AND *TABANUS CONTERMINUS* IN NEW JERSEY (DIPTERA: TABANIDAE)[1]

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Abstract.—The salt marsh greenhead flies in New Jersey comprise a pair of cryptic species, *T. nigrovittatus* and *T. conterminus*, that can be discriminated completely with protein electrophoresis. Although they overlap in size, *T. conterminus* is somewhat larger on the average, but it is far less abundant throughout the state and during the summer breeding season. Some aspects of the population dynamics of these species are discussed in reference to potential control strategies.

The mingling of two or more closely related species that cannot be distinguished by conventional taxonomic techniques provides a special problem for pest management programs. Attempts at biological or chemical control may fail, or even exacerbate a problem, because of the inherent differences in breeding seasons, life history dynamics, and susceptibilities among the members of a cryptic species complex. We recently recognized a cryptic species pair in the *Tabanus nigrovittatus* (*sensu lato*) Macquart complex in New Jersey. Electrophoretic studies revealed the presence of two reproductively isolated populations in most of our samples (Jacobson et al., 1981). Although the two species exhibit somewhat different but overlapping size distributions, they are easily separated by allozyme phenotypes encoded by several gene loci. This work corroborated earlier suspicions that *T. nigrovittatus* might represent a cryptic species complex (Freeman, 1962; Freeman and Hansens, 1972). The larger of the two flies (Group II of Jacobson et al., 1981) is *T. conterminus* Walker (Burger et al., 1985). The smaller species is *T. nigrovittatus* (*sensu stricto*).

The seasonal distribution of the *T. nigrovittatus* complex extends from mid-June to mid-September in New Jersey, with the greatest abundance in July (Hansens, 1952). The purpose of this study was to delineate seasonal activity patterns and size distributions of adult *T. nigrovittatus* and *T. conterminus*.

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Table 1. The mean body length of *T. nigrovittatus* and *T. conterminus* from four sites in New Jersey.[1]

Site	Mean Body Length ± SD	
	T. nigrovittatus	*T. conterminus*
Island Beach State Park	10.69a* ± 0.62 (499)	13.44a (1)
Cedarville	10.62ab ± 0.68 (649)	12.89a ± 0.60 (8)
Leeds Point	10.56b ± 0.69 (477)	12.80a ± 0.76 (55)
Stone Harbor	10.42c ± 0.68 (560)	12.48a ± 0.73 (51)

[1] Sample size is in parentheses.

* Means with the same letter in vertical columns do not differ significantly at $P = 0.05$, by Duncan's multiple range test.

MATERIALS AND METHODS

Samples of *T. nigrovittatus* and *T. conterminus* were collected at weekly intervals from the end of June to the end of August, 1980. Female flies were collected from box traps (Hansens and Race, 1979) located on salt marshes at four sites in New Jersey: Cedarville, Stone Harbor, Leeds Point and Island Beach State Park. The flies were transported to the laboratory in cloth cages and a sample of 40–80 living flies was frozen and stored at −50°C prior to electrophoretic analysis.

The flies were thawed and their total lengths measured. The carcasses were crudely homogenized in 0.2 ml of a pH 7.0 buffered grinding solution (Vrijenhoek, 1978). Homogenates were centrifuged for 1 min. at 2500 g and the supernatant fluid was subjected to electrophoresis.

The horizontal electrophoretic procedure was essential as described by Buroker et al. (1975). The gels, 12% by weight, were made of a 4:1 mixture of Sigma Starch (Sigma Chemical Co., St. Louis, MO) and Electrostarch (Electrostarch Co., Madison, WI). Buffer used in the gel and electrode was n-(3-aminopropyl)-morpholine citrate at pH 6.0 (Clayton and Tretiak, 1972). Histochemical stains were modified after those of Shaw and Prasad (1970).

The identification of species was based on 6-phosphogluconate dehydrogenase and glyceraldehyde-3-phosphate dehydrogenase. The alleles encoding both enzymes are diagnostic for *T. nigrovittatus* and *T. conterminus* (Jacobson et al., 1981). No heterozygous individuals have ever been observed at either locus.

RESULTS

All of the flies in five samples from Leeds Point were measured and examined electrophoretically. In total, 18 *T. conterminus* and 274 *T. nigrovittatus* were found. The mean body length of the *T. conterminus* was 12.78 ± 0.79 mm (range: 11.58–14.01 mm). The mean length of the *T. nigrovittatus* was 10.47 ± 0.71 mm (range: 8.44–12.44 mm). Flies of less than 10.6 mm were well outside the 99% confidence limits of the *T. conterminus* distribution. We used the 10.6 mm size criterion to examine the data of Jacobson et al. (1981: fig. 2), and found that it

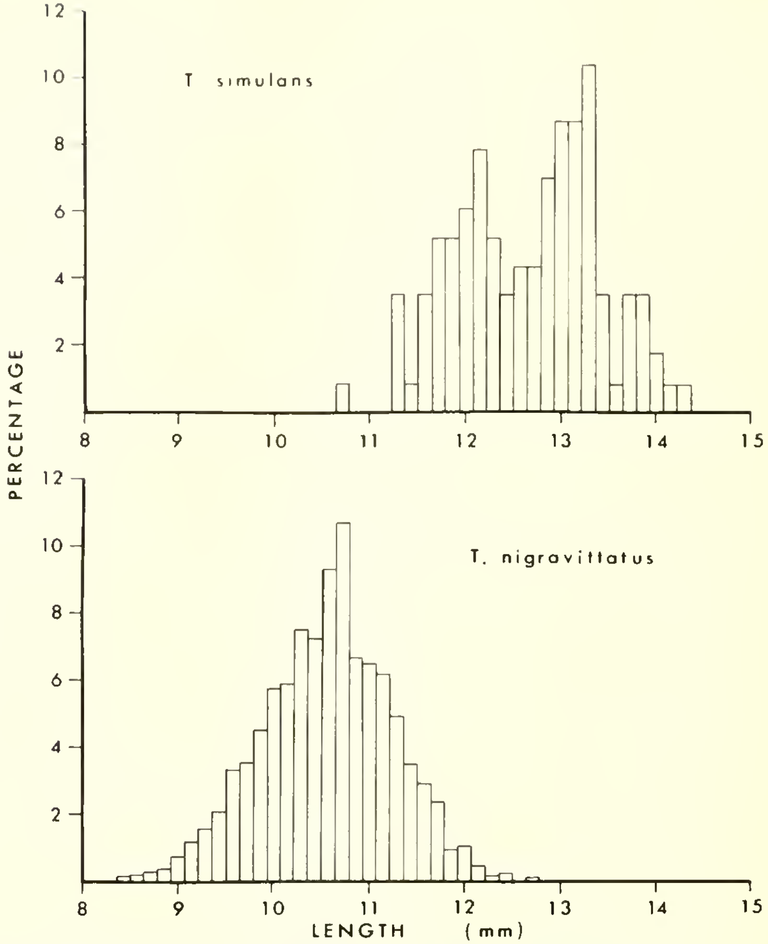

Fig. 1. Size distribution of *T. nigrovittatus* (n = 2185) and *T. conterminus* (n = 115).

resulted in no misidentifications of the 53 *T. conterminus* identified electrophoretically. Thus, for the remainder of the samples only flies over 10.6 mm were identified by electrophoresis since smaller flies were invariably *T. nigrovittatus*. This convenience reduced by about one-half the number of the flies subjected to electrophoresis, with considerable savings in time and expensive materials.

The mean body length of *T. nigrovittatus* collected at Stone Harbor was significantly shorter than *T. nigrovittatus* collected from Island Beach State Park, Cedarville, and Leeds Point (Table 1). The reason for this difference is unknown. There was, however, no significant difference in mean body length at the four sites for *T. conterminus* (Table 1). With all four populations combined, the mean length was 10.57 ± 0.68 mm for *T. nigrovittatus* and 12.67 ± 0.75 mm for *T. conterminus*. The combined size distributions for the two species is shown in Fig. 1. These measurements are not significantly different from those reported by Jacobson et al. (1981). They reported mean lengths of 10.5 and 12.8 mm for *T. nigrovittatus* and *T. conterminus* respectively.

Table 2. Total body length of *T. nigrovittatus* collected from four sites in New Jersey.

Date	N	Mean
20 June	181	10.792a*
27 June	204	10.712ab
2 July	46	10.725ab
9 July	202	10.569b
18 July	185	10.650b
25 July	267	10.571b
1 August	309	10.654b
6 August	237	10.618b
13 August	127	10.516b
20 August	193	10.307c
26 August	234	10.306c

* Means with the same letter in vertical columns do not differ significantly at $P = 0.05$, by Duncan's multiple range test.

The total body length of *T. nigrovittatus* decreased over the summer. The mean lengths of flies collected in the last two weeks of August were significantly shorter than the lengths of those collected earlier in the season (Table 2). This trend was not observed in *T. conterminus* perhaps because the sample size was quite small.

DISCUSSION

Based on box trap collections, *T. nigrovittatus* is the dominant species in the *nigrovittatus* species complex in New Jersey. It constituted greater than 95 percent of the total number of flies in collections from Cedarville and Island Beach State Park (Table 3). *T. conterminus* was relatively more abundant at Leeds Point and Stone Harbor although it never numerically dominated *T. nigrovittatus* at any locality. Leeds Point and Stone Harbor marshes are both extensively ditched for mosquito control, whereas Cedarville and Island Beach marshes are relatively undisturbed. However, the influence of marsh ditching on these two species of tabanids is unclear. Freeman and Hansens (1972) reported that the larvae of *T. conterminus* (referred to as *T. species 3*) were most often found in the higher ground near drainage ditches, but Rockel and Hansens (1970) found that this species was uniformly distributed on the salt marsh. In order to resolve this dilemma, large samples of larval tabanids must be collected from the salt marshes and at the same time information on soil conditions (pH, moisture, salinity, etc.) and vegetation must be obtained. It is likely that electrophoretic techniques can also be developed to corroborate the identification of the larval stages of these species. The relative seasonal abundance of the two species differs considerably (Table 3). Over all the sites, *T. conterminus* reached its peak of abundance in mid-July and declined rapidly in August. This peak is most evident at Stone Harbor and Leeds Point where *T. conterminus* constituted maxima of 30.2 and 41.4 percent of the adult flies, respectively, on July 18. Jacobson et al. (1981) reported that 30 percent of their sample was *T. conterminus*. The samples were all collected in July (Jacobson, personal communication).

The rapid decline in the proportion of *T. conterminus* after mid-July corresponds with the overall decline in the population density of tabanids on the New Jersey salt marshes (Hansens, 1952). It is apparent from the present data that *T.*

Table 3. Percentage of *T. conterminus* in box trap collections in 1980.[1]

	Collection Site			
Week Ending	Cedarville	Stone Harbor	Leeds Point	Island Beach State Park
June 20	3.7% (54)	0.0 (72)	0.0 (58)	—
June 27	5.0 (60)	12.5 (48)	13.5 (52)	0.0 (60)
July 4	2.1 (47)	—	—	—
July 11	2.0 (51)	13.0 (54)	15.8 (57)	0.0 (59)
July 18	1.7 (58)	30.2 (43)	41.4 (58)	0.0 (65)
July 25	0.0 (64)	22.3 (94)	13.9 (72)	1.4 (69)
August 1	0.0 (83)	2.8 (71)	1.3 (77)	0.0 (82)
August 8	0.0 (76)	3.4 (58)	5.7 (53)	0.0 (56)
August 15	0.0 (66)	0.0 (61)	—	—
August 22	0.0 (43)	0.0 (39)	0.0 (56)	0.0 (54)
August 29	0.0 (58)	0.0 (71)	2.0 (49)	0.0 (58)

[1] Sample size is indicated in parentheses.

nigrovittatus declines more slowly than *T. conterminus*. Perhaps *T. nigrovittatus* has greater longevity during this period. Alternatively, it may have a prolonged period of adult emergence compared to *T. conterminus*. Hansens (1952) suggested that *T. nigrovittatus* (*sensu lato*) might be partially bivoltine in New Jersey. The reduction in body size that we observed during the last two weeks in August supports this hypothesis. The tight clustering of emergence in *T. conterminus* indicates that it is univoltine.

Coastal tabanids have an important economic impact on both the recreational and agricultural industries in New Jersey (Hansens, 1980). The relative nuisance levels contributed by *T. nigrovittatus* and *T. conterminus* is not known at this time. Differences in the nuisance levels may be affected by the degree to which they penetrate inland, their persistence in hostseeking, the severity of biting, and the breadth of their host range. The absolute numbers of these tabanids coming to box traps, which we equate with population density, are greatest in mid-July (Hansens, 1952). *T. conterminus* makes its greatest numerical contribution in mid-July. Whether it adds to the number of tabanids and the severity of the problem during this month, or if it simply displaces a similar number of *T. nigrovittatus* is not known. Control programs designed to eliminate flying adults during this peak should affect *T. conterminus* more severely than *T. nigrovittatus* since oviposition in *T. conterminus* is restricted to this narrower time period.

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LITERATURE CITED

Burger, J. F., R. K. Sofield, and J. V. Freeman. 1985. Status of some names associated with the salt marsh greenhead fly, *Tabanus nigrovittatus* Macquart (Diptera: Tabanidae) in eastern coastal North America and lectotype designation for *Tabanus conterminus* Walker. Ann. Entomol. Soc. Am.

Buroker, N. E., W. K. Hershberger, and K. K. Chew. 1975. Genetic variation in the Pacific oyster, *Crassostrea gigas*. J. Fish. Res. Board Can. 32: 2471–2477.

Clayton, J. W. and D. N. Tretiak. 1972. Amine-citrate buffers for pH control in starch gel electrophoresis. J. Fish. Res. Board Can. 29: 1169–1172.

Freeman, J. V. 1962. Biology, ecology, and taxonomy of *Tabanus nigrovittatus* Macquart (Diptera, Tabanidae) of the salt marsh at Leeds Point, New Jersey. Ph.D. thesis, Rutgers University, New Brunswick, N.J. 209 pp.

Freeman, J. V. and E. J. Hansens. 1972. Collecting larvae of the salt marsh greenhead *Tabanus nigrovittatus* and related species in New Jersey: Comparison of methods. Environ. Entomol. 1: 653–658.

Hansens, E. J. 1952. Some observations on the abundance of salt marsh greenheads. Proc. N.J. Mosq. Exterm. Assoc. 39: 93–98.

———. 1980. Review: Tabanidae of the East Coast as an economic problem. J. N.Y. Entomol. Soc. 87(4): 312–318.

Hansens, E. J. and S. R. Race. 1979. The greenhead and you. N.J. Coop. Exten. Serv. Leaflet 574.

Jacobson, N. R., E. J. Hansens, R. C. Vrijenhoek, D. L. Swofford, and S. H. Berlocher. 1981. Electrophoretic detection of a sibling species of the salt marsh greenhead, *Tabanus nigrovittatus*. Ann. Entomol. Soc. Am. 74: 602–605.

Rockel, E. G. and E. J. Hansens. 1970. Distribution of larval horse flies and deer flies (Diptera: Tabanidae) of a New Jersey salt marsh. Ann. Entomol. Soc. Am. 63: 681–684.

Shaw, C. R. and R. Prasad. 1970. Starch gel electrophoresis: A compilation of recipes. Biochem. Genet. 4: 297–320.

Vrijenhoek, R. C. 1978. Genetic differentiation among larval nematodes infecting fish. J. Parasitol. 64: 790–798.

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87(3), 1985, pp. 578–582

A NEW SPECIES OF *HERSHKOVITZIA* (DIPTERA: NYCTERIBIIDAE) FROM BRAZIL, WITH A KEY TO THE DESCRIBED SPECIES OF THE GENUS

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Abstract.—A new species of nycteribiid bat fly *Hershkovitzia* ***cabala*** is described and illustrated. This genus is recorded from Brazil for the first time, and a key to the described species is presented.

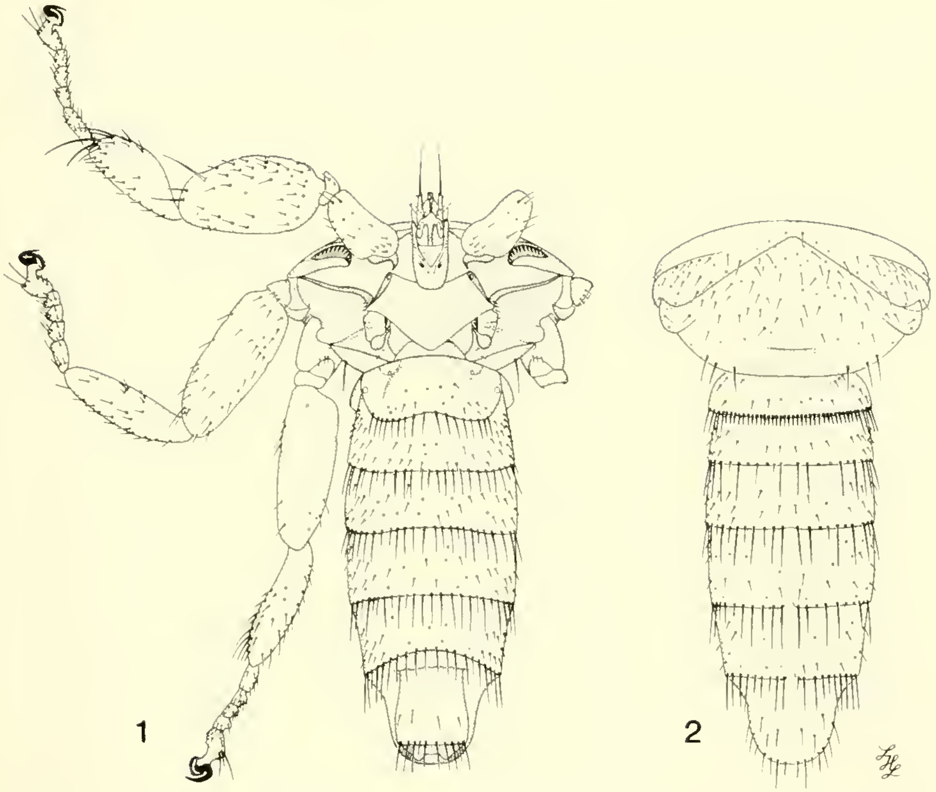
To date, the genus *Hershkovitzia* Guimarães and d'Andretta (1956) has been known from less than a dozen specimens representing three neotropical species. A fourth species is described herein, based on a single female specimen taken from a disk-winged bat, *Thyroptera tricolor* Spix (subspecies *albiventer* Tomes). The host bat was captured in a mist net placed along a trail leading to the cataracts of the Rio Tapajós, in the Parque Nacional da Amazônia, at Uruá, Brazil. The mist net was strung near a recently cleared area just inside secondary forest on the fringe of littoral primary forest. Specimens of this species of bat are infrequently captured by mist netting. The roosting habits of the bat do not favor the propagation of large ectoparasite populations. Evidence suggests that this bat is limited to roosting in small numbers in rolled new leaves of members of the banana family (Musaceae), and that this very specialized type of roost is both temporary and limited in its availability (Findley and Wilson, 1974). Therefore, the discovery of an ectoparasitic fly from such a bat is exciting and, in this instance, noteworthy because the fly represents a new species. We take the opportunity to describe the new species, and to report the first species of *Hershkovitzia* definitely known from Brazil.

Hershkovitzia cabala **Peterson and Lacey, New Species**

Figs. 1–2

Description.—Female (holotype): General body color entirely pale yellow with a faint brownish tinge. Length, 1.55 mm.

Head.—Anterodorsal margin of head capsule concavely U-shaped surrounding membranous ptilinal area, and bearing 4 short setae, 1 medial to and near hind margin of each eye, and 1 longer seta directly in front of each eye. Ventral margin of gena with 3 setae. Eye consisting of a single lens projecting from surface, with a dark base. Palpus rather uniformly narrow, only slightly broadened beyond midlength; bearing 2 long subterminal setae and 4 shorter setae along its length.



Figs. 1–2. *Hershkovitzia cabala*, n. sp. 1, Habitus, female holotype (dorsal view). 2, Thorax and abdomen (ventral view). Note.—The head, as shown, is partially tilted backward onto the thorax. The ventral margins of the legs have been rotated anterodorsally through an arc of 90° to show the anterior surface of each leg.

Prementum (theca) of proboscis pyriform, about twice as long as labella. Antenna with a dorsal median thumb-like projection; arista digitiform, apex slightly curved and somewhat wider than stem or base, rather uniformily micropubescent.

Thorax.—Wider than long; length to width = 2:3. Notopleural ridges (notopleural sutures) diverging posteriorly, with 3 notopleural setae but without lateral expansions; pleural plates rod-like, one each directed toward, and articulating with mid coxa and hind coxa. Postnotum reduced to a narrow V-shaped bar. Halter present, its groove not covered. Thoracic ctenidium with 10 spines. Angle between ventral oblique sutures about 90°. Median longitudinal suture absent. Ventral surface of thoracic sternites with about 50 stout setae of varying lengths; general discal setulae relatively sparse, concentrated near anterior margin of sternal plate; hind margin of sternal plate with a few long setae. Legs relatively short and stout, only moderately bristly. Foreleg with femur broad, slightly less than twice as long as wide; tibia cleaver-like in shape, 2.5 times as long as wide, its ventral margin strongly curved and bearing 4 rows of setae in distal half; basitarsus subequal in length to combined tarsomeres 2–4, and more than ½ as long as tibia.

Midleg with femur cylindrical, about 3 times as long as wide; tibia more slender, about 4 times as long as wide, and bearing 3 ventral rows of short setae in proximal half; basitarsus slightly less than ¼ as long as tibia. Hindleg with femur cylindrical, about 2.5 times as long as wide; tibia slender, slightly more than twice as long as wide, bearing 5 ventral rows of setae in distal ⅔; basitarsus about ⅕ as long as tibia.

Abdomen.—With 7 sclerotized tergites (including syntergite 1+2) and sternites. Syntergite 1+2 with 20 short discal setae on posterior half, and with a posterior marginal row of 18 moderately long setae. Tergites 3–6 with 10–30 short, scattered discal setae, and their hind margins each with a row of longer setae. Tergite 7 with 4 discal setae, its hind margin rounded and bearing a row of 10 longer setae. Terminal segment short, narrowing and rounded posteriorly, with 6 setae near hind margin. Dorsal genital plate subtriangular, weakly sclerotized, bearing 6 setulae. Anal sclerite absent. Postspiracular sclerite small and difficult to distinguish. Sternite 2 with a ctenidium consisting of 32 spines whose bases do not touch, and 5 long setae on each side of ctenidium; a submarginal row of short setae present, and with a few scattered setae near anterolateral corners of sternite. Hind margins of sternites 3–6 each with a row of about 10 long setae interspersed with a few short setae, remainder of sternal surfaces sparsely beset with short setae but which are more numerous laterally. Sternites 3–4 undivided but with a pale, less sclerotized median strip; sternites 5–6 each indistinctly divided medially to form 2 lateral plates. Sternite 7 entire, posterior margin rounded, bearing 14 long and shorter setae, discal surface with 6 short setae.

Male unknown.

Holotype.—Female (in alcohol), trail to cataracts, Rio Tapajós, Parque Nacional da Amazônia, Uruá, Brasil, June 17, 1979, L. A. Lacey. Host, *Thyroptera tricolor* Spix (subspecies *albiventer* Tomes). The holotype will be deposited in the collection of the Museu de Zoologia da Universidade de São Paulo, Brasil.

Etymology.—The name *cabala* is a noun in apposition. It is a medieval Latin term meaning "secret," referring to the unknown habits of this species.

Remarks.—This is the smallest known species of the genus and is readily distinguished from the other three described species by the characters given in the following key. *Hershkovitzia cabala* is most similar to *H. primitiva* Guimarães and d'Andretta. However, *H. cabala* is smaller, much less setose, and sternites 3–4 are not divided medially into 2 lateral plates, whereas these sternites are divided in *H. primitiva*. For descriptions and illustrations of the other species in the genus see Guimarães and d'Andretta (1956), and Theodor (1967).

Species of *Hershkovitzia* have been found only on bats of the genus *Thyroptera* Spix (Family Thyropteridae) and thus might be restricted to this family of bats. If they are host specific, as seems probable, then it is interesting that while *Thyroptera* contains only two species with five currently recognized subspecies, there are four known species of *Hershkovitzia*. This raises some interesting questions. Is it possible that each of the subspecies of the two recognized species of *Thyroptera* carries its own species of *Hershkovitzia*? If so, could these subspecies of *Thyroptera* actually be full species? Since both *Hershkovitzia primitiva* and *inaequalis* seemingly occur on the same subspecies, *Thyroptera discifera discifera* (L. & P.), the latter possibility would seem to be negated. However, it is possible that the hosts of these two bat flies were either not identified or recognized at the subspecies level, or that a still unrecognized subspecies might be present in the region of Colombia and Peru where these two bat flies occur. As with all the subspecies, the distributional limits of the two subspecies of *Thyroptera discifera*, i.e. *T. d. discifera* and *T. d. abdita* Wilson, are not fully known because of a paucity of both specimens and published records. Other possibilities are that the populations of *Hershkovitzia* historically have been isolated by the unusual roosting habits of the hosts, and/or have undergone a more visible degree of speciation than have the host species. Answers to these and other questions can be attempted only after much more data and many more specimens have been collected of both these interesting bat hosts and their complement of ectoparasitic flies.

KEY TO SPECIES OF *HERSHKOVITZIA*

Females

1. Eye absent. Notopleural ridge with 2 setae. Angle between oblique sutures of sternum about 98°. Labella of proboscis about ⅓ length of prementum (theca). Dorsal genital plate broadly rounded, bearing about 10 setulae . . . . *coeca* Theodor
Host: unknown species of bat. Distribution: unknown (probably from Central or South America).

– Eye present. Notopleural ridge with 3 or 4 setae. Angle between oblique sutures of sternum about 90°, 92°, or 105°. Labella of proboscis about ½ or more as long as prementum. Dorsal genital plate more triangular, with 6 or fewer setulae 2

2. Abdominal ctenidium consisting of 32 spines. Syntergite 1+2 with fewer (20) short discal setae scattered on posterior half. Sternites 3–4 not divided into lateral plates. Small species, 1.55 mm long . . . . *cabala* n. sp.
Host: *Thyroptera tricolor* Spix. Distribution: Brazil.

– Abdominal ctenidium consisting of about 47–58 spines. Syntergite 1+2 with more numerous (30 or more) discal setae that are not confined to posterior half. At least sternites 4–6 divided into lateral plates. Larger species, 2.5–3.23 mm long 3

3. Anterodorsal margin of head capsule with a V-shaped emargination at middle. Labella of proboscis about ½ as long as prementum. Angle between oblique sutures of sternum about 92°. Sternite 7 with lateral and posterior margins continuous and broadly rounded. 2.5 mm long . . . . *primitiva* Guimarães and d'Andretta
Host: *Thyroptera discifera* (Lichtenstein and Peters). Distribution: Colombia.

– Anterodorsal margin of head capsule entire, without a median emargination. Labella of proboscis subequal in length to prementum. Angle between oblique sutures of sternum 105°. Sternite 7 somewhat triangular, lateral margins slightly concave and diverging posterolaterally so that hind margin is wide and shallowly concave in middle. 3.0–3.25 mm long . . . . *inaequalis* Theodor
Host: *Thyroptera discifera*. Distribution: Peru.

Males

Males of *coeca* and *cabala* are unknown.

1. Abdominal ctenidium consisting of 47–48 stout spines, and extending full width of segment. Angle between oblique sutures of thoracic sternum about 92°. Surstyli nearly straight, angled so that tips are convergent. Aedeagus cylindrical, of nearly uniform width, apex broad and membranous .... *primitiva*

– Abdominal ctenidium consisting of 53 narrow spines, not extending full width of segment, lateral quarters of segment with only normal setae. Angle between oblique sutures of thoracic sternum about 105°. Surstyli slightly bowed inwardly so that tips are divergent. Apex of aedeagus with a narrow, beak-like ventral process .... *inaequalis*

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We are grateful to Linda H. Lawrence, staff artist, Systematic Entomology Laboratory, for her careful rendition of the accompanying illustrations. We thank D. E. Wilson, Chief, U.S. Fish and Wildlife Service, Department of Interior, % National Museum of Natural History, Washington, D.C., for identifying the host bat, and R. L. Wenzel, Field Museum of Natural History, Chicago, Illinois, for reading the manuscript.

LITERATURE CITED

Findley, J. S. and D. E. Wilson. 1974. Observations on the neotropical disk-winged bat, *Thyroptera tricolor* Spix. J. Mammal. 55: 562–571.

Guimarães, L. R. and M. A. V. d'Andretta. 1956. Sinopse dos Nycteribiidae (Diptera) do Novo Mundo. Arq. Zool. Est. S. Paulo 10: 1–184.

Theodor, O. 1967. An illustrated catalogue of the Rothschild collection of Nycteribiidae (Diptera) in the British Museum (Natural History) with keys and short descriptions for the identification of subfamilies, genera, species and subspecies. Brit. Mus. (Nat. Hist.) Publ. 655: 1–506, 5 pls.

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GYNANDROMORPHISM IN THE ANT *PHEIDOLE DENTATA* MAYR (HYMENOPTERA: FORMICIDAE)

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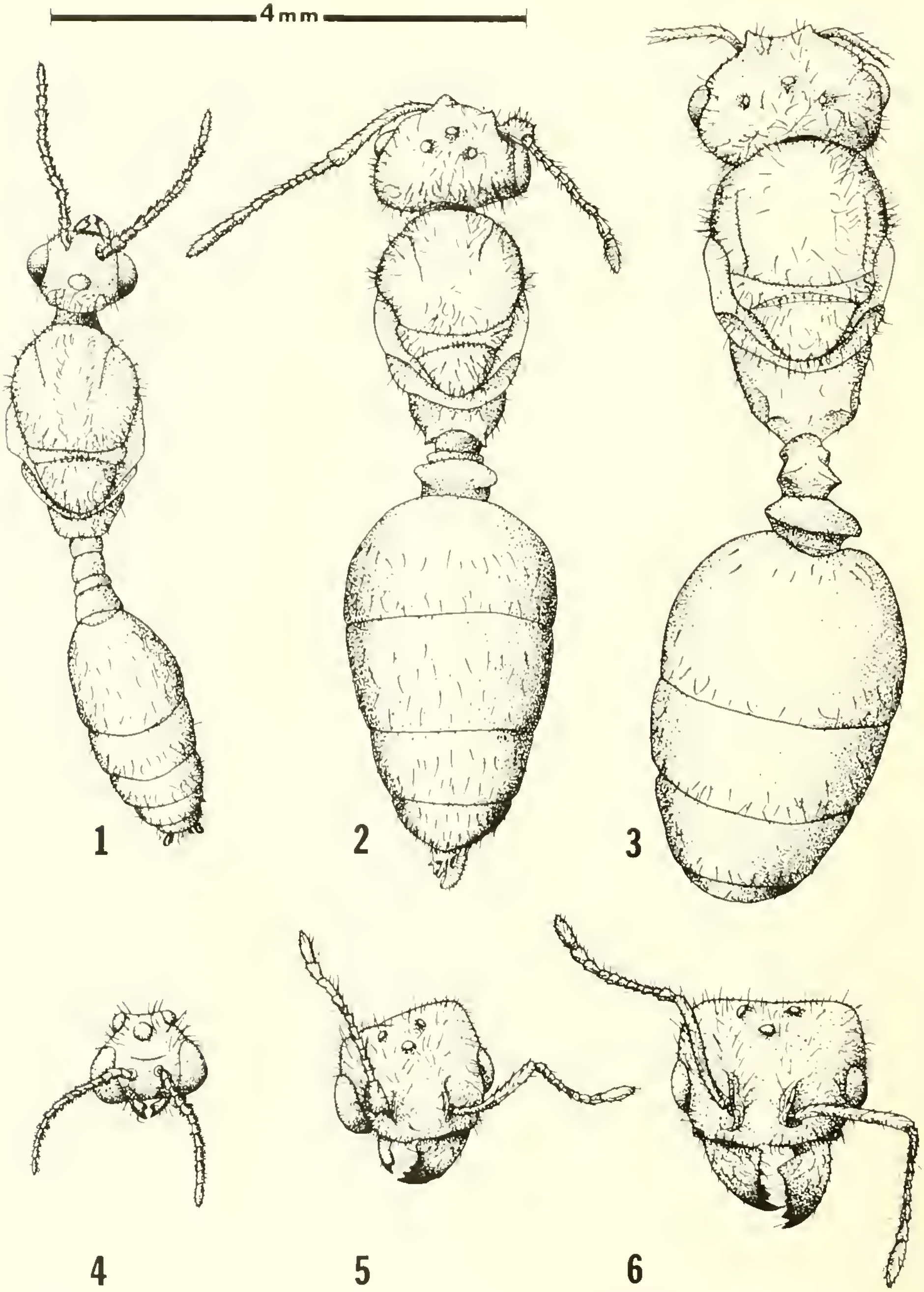
Abstract.—A gynandromorph of the ant *Pheidole dentata* Mayr is described. It was found in a colony collected on the Texas Tech University campus, Lubbock. While the most notable differences occur in the head, the specimen is intermediate in size, with the right half of all body regions exhibiting discrete male characteristics. The external genitalia are predominantly male, whereas the internal reproductive system is female.

Gynandromorphism is a condition in which both male and female characters are discretely present in one individual (Donisthorpe, 1929; Hall and Smith, 1953). In ants, the various combinations of male and female forms include queen-male (gynandromorph), worker-male (ergatandromorph), and soldier-male (dinergatandromorph) (Donisthorpe, 1929). Berndt and Kremer (1983) have proposed several new categories of gynandromorphism in ants based not only upon the dominant sex, but the dominant caste as well. These new categories include gynergatandromorph (queen-worker), ergatogynandromorph (worker-queen), and androergatogynomorph (male-worker).

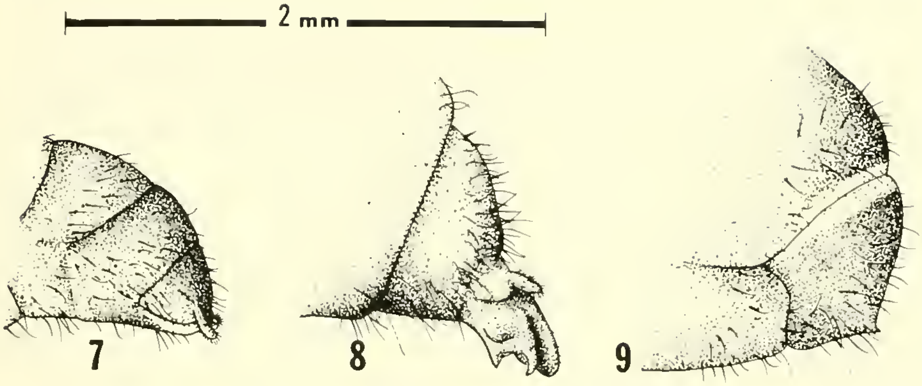
Insect gynandromorphism has been studied both genetically and cytologically. From such studies, various mechanisms have been derived to explain the phenomenon of gynandromorphism, most of which include fertilization anomalies and cytogenetic abnormalities during embryogenesis (Morgan and Bridges, 1919; Rothenbuhler et al., 1952; Brust, 1966). Although Wheeler (1903) suggested causes for gynandromorphism in ants, the definitive causes remain unknown (Berndt and Kremer, 1982).

Gynandromorphism has been reported from 41 species in 22 genera of ants (Donisthorpe, 1929; Wheeler, 1931, 1937; Buschinger and Stoewesand, 1971; Hung et al., 1975; Cokendolpher and Francke, 1983; Berndt and Kremer, 1983). However, Vandel (1931) has provided the only record of a gynandromorph from the genus *Pheidole*. A dinergatandromorphic specimen of *Pheidole pallidula* Nylander was discovered in which the right side of the head contained soldier characteristics, and the left side of the head contained male characters. Therefore, the specimen described herein represents not only the first gynandromorph of *Pheidole dentata* Mayr, but the first description of a gynandromorph *sensu stricto* from this genus.

The specimen was discovered in a colony collected from the campus of Texas Tech University, Lubbock, on July 1, 1984. It is preserved along with normal



Figs. 1–6. *Pheidole dentata* Mayr. 1, Dorsal view of male. 2, Dorsal view of gynandromorph, wings omitted. 3, Dorsal view of queen. 4, Frontal view of normal male head. 5, Frontal view of gynandromorph head. 6, Frontal view of normal queen head.



Figs. 7–9. *Pheidole dentata* Mayr. 7, Lateral view of terminalia of male. 8, Lateral view of terminalia of gynandromorph, genitalia everted. 9, Lateral view of terminalia of queen.

male and female siblings (cat. no. 6480) in the Entomological Collection, The Museum, Texas Tech University.

The gynandromorph is intermediate in size between a normal queen and a normal male (Figs. 1–3). Male characteristics are generally confined to the right half of the gynandromorph. The thorax appears twisted to the male side, with both right wings noticeably shorter than those on the left. No differences in wing venation were observed between male, female, and gynandromorph. The petiole and propodeum are decidedly female, with the gaster appearing predominantly queen-like, but intermediate in size between a male and queen. The gynandromorph contains four gastric segments as does a normal queen, whereas a normal male contains five segments. The most noticeable differences are found on the head (Figs. 4–6). Again, the right half of the gynandromorph head has male characteristics, giving the head an asymmetrical appearance. The right mandible is shaped like that of a normal male, though larger. The left mandible is like that of a queen, but somewhat smaller. The right compound eye of the gynandromorph resembles that of a male, and the left resembles that of a queen. The ocelli are distinctly queen-like. The right antennal scape of the gynandromorph is malformed, being similar in length to a normal male, but considerably wider. Despite the male-like scape, both antennae contain twelve segments, as do the antennae of a normal queen. A normal male contains thirteen antennal segments. The right frontal carina is less pronounced than that of the left. The gynandromorph has everted genitalia resembling those of a normal male, though malformed (Figs. 7–9). A normal female reproductive system was observed after dissection of the abdomen. No developing oocytes were observed. The gynandromorph is pale yellow in color, similar to a male. The posterior portion of the abdomen is somewhat darker in color, resembling that of a queen.

Acknowledgments

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LITERATURE CITED

Berndt, J. P. and G. Kremer. 1982. Heat shock-induced gynandromorphism in the pharoah's ant *Monomorium pharaonis* (L.). Experientia 38: 798–799.

———. 1983. New categories in the gynandromorphism of ants. Ins. Soc. 30: 461–465.

Brust, R. J. 1966. Gynandromorphs and intersexes in mosquitoes (Diptera: Culicidae). Can. J. Zool. 44: 911–921.

Buschinger, A. and H. Stoewesand. 1971. Teratologische untersuchungen an ameisen (Hymenoptera: Formicidae). Beitr. Entomol. 21: 211–241.

Cokendolpher, J. C. and O. F. Francke. 1983. Gynandromorphic desert fire ant, *Solenopsis aurea* Wheeler (Hymenoptera: Formicidae). J. N.Y. Entomol. Soc. 91: 242–245.

Donisthorpe, H. 1929. Gynandromorphism in ants. Zool. Anz. 52: 92–96.

Hall, D. W. and I. C. Smith. 1953. Atypical forms of the wingless worker and the winged female in *Monomorium pharaonis* (L.) (Hymenoptera: Formicidae). Evolution 7: 127–135.

Hung, A. C. F., W. N. Norton, and S. B. Vinson. 1975. Gynandromorphism in the red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae). Entomol. News 86: 45–46.

Morgan, T. H. and C. B. Bridges. 1919. Contributions to the genetics of *Drosophila melanogaster*. I. The origin of gynandromorphs. Carnegie Inst. Wash. Publ. No. 278, pp. 3–122.

Rothenbuhler, W. C., J. W. Gowen, and O. W. Park. 1952. Androgenesis with zygogenesis in gynandromorphic honeybees (*Apis mellifera* L.). Science 115: 637–638.

Vandel, A. 1931. Etude d'un gynandromorphe (dinergatandromorphe) de *Pheidole pallidula* Nyl. Bull. Biol. France Belg. 65: 114–129.

Wheeler, W. M. 1903. Some new gynandromorphous ants with a review of the previously recorded cases. Bull. Am. Mus. Nat. Hist. 19: 653–683.

———. 1931. Concerning some ant gynandromorphs. Psyche 38: 80–85.

———. 1937. Mosaics and other anomalies among ants. Harvard Univ. Press. Cambridge, Mass. 95 pp.

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A REVIEW OF THE GENUS *NEOBAPHION* BLAISDELL WITH DESCRIPTION OF A NEW SPECIES FROM NEVADA (COLEOPTERA: TENEBRIONIDAE: ELEODINI)

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Abstract.—A new species of *Neobaphion* is described and illustrated. A key is given to the three known members of the genus. The systematic position of the genus within the tribe Eleodini is discussed. Distributional data on each species are presented.

Blaisdell (1925: 390) proposed the genus *Neobaphion* to receive *Eleodes planipennis* LeConte, which became the type by monotypy. Suggesting placement "between *Eleodes* Esch. and *Embaphion* Say," Blaisdell characterized the genus by: "the [female] genital characters are embaphionoid and the body form that of an *Eleodes*." In the same paper, Blaisdell (loc. cit.) mentioned that "at least 3 new species have been studied, unfortunately as uniques, but all referable to the genus as given above [*Neobaphion*]," although these were not characterized (see below). The description of *Neobaphion* is only 8 lines long but is sufficient to validate the name.

Eleodine ovipositors are among the most specialized in the Tenebrionidae. Among some of the specialized characters mentioned by Tschinkel and Doyen (1980) are shortened ovipositor with dorsolateral gonostyles, paraprocts partly enclosing coxites, oblique orientation of baculi-1 (baculi of paraprocts); all characters are shared with the Opatrini. Furthermore, eleodines often have a complete fusion of coxites and an oblique orientation of baculi-2 (baculi of coxites); this combination of characters is apparently unique in tenebrionids.

To determine what is meant by Blaisdell's "embaphionoid" female genitalia, one must consult his 1909 revision of Eleodiini (p. 451) in which he describes "the genital segment [ventral view of coxites] triangular, or without the apices triangulo-trapezoidal, somewhat depressed; dorsal surface quite plane, not setose. Apices of the valves [coxites] produced, chitinous, more or less everted, convex above and concave beneath. Valves contiguous beneath; inferior pudendal membrane not visible. Genital fissure narrow and subapical. Superior pudendal membrane reaching to about the middle of the dorsal plates. Appendages [gonostyles] short mammiliform, with a pencil of rather long hairs at their tips." Blaisdell (1909) figures the female genitalia of five species of *Embaphion* (pl. 5, figs. 7, 8, 9, 14, & 20). On the same plate (fig. 6) he illustrates the genitalic structures of *Neobaphion planipenne* (placed in *Eleodes* in the 1909 revision).

We find no quarrel with characterizing *Neobaphion* as eleodine beetles with embaphionoid female genitalia and the body form of an *Eleodes*. Blaisdell had enough information in 1933 (p. 210) to have mentioned also that all species of *Embaphion* have the lateral margins of the elytra sharply acute and at least slightly reflexed, but neglected to do so. All three of the *Neobaphion* species discussed herein have the lateral margins of the elytra rounded. Both males and females of *Embaphion* are easy to place to genus but males of *Neobaphion* could understandably pass for *Eleodes*. Blaisdell cautions repeatedly that his classification of Eleodini, particularly the subgeneric arrangement, is based primarily on the female genitalia.

All species of *Embaphion* have the pronotal margins moderately (*E. depressum* LeConte) to strongly (*E. muricatum* Say) sharply margined and reflexed. This character will not separate all *Eleodes* from *Embaphion* since several species of *Eleodes* have either the pronotum, the elytra, or both sharply margined and reflexed (i.e. *E. opacus* (Say), *E. veterator* Horn, *E. acutus* (Say), *E. suturalis* (Say), et al.). Sharply margined elytra thus occur in at least 3 subgenera of *Eleodes*.

Both La Rivers (1948: 98) and Tanner (1961: 58) attempted keys to the genera of Eleodini based on external characters. Both keys are a decided improvement over that of Blaisdell (1909: 29). The Tanner key was slightly modified by Arnett (1960: 654). Since these keys are readily available they will not be repeated here. None will work perfectly, but they are the best available.

La Rivers (1948: 98) considered *Neobaphion* a subgenus of *Eleodes*. At present we prefer to retain them as separate genera, acknowledging that they are very closely related, until the problems of *Eleodes* subgenera are better understood. These problems will not be resolved until the Mexican eleodine fauna is thoroughly studied, a project now underway by the senior author. Any speculation on generic or subgeneric relationships at this time would be premature.

In a recent shipment of miscellaneous Tenebrionidae sent to us by Fred G. Andrews (Laboratory Services, California Dept. of Food and Agriculture, Sacramento) for identification, the following interesting new species was found.

Neobaphion papula **Triplehorn and Aalbu, NEW SPECIES**

Fig. 1

Holotype, female: Length: 15.8 mm; width: 6.4 mm. Body elongate, slender, subopaque, black.

Head subquadrate, $\frac{6}{7}$ as long as broad, flattened; clypeal suture entire, epistomal margin truncate; surface dull, with numerous fine, rounded tubercles, each bearing a short pale seta at apex; eyes moderately small, narrow, slightly reniform, dorsal lobe larger, more rounded than ventral lobe; antenna relatively short, stout, apical 6 segments moniliform; ratio of lengths of antennal segments (from base to apex): 17:7:23:13:11:10:10:10:10:11:12.

Pronotum $\frac{5}{6}$ as long as broad, broadest anterior to midlength, with 2 slight depressions medio-laterally behind midlength; in dorsal view, lateral margins strongly arcuate, marginal bead narrow, finely denticulate from base to apex; anterior margin broadly, shallowly concave, very slightly sinuate medially, angles slightly acute, prominent; base nearly straight, angles obtuse; disc strongly convex from side to side, surface with tubercles similar to those of head but larger, moderately dense to dense, with a short seta originating on caudal side of each tubercle.

Scutellum triangular, rounded caudally, finely sculptured.

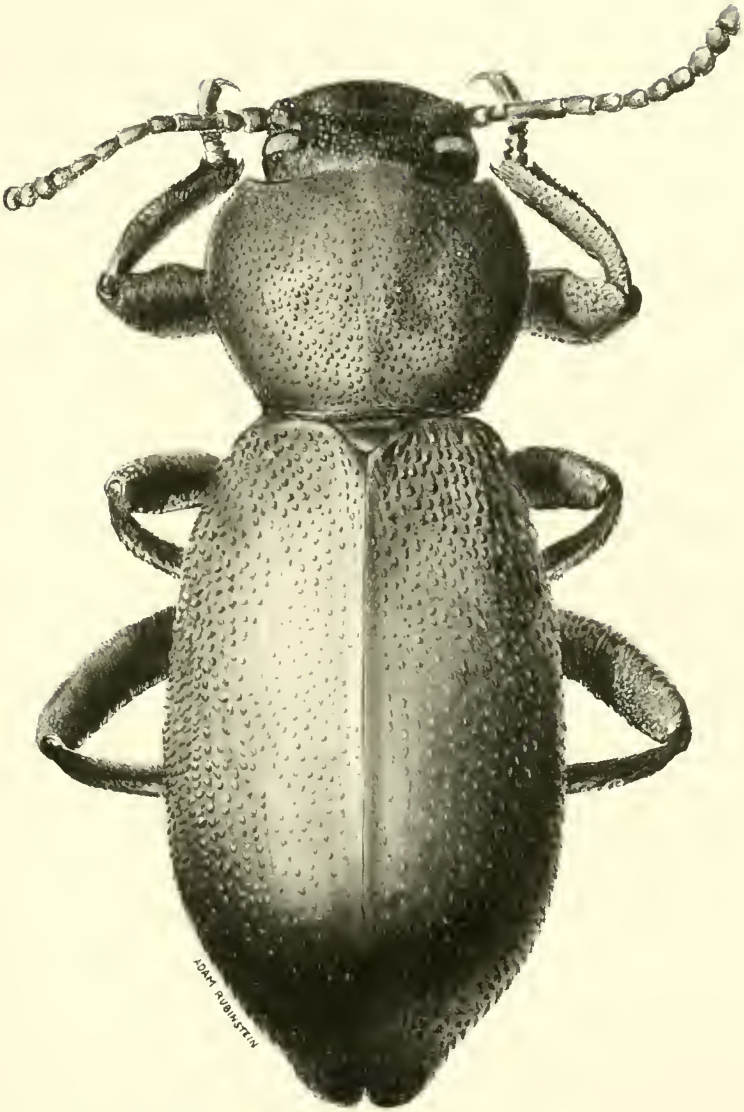

Fig. 1. *Neobaphion papula* Triplehorn & Aalbu. Habitus, female.

Elytra flattened on disc, at suture turned sharply upward, forming a distinct keel extending from apical declivity toward base, diverging anteriorly to enclose scutellum; sides subparallel, widest behind midlength, abruptly deflexed posteriorly with caudal lobe not pronounced; base slightly concave with humeri obsolete (epipleural base not visible dorsally); surface with dense, conspicuous muricate punctures, each with a short pale seta directed caudally, muricate punctures larger, closer and more confusedly distributed laterally, longitudinal serial arrangement somewhat evident discally.

Legs moderate in size, finely, densely, muricately punctate; profemur slightly emarginate subapically; protibial spurs about equal; basal protarsomere with dense tuft of golden setae interrupting plantar groove. Ventral surface alutaceous with coarse, dense tubercles on ventral side of prothorax, less coarse on meso- and metasternum, finer, less dense on basal 3 abdominal sterna, smaller, scarcely evident on apical and subapical sterna; prosternal process acute, slightly declivous then mucronate behind coxae, prominent. Genital segment with coxites fused, coxites 1 & 2 triangular in outline ventrally, concave, dorsally convex, coxite segments 3 & 4 forming a strongly sclerotized spathulate process, divergent and acute apically; gonostyle minute with single long apical seta.

Allotype, male: Similar to female but slightly smaller and more slender. Emargination of profemur more pronounced. Length: 14.9; width 5.2 mm.

Variation.—"Keel" formed along elytral suture varies slightly in magnitude and is not always so strong at base. It frequently does not diverge to enclose scutellum. Otherwise, type series quite uniform. Fifty specimens examined: Length: 11.9–17.2 mm; width: 4.2–6.4 mm.

Diagnosis.—This moderately small species can easily be separated by the presence of the medial keel on the elytra, the densely, finely tuberculate head and pronotum and the finely denticulate marginal bead of the pronotum.

Types.—*Holotype (♀) and 4 paratypes:* NEVADA, Mineral County, Teels Marsh sand dunes, 7-VI to 31-VIII-1980, antifreeze pit trap on sand dune, D. Giuliani col.; allotype (male) and 36 paratypes same data except 22-IX-1979 to 30-I-1980; 5 paratypes: same data except 17-II to 16-VII-1979; 1 paratype: same data except 20-V-1973 [not in pit trap]; 2 paratypes: NEVADA, Esmeralda County, Clayton Valley Dunes, 17-IX-1974, F. G. Andrews and A. R. Hardy cols. Holotype and allotype deposited in California Academy of Sciences Collection, San Francisco (CASC); paratypes in California Department of Food and Agriculture, Sacramento (CDAE); Nevada Department of Agriculture, Reno (NSDA); The Ohio State University Collection of Insects and Spiders, Columbus (OSUC); and Rolf L. Aalbu Collection (RLAC).

Etymology.—The name *papula* means pimple and is treated here as a noun in apposition.

DISCUSSION

In 1933 (p. 208), Blaisdell described *N. elongatum* from the male holotype (Yerrington [sic], Nevada, July–August, 1908, California Academy of Sciences type No. 3718). He also listed another male paratype from "Constantia, Nevada" collected by Geo. Haley, which we assumed was also in the California Academy collection. *N. elongatum* is perhaps at least one of the "new species" [of *Neobaphion*] mentioned in Blaisdell's 1925 paper (p. 390).

Through the courtesy of David H. Kavanaugh and Gary L. Peters, we were able to study the holotype of *N. elongatum* plus two additional specimens determined by Blaisdell as that species and not heretofore mentioned in the literature. The two are labelled "Plms Jn. Cal.," 20 June, 1905 and are originally from the A. Fenyes Collection. The "Constantia, Nevada" specimen could not be located by Kavanaugh and Peters.

More recently, one of us (C.A.T.) discovered a "Constantia, Nevada" specimen of *N. elongatum* and another labelled "Plms Jn. Cal.," in the Ira La Rivers Collection, now housed at the Nevada Department of Agriculture in Reno. The

Constantia specimen is almost certainly the one Blaisdell designated a paratype although it is not labelled as such.

Dr. Robert C. Bechtel (Nevada Department of Agriculture in Reno) not only allowed us to borrow the two above-mentioned specimens but provided valuable information on the two localities we were unable to locate. The abbreviation "Plms Jn." undoubtedly stands for Plumas Junction and Constantia is in California rather than in Nevada. Both localities are in the narrow corridor of Lassen County, California between Plumas County, California and the California-Nevada state line, separated by a distance of about 13 kilometers. Plumas Junction is about 8.5 km N.N.W. of Halleluja Junction and was located on an old California map found by Bechtel.

Finally, one more specimen of the rare or elusive *N. elongatum* was found by one of us (R.L.A.) in a previous shipment of cryptoglossines (also from California Department of Food and Agriculture), mixed with specimens of *Centrioptera muricata* LeConte which is superfically similar in dorsal view. This specimen, a female, was collected under a rock in Lander County, Nevada, New Pass Summit (6348′), 1-V-1978, by Alan R. Hardy and Fred G. Andrews.

Thus *N.elongatum* is known from only six specimens (two males, four females), all of which we have on hand as this is written. These vary only slightly in size (males: 17–19.9 mm long, 5.7–6.5 mm wide; females: 18.1–19.9 mm long, 6.5–7.4 mm wide), sculpture and luster. The females (which were unknown to Blaisdell) do not have the metatibia expanded in the apical half as in the male. The lateral pronotal margins of the holotype are slightly more explanate than in the other specimens.

Neobaphion planipenne LeConte, the type of the genus, is widespread and locally abundant in New Mexico, Arizona, southwestern Colorado and southern Utah.

The three species of *Neobaphion* may be separated by the following key.

KEY TO ADULTS OF *NEOBAPHION*

1. Head and pronotum densely, finely tuberculate; lateral marginal bead of pronotum finely denticulate; elytra raised along suture to form a distinct keel extending from scutellum to apical declivity ...... *papula* new species

– Head and pronotum with simple punctures, at least on disc (lateral areas may have a few scattered tubercles); lateral marginal bead of pronotum smooth; elytra flattened on disc 2

2. Prosternal process deflexed behind procoxae, not prominent; base of pronotum much narrower than base of elytra; pronotum in dorsal view with lateral margins narrowly but distinctly constricted near base; metatibia similar in the sexes .... *planipenne* (LeConte)

– Prosternal process mucronate, acute and prominent behind procoxae; base of pronotum only slightly narrower than the base of elytra; pronotum in dorsal view with lateral margins scarcely or not constricted basally; metatibia of male slender in basal half, abruptly expanded and parallel-sided apically, that of female unmodified .... *elongatum* Blaisdell

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LITERATURE CITED

Arnett, R. H., Jr. 1960. The beetles of the United States. Catholic University Press, Washington, D.C. 1112 pp.

Blaisdell, F. E. 1909. A monographic revision of the Coleoptera belonging to the tenebrionide tribe Eleodiini inhabiting the United States, Lower California, and adjacent islands. U.S. Nat. Mus. Bull. 63: 1–524, 13 pls.

———. 1925. Studies in the Tenebrionidae, No. 2 (Coleoptera). Proc. Calif. Acad. Sci. (4th ser.) 14(16): 369–390.

———. 1933. Studies in the Tenebrionidae, No. 3 (Coleoptera). Trans. Am. Entomol. Soc. 59: 191–210.

La Rivers, I. 1948. Notes on the Eleodini (Coleoptera: Tenebrionidae). Entomol. News 59: 96–101.

Tanner, V. M. 1961. A checklist of the species of *Eleodes* and descriptions of new species (Coleoptera: Tenebrionidae). Great Basin Nat. 21(3): 55–78.

Tschinkel, W. R. and J. T. Doyen. 1980. Comparative anatomy of the defensive glands, ovipositors and female genital tubes of tenebrionid beetles (Coleoptera). Int. J. Insect Morphol. Embryol. 9: 321–368.

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THE NYMPH OF *HANSONOPERLA APPALACHIA* NELSON (PLECOPTERA: PERLIDAE)

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Abstract.—The mature nymph of *Hansonoperla appalachia* Nelson is described and illustrated for the first time from specimens collected in West Virginia. Nymphs of this genus are morphologically similar to those of the nearctic genus *Perlinella* Banks and characters for separation are given.

During a 1975 collecting trip to Nicholas and Greenbrier counties, West Virginia, an unknown *Perlinella*-like nymph was collected from the North Fork of Cherry River. In 1979 Nelson described the adults of *Hansonoperla appalachia*, as a new nearctic genus and species of Perlidae. His material included two males and two females collected from Tennessee and Maine. At that time we suspected that our *Perlinella*-like nymph from West Virginia could be the undescribed nymph of this new taxon. Efforts were made in March 1983 and February 1984 to secure additional material. Five nymphs were collected from Panther Creek, Nicholas County, and two adult males were successfully reared, confirming our tentative identification. An additional nine nymphs were collected in April 1984 from North Fork of Cherry River, Greenbrier County, West Virginia by Stewart, Kondratieff, and Kirchner and were transported to North Texas State University for rearing and recording of adult drumming signals.

Hansonoperla appalachia apparently prefers cool montane streams at the higher elevations of the Appalachian Mountains. Nearly all nymphs were collected from undercut banks of riffle areas where roots of riparian vegetation trapped coarse detritus material and caused deposits of sand to accumulate. The early emergence (mid-April to mid-May), atypical for many eastern perlids, may account for the rarity of adults in collections. This species is currently being considered by the U.S. Fish and Wildlife Service, Department of Interior, for addition to the list of "Endangered and Threatened Wildlife and Plants" of the United States (Federal Register, 1984). Other Plecoptera collected with *H. appalachia* were *Tallaperla maria* (Needham and Smith), *Acroneuria abnormis* (Newman), *A. carolinensis* (Banks), *Sweltsa lateralis* (Banks), *S. onkos* (Ricker), *Isoperla similis* (Hagen),

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[1] The views of the author do not purport to reflect the position of the Department of the Army or the Department of Defense.

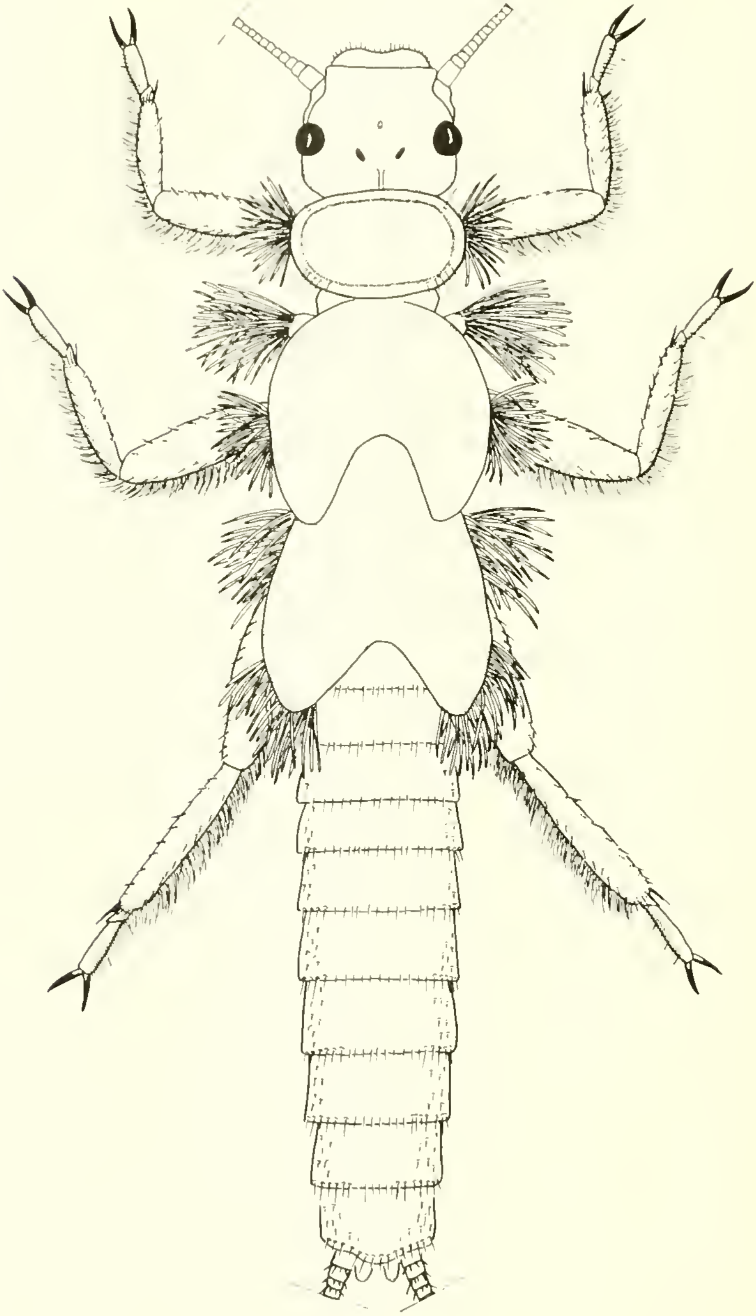

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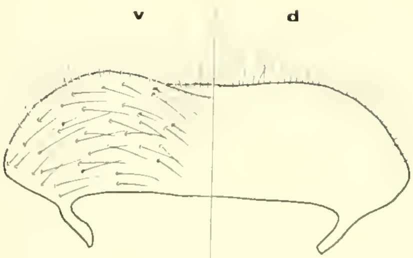
Fig. 1. *Hansonoperla appalachia.* General habitus of mature nymph.



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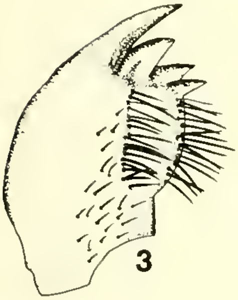

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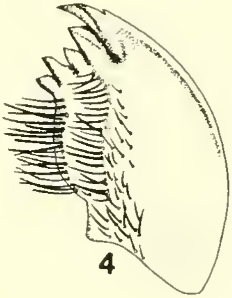

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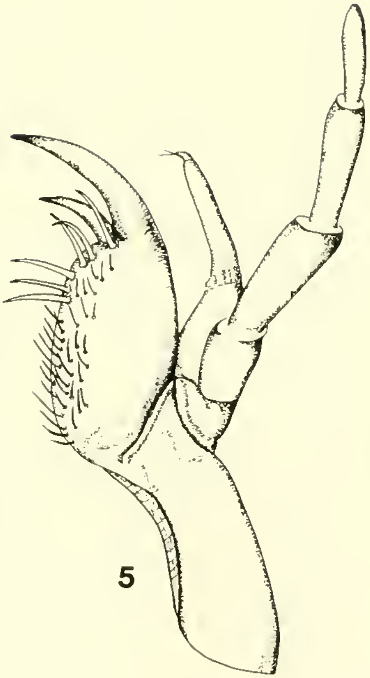

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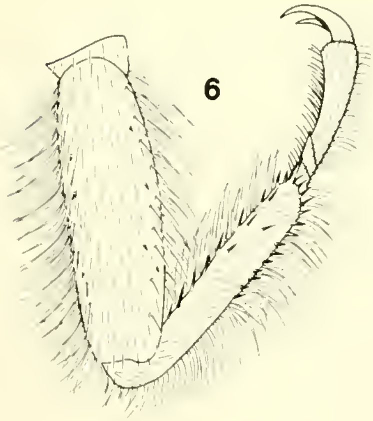

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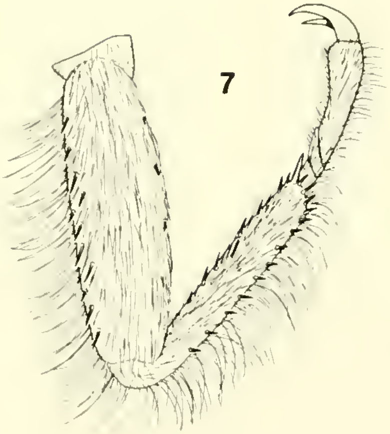

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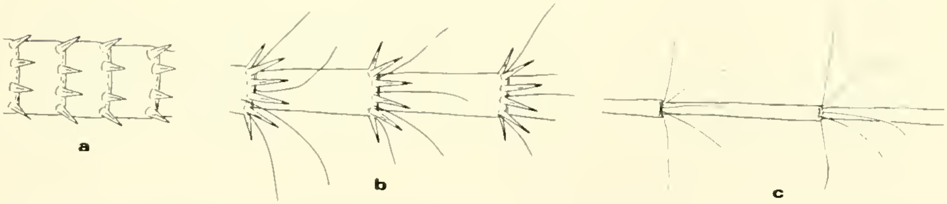

Figs. 2–5. *Hansonoperla appalachia.* 2, Labrum, ventral and dorsal view. 3, Right mandible (ventral). 4, Left mandible (ventral). 5, Left maxillary palpus (ventral). Fig. 6. *Perlinella drymo,* right foreleg. Figs. 7–8. *Hansonoperla appalachia.* 7, Right foreleg. 8, Cerci segments, a. basal, b. medial, c. distal.

Diploperla duplicata (Banks), *D. robusta* Stark and Gaufin, *Isogenoides hansoni* (Ricker), *Malirekus hastatus* (Banks) and *Allonarcys proteus* (Newman).

***Hansonoperla appalachia* Nelson, 1979**

Description of Nymph.—Body length 14–20 mm; antennae up to 10 mm; cerci up to 11 mm. Body clothed with appressed brown hairs; color golden brown, without distinct pattern (Fig. 1).

Head almost as long as wide; three ocelli forming an equilateral triangle; eyes set forward on head nearly in line with anterior ocellus. Labrum four times as wide as long; ventral surface with long setae (Fig. 2). Right mandible with four teeth (Fig. 3); left mandible with five teeth (Fig. 4). Lacinia with two large apical teeth, second tooth smaller; six stout setae on inner margin, followed by more slender setae to base of lacinia (Fig. 5).

Pronotum with dark narrow marginal groove; sides and angles broadly rounded. Mesonotum and metanotum irregularly marked with appressed brown hairs. Legs with dorsal fringe of long silky hairs; femora and tibia heavily clothed with appressed setae, dorsal and ventral margins with scattered stout spines (Fig. 7). Gills branched with long filaments. Gill formula (follows usage of Shepard and Stewart, 1983): ASC_1 (anterior supracoxal), PSC_1 (posterior supracoxal), AT_2 (anterior thoracic), PSC_2, AT_3, PSC_3, PT_3 (posterior thoracic), A_1 (abdominal).

Abdomen with tergal intercalary spines confined to lateral margins; posterior margins with mesal section of slender setae. Cerci slender, nodes with whorls of spines and/or long setae (Fig. 8). Subanal lobe (SL) without gills.

Diagnosis.—The general habitus and morphology of *Hansonoperla* nymphs are most similar to those of the genus *Perlinella* Banks. However, they are easily distinguished from this genus by: (1) legs with only a dorsal hair fringe, (2) left mandible with five teeth, and (3) subanal lobes without gills. *Perlinella* nymphs have a dorsal and ventral hair fringe on the legs (Fig. 6), left mandible with four teeth, and gills on the subanal lobes.

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We thank B. P. Stark, Mississippi College, and K. W. Stewart, North Texas State University, for providing additional specimens of *Perlinella*. We also thank C. H. Nelson, University of Tennessee at Chattanooga, for confirming the identification of *H. appalachia*.

LITERATURE CITED

Nelson, C. H. 1979. *Hansonoperla appalachia*, a new genus and a new species of eastern Nearctic Acroneuriini (Plecoptera: Perlidae), with a phenetic analysis of the genera of the tribe. Ann. Am. Entomol. Soc. 72: 735–739.

Shepard, W. D. and K. W. Stewart. 1983. Comparative study of the nymphal gills in North American stonefly (Plecoptera) genera and a new, proposed paradigm of Plecoptera gill evolution. Misc. Publ. Entomol. Soc. Am. 55: 1–57.

U.S. Fish and Wildlife Service. 1984. Endangered and threatened wildlife and plants: review of invertebrate wildlife for listing as endangered or threatened species (Part 3). Federal Register 49: 21664–21675.

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REPRODUCTIVE BEHAVIOR OF MALE *AMMOPHILA HARTI* (FERNALD) (HYMENOPTERA: SPHECIDAE)

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Abstract.—The behavior of male *Ammophila harti* (Fernald) was observed during the summers of 1982–1984 on a sand-gravel ridge in Cayuga County, New York. Daily and seasonal activity patterns (general and reproductive) were delineated. At least two generations occurred per year. Males lived approximately three weeks and were usually present at the beginning of each generation. Male activity was bimodal daily with high levels of activity in the morning and late afternoon. Copulatory activity and position were defined. Males were subjected to interference from conspecific males while mating. Reproductive behavior components are discussed and compared with those of other members in the genus.

Studies on the behavior of male solitary wasps lag far behind those on female behavior. This discrepancy is probably due to the inconspicuous nature of the males; they are smaller than the females, usually live one-third to one-half as long, and do not exhibit elaborate, sometimes stereotypic, hunting, nest construction, or provisioning behavior. Few papers have dealt specifically with male behavior until rather recently (see Lin, 1963; Kurczewski, 1966; Alcock, 1975a, b, c; Steiner, 1978; Gwynne, 1978; Evans and O'Neill, 1978; O'Neill, 1979, 1983; for synopsis of male reproductive strategies, see Alcock et al., 1978).

Study Site and Methods

We observed *A. harti* (Fernald) males near Auburn, Cayuga Co., New York on a 150 m^2 sand and gravel ridge sparsely covered with grasses, horsetails (*Equisetum* spp.), clovers (*Melilotus alba* Desr., *Trifolium* sp.), Queen Anne's lace (*Daucus carota* L.), milkweed (*Asclepias* sp.), and goldenrod (*Solidago* sp.) (Fig. 1). Observations of males were made almost daily, 2 June–29 Aug. 1982 and 21 June–22 Aug. 1983. Additional, periodic observations were made in June and July 1984. Daily hours of observation ranged from 0800 to 1730 (EDT).

We observed general (flying, feeding, grooming) and reproductive behavior of the males. Reproductive behavior included: (1) attempts by a male to grasp a conspecific (male or female) and initiate mating; and (2) actual coupling of a male and female. We collected and color-coded the males in order to follow them daily. Hourly records were kept of the number of males performing general and reproductive behaviors. These two categories were averaged for day, week, and year. In order to compensate for differences in sampling effort, the number of wasps observed performing a particular behavior is reported as observations/hr. This

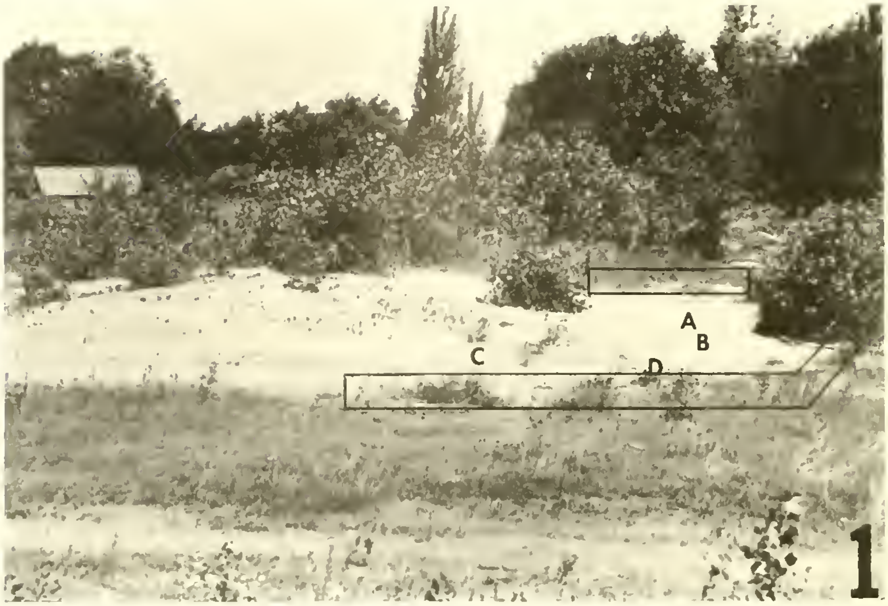


Fig. 1. Study site near Auburn, NY. Letters (A, B, C, D) indicate quadrats within main nesting area of *A. harti.* Male patrol flight areas are designated by rectangles.

enables a comparison of the levels of behavior at different times of the day and season.

EMERGENCE AND LONGEVITY

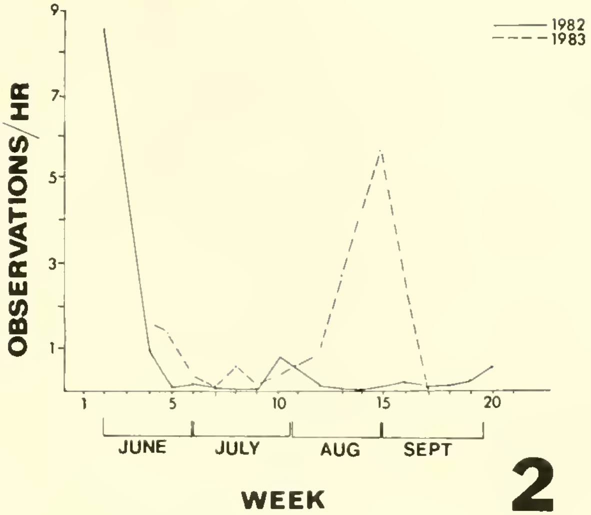
A. harti is slightly protandrous. In 1982 we sighted the first males on 2 June, six days before the first female was seen constructing a nest. In 1983 males were first seen on 18 June, three days before the first nesting females. In 1984 we observed a male on 6 June, 15 days before the first female. The differences in the emergence dates preclude analyzing the data by calendar date (Fig. 2). In order to pool the data across years, the calendar date is adjusted to reproductive date. Reproductive date 1 corresponds to the first day of observed activity (Fig. 3).

Based on the emergence records of reared wasps, longevity records of females and field observations, there are two overlapping generations of *A. harti* per year; the first occurs in June and the second in Aug. (Fig. 2). In addition there is a weather-dependent, partial third generation in Sept.–Oct. In 1982 the last male was observed on 10 Oct., and in 1983 a male emerged on 30 Sept.

Male longevity was not determined accurately. Males were most numerous for a two–three week period at the beginning of each generation (Fig. 3) and this might well represent their life span. Marked males were never recaptured after this period of time and the male population declined abruptly after three weeks.

ACTIVITY PATTERNS

The mean number of males observed/hr fluctuates significantly among weeks, with two major peaks corresponding to the two generations (ANOVA F = 1.87, 15;382 df, $P < .05$, Fig. 3). (Degrees of freedom are reported as: numerator;



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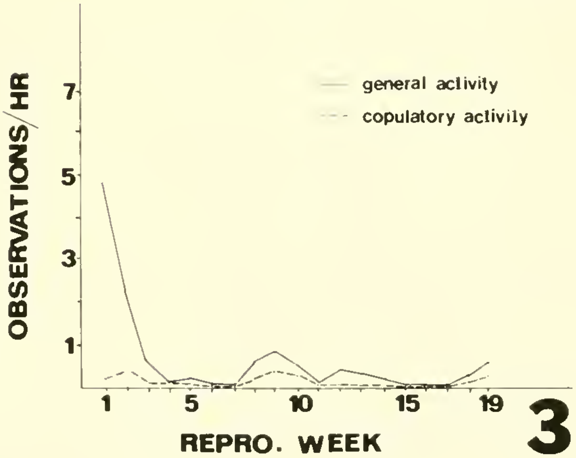

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Figs. 2–3. 2, Seasonal activity of male *A. harti* (1982–1983) based on calendar date. 3, Seasonal activity of male *A. harti* (1982–1983) based on reproductive date. Reproductive data 1 corresponds to the first day of male activity. Copulatory activity follows the pattern of general activity.

denominator.) Reproductive activity (attempted copulations) follows the pattern of total male activity but with no significant difference among weeks.

The daily pattern of male activity does not differ significantly between generations. The greatest activity occurs in the morning (0800–1100) and late afternoon (1500–1700) (Fig. 4). At these times males fly in quick, sinuous, patrolling flights through the vegetation at the periphery of the nesting area and occasionally enter the nesting site. These flights are mildly reminiscent of the "sun-dances" of some nyssonine wasps (see Evans, 1966). Males flying early in the morning (0800–0900) often land in sunny areas where they rest on the sand and groom. Attempted copulation takes place at all times except in early morning. These attempts take place at both the periphery of the nesting aggregation and within it. During midday

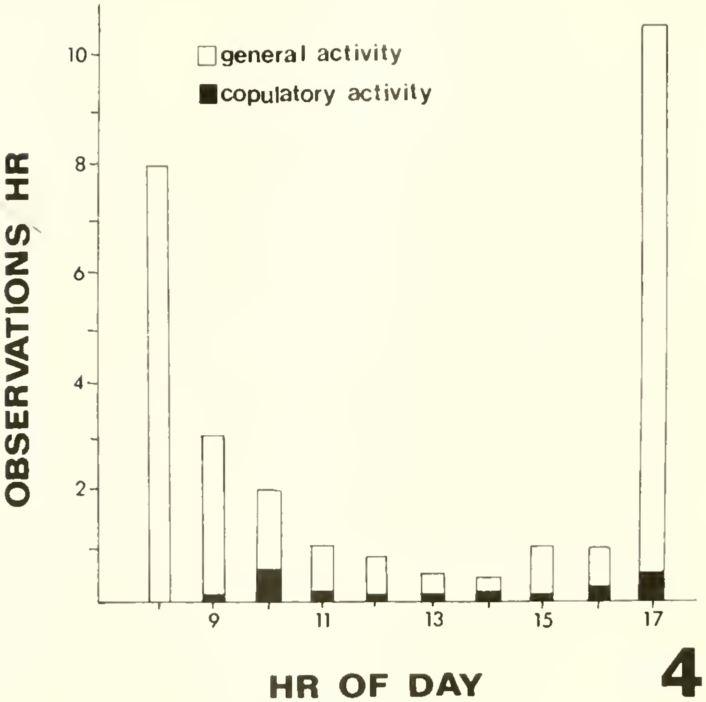

Fig. 4. Daily activity of male *A. harti.*

most observed copulatory attempts occur within the nesting site. Patrol flights decrease drastically between 1100 and 1500; the few males observed at these times were usually attempting copulation.

Patrol Flights and Mating

Males are non-territorial; that is, they do not defend a particular site. However, marked males are often recaptured in the area in which they are first collected and marked. Patrol flights occur 10–35 cm above the ground and the male may pursue any flying insect within sight or pounce upon wasp-like objects on the ground. The flight of one male may precipitate others to follow in a "chain reaction." When a wasp on the ground is encountered, the patrolling male attempts to grasp it behind the head with its mandibles. If this fails, the male flies away or lands on the sand nearby and grooms. This suggests that recognition of a potential mate is visual and successful copulation may depend upon the use of tactile and/or olfactory stimuli.

During the initial stages of copulation, the male flies in and grasps the female

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Figs. 5–7. 5, Copulatory position of *A. harti* with the male atop the female. Note the twisted abdomen of the male. 6, Second male attempting to copulate with the female. He is using his mid- and hindtibiae to push the first male's abdomen away from the female. 7, Second male successfully copulates with female. The first male's abdomen is extended outward from the pair.

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by the back of her neck with his mandibles. He also grasps her mesosoma with his front legs. If the grasp is secure, the pair usually moves to vegetation either by flying or walking. In flight the female hangs at about a 45° angle from the longitudinal axis of the male with the male retaining his grasp of the female's cervix. On the ground the female walks to and climbs up vegetation.

After arriving on vegetation, the male taps his antennae on top of the female's head while opening and closing and probing the apex of the female's abdomen with his claspers. The female grasps the vegetation between her mandibles and, when receptive, bends her abdomen into a z-shaped configuration or extends it upward. The male twists his abdomen around the side of hers and clasps the female's genitalia from the side or below (Fig. 5). If unreceptive, the female lowers her abdomen. The male, after several minutes, may abandon his attempt to copulate.

Copulation is continuous or broken into brief intervals. Two copulations observed from inception lasted 3.3 and 4.5 min; the former was broken into intervals of 31, 108, 40, and 20 sec. During the intermittent "resting" periods, the male rubbed his abdomen with his hindlegs, the female rubbed her abdomen with her hindlegs, and the male rubbed his abdomen along the female's abdomen.

Matings are subject to interference from other males. "Mating balls," consisting of more than one male and a single female, were observed several times. Such behavior terminates with either a single male remaining atop a female or separation of all wasps. A single, interfering male may achieve a brief coupling with the female by displacing the original, coupled male (Figs. 6, 7). In such a case, the female's abdomen is extended at about a 75° angle to her body axis and the male atop the first male is able to push the other male's abdomen away and clasp the female's genitalia. A male already mating may try to prevent access to a female's genitalia by extending his hindfemora parallel and above the female's abdomen with his hindtibiae and hindtarsi spread to protect the sides of the female's abdomen (M. G. Spofford, 1984, pers. comm.). A pair disturbed while mating may fly off in a tail to tail position to avoid further interference.

Discussion

Male solitary wasps usually emerge before the females (Evans, 1966; Bulmer, 1983). *A. harti* is no exception, although the time between male and female emergence may be short. Bulmer (1983) suggests that protandry occurs in insects which have a restricted breeding season and in which the females mate only once soon after eclosion, probably assuming there is no incidence of sperm precedence. Therefore, males emerging early have a better chance of reproducing than males emerging later. The mechanism generating early male emergence may take the form of either producing more males early in a generation [protarrhenotoky (Jayakar, 1963)] or via differentiation in developmental rates of the sexes in the larval, prepupal or pupal stages (Evans and Eberhard, 1970).

Evans and Eberhard (1970) believe that protandry is the result of faster development of the pupal stages of males rather than protarrhenotoky. Evidence to support their claim abounds in the literature on twig-nesting wasps (Krombein, 1960, 1964; Medler and Fye, 1956; Medler, 1964). In these species, the female regulates cell size based on the sex of the egg she will place in the cell. An examination of cell sizes reveals preferential laying of female eggs early in the generation (deuterarrhenotoky), yet the males laid later emerge before the females and thus they must develop at a faster rate.

Cocoon length is related to sex of wasp in *A. harti* (Hager and Kurczewski, in prep.). Although the overall sex ratio based on cocoon size is biased in favor of females (1:2.71, male : female), there is no significant trend in the exclusive production of one sex at any time in a generation. Differential development of the sexes is therefore suspected and data on emergence shows a faster rate for the pupal stage in the male (Hager and Kurczewski, in prep.).

Much of the behavior of male *A. harti* is directed toward reproduction. The primary function of the non-territorial, patrolling flights appears to be to obtain matings. Patrol of the nesting area also occurs in the Palearctic *A. pubescens* Curtis (Baerends, 1941) and the Nearctic *A. azteca* Cameron (Evans, 1965) and *A. aberti* Haldeman (Powell, 1964). Searching males use abdominal color patterns to locate females (Teschner, 1959). In most species of *Ammophila* the two sexes have different abdominal color patterns (Menke, 1965). Males of *A. harti* generally have a lighter, orange-colored abdomen than do the females.

Patrolling behavior in solitary wasps is associated with clumped nest distribution in open areas (Alcock, 1975b; Alcock et al., 1978). Alcock et al. (1978) define clumped nesting as occurring when an observer can readily view at least ten nest entrances from one vantage point. Patrolling a clumped nesting site is advantageous for males whether the females are monogamous (males copulate with emerging virgin females) or polyandrous (males mate with inseminated nesting females). Copulatory attempts occurring within and at the periphery of the nesting site confirm their importance as mating areas. In those species of *Ammophila* that nest solitarily (dispersed), flowers and hunting and sleeping sites are the primary areas of reproductive activity (Alcock et al., 1978).

Copulation has been observed and described for several species of *Ammophila* (Turner, 1912; Baerends, 1941; Olberg, 1959; Powell, 1964). *A. harti* differs slightly from the basic copulatory position exhibited by other species in the genus in that the abdomen of the male is twisted while coupling occurs from the side (with the female's abdomen slightly twisted) or from below. The female's abdomen is usually bent into a z-shaped configuration. In other species of *Ammophila* the females hold their abdomen straight or extend their abdomen upward at an angle. Successful copulation in *Ammophila* depends on the cooperation of the female; she must raise her abdomen in order to make her genitalia accessible to the male (Powell, 1964; Menke, 1965). Powell (1964) attributes the necessity of raising her abdomen to the female's larger size. Likewise, the bending of *A. harti*'s abdomen may be related to size differences between the sexes. Males average 85% the length of the females.

Repeated coupling and uncoupling during a mating bout occur in *A. pubescens* (Baerends, 1941) and *A. sabulosa* (L.) (Olberg, 1959). Baerends (1941) observed one copulation lasting almost an hour, with 10 couplings during this period.

Interruption of mating by conspecifics appears to be a common strategy in *Ammophila*. "Mating balls" have been observed in *A. sabulosa* (Olberg, 1959), *A. procera* Dahlbom (Bohart and Knowlton, 1953), and *A. pubescens* (Baerends, 1941). Males successful in interrupting a mating pair may receive either an immediate or delayed benefit. Copulation takeover is the immediate benefit. If the "intruding" male separates the coupled pair but does not copulate with the female, he still may benefit if he later encounters the female and mates with her. However, simply preventing another male from mating may increase the chances of the "intruder's" genes being expressed while decreasing the chances of the other male's genetic contribution to the population.

Most incidences of interrupted mating in *A. harti* appear to take place in bare or sparsely vegetated sand. By moving to vegetation surrounding the nesting site the chances of discovery of the pair by other males may be diminished.

Acknowledgments

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Literature Cited

Alcock, J. 1975a. The behaviour of western cicada killer males, *Sphecius grandis* (Sphecidae, Hymenoptera). J. Nat. Hist. 9: 561–566.

———. 1975b. Territorial behaviour by males of *Philanthus multimaculatus* (Hymenoptera, Sphecidae) with a review of territoriality in male sphecids. Anim. Behav. 23: 889–895.

———. 1975c. Male mating strategies of some philanthine wasps (Hymenoptera, Sphecidae). J. Kans. Entomol. Soc. 48: 532–545.

Alcock, J., E. M. Barrows, G. Gordh, L. J. Hubbard, L. Kirkendall, D. W. Pyle, T. L. Ponder, and F. G. Zalom. 1978. The ecology and evolution of male reproductive behaviour in the bees and wasps. J. Linn. Soc. 64: 293–326.

Baerends, G. P. 1941. Fortpflanzungsverhalten und orientierung der Grabwespe *Ammophila campestris*. Tijdschr. Entomol. 84: 68–275.

Bohart, G. E. and G. F. Knowlton. 1953. Notes on mating, prey provisioning and nesting in *Sphex procerus* (Dahlbom). Proc. Entomol. Soc. Wash. 55: 100–101.

Bulmer, M. G. 1983. The significance of protandry in social Hymenoptera. Am. Nat. 121: 540–551.

Evans, H. E. 1965. Simultaneous care of more than one nest by *Ammophila azteca* Cameron (Hymenoptera:Sphecidae). Psyche 72:8–23.

———. 1966. Behavior patterns of solitary wasps. Ann. Rev. Entomol. 11: 123–154.

Evans, H. E. and M. J. W. Eberhard. 1970. The Wasps. Univ. Mich. Press, Ann Arbor, Mich., 265 pp.

Evans, H. E. and K. O'Neill. 1978. Alternative mating strategies in the digger wasp *Philanthus zebratus* Cresson. Proc. Natl. Acad. Sci. USA. 75: 1901–1903.

Gwynne, D. T. 1978. Male territoriality in the bumblebee wolf *Philanthus bicinctus*. Z. Tierpsychol. 47: 89–103.

Jayakar, S. P. 1963. "Proterandry" in solitary wasps. Nature 198: 208–209.

Krombein, K. V. 1960. Biological notes on some Hymenoptera that nest in sumach pith. Entomol. News 71: 29–36, 63–69.

———. 1964. Results of the Archbold Expeditions. No. 87. Biological notes on some Floridian wasps. Am. Mus. Novit. 2201: 1–27.

Kurczewski, F. E. 1966. Comparative behavior of male digger wasps of the genus *Tachysphex* (Hymenoptera:Sphecidae, Larrinae). J. Kans. Entomol. Soc. 39: 436–453.

Lin, N. 1963. Territorial behavior in the cicada killer wasp *Sphecius speciosus* (Drury) (Hymenoptera: Sphecidae). Behaviour 20: 115–133.

Medler, J.T. 1964. Biology of *Rygchium foraminatus* in trap-nests in Wisconsin. Ann. Entomol. Soc. Am. 57: 56–60.

Medler, J. T. and R. E. Fye. 1956. Biology of *Ancistrocerus antilope* in trap-nests in Wisconsin. Ann. Entomol. Soc. Am. 49: 97–102.

Menke, A. S. 1965. A revision of the North American *Ammophila* (Hymenoptera:Sphecidae). Ph.D. dissertation. Univ. of Calif., Davis, 247 pp.

Olberg, G. 1959. Das verhalten der solitaren Wespen Mitteleuropas (Vespidae, Pompilidae, Sphecidae). Dtsch. Verlag Wiss. Berlin, 401 pp.

O'Neill, K. 1979. Territorial behavior in males of *Philanthus psyche* (Hymenoptera:Sphecidae). Psyche 86: 19–43.

———. 1983. The significance of body size in male territorial interactions of beewolves. Anim. Behav. 31: 404–411.

Powell, J. A. 1964. Additions to the knowledge of the nesting behavior of North American *Ammophila* (Hymenoptera:Sphecidae). J. Kans. Entomol. Soc. 37: 240–258.

Steiner, A. L. 1978. Observations on spacing, aggressive and lekking behavior of digger wasp males of *Eucerceris flavocincta*. J. Kans. Entomol. Soc. 51: 492–498.

Teschner, W. 1959. Starrheit und Variabilitat in Verhalten von Sandwespen. Zool. Beitr. (n.s.) 4: 411–472.

Turner, C. H. 1912. The copulation of *Ammophila abbreviata* Fabr. Psyche 19: 137.

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NEW MICROCADDISFLIES (TRICHOPTERA: HYDROPTILIDAE) FROM ALABAMA

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Abstract.—Ten new species of Hydroptilidae (Trichoptera) from Alabama are described and illustrated: *Hydroptila* ***circangula***, *H.* ***paralatosa***, *H.* ***choccolocco***, *H.* ***fusina***, *H.* ***cretosa***, *H.* ***oakmulgeensis***, *H.* ***talladega***, *H.* ***paramoena***, *H.* ***oneili***, and *Stactobiella* ***cahaba***.

The Hydroptilidae, or microcaddisflies, include the smallest species of Trichoptera, ranging in size from 2 to 6 mm. In North America, there are 14 genera with approximately 200 species. The larvae are unusual because, unlike other case-making caddisflies, the first four larval instars are free living. The genera considered in this paper build a purse case consisting of two silken valves joined at the dorsal and ventral edges and open at each end. Hydroptilid larvae occur in a variety of lotic and lentic habitats and most are thought to feed on algae, either filamentous or periphytic. Most microcaddisflies have a life cycle of one year or less.

The rivers and streams of Alabama support a great diversity of microcaddisflies. In a recent paper, Harris (1985) reported a total of 79 species from Alabama, more than twice as many as neighboring states. The new species described herein, plus new records for the state, increase this total to 97 species.

Terminology and species groupings follow that of Marshall (1979). Types will be deposited at the National Museum of Natural History (USNM), Illinois Natural History Survey (INHS), University of Alabama (UA), and collection of the author.

Hydroptila circangula Harris, New Species

Fig. 1

This species, a member of the *H. consimilis* group, has similarities with *H. quinola* Ross and *H. carolae* Holzenthal and Kelley. The new species can be distinguished on the appearance of the subgenital plate and structure of the phallus.

Male.—Length 2.2–2.6 mm. Antennae 30-segmented. Color brown in alcohol. Venter of abdominal segment VII with short, apico-mesal process. Segment VIII quadrate in lateral view. Segment IX approximately half width of VIII and extending anteriorly into that segment, with several short setae on ventral posterior margin. Segment X largely membraneous; in dorsal view, broadly cleft with diverging apico-lateral extensions; in lateral view dome-shaped. Subgenital plate as long as inferior appendages; in ventral view evenly rounded baso-laterally, tapering to narrow, apical point bearing two divergent, subapical setae. Inferior appendages

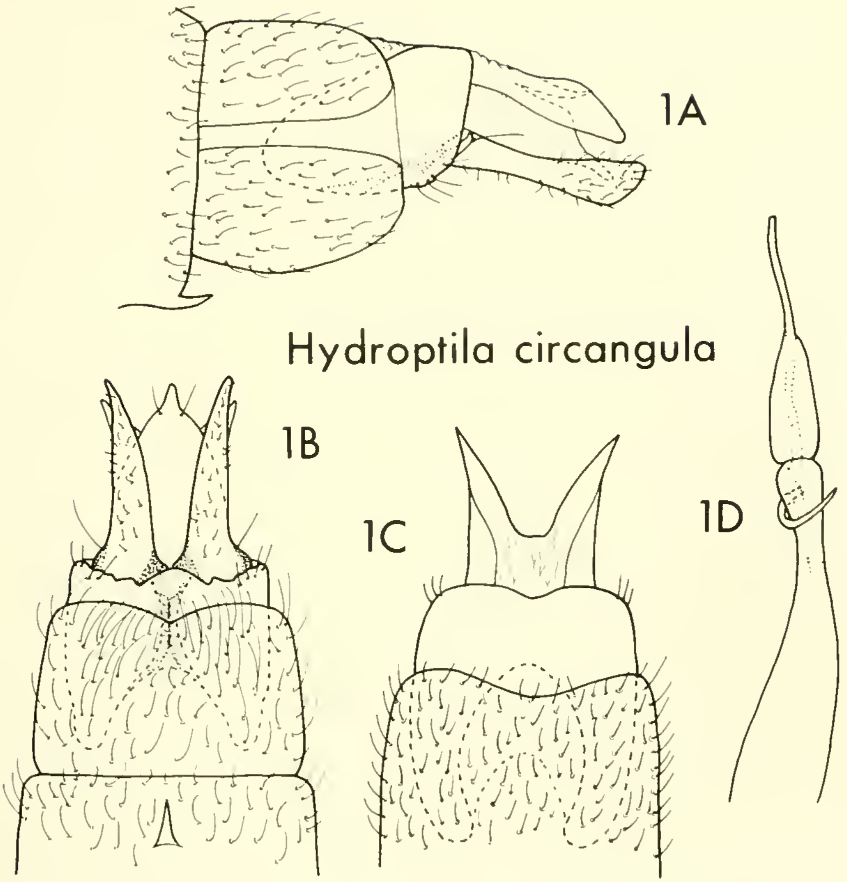

Fig. 1. *Hydroptila circangula* n. sp., male genitalia. 1A, lateral view. 1B, ventral view. 1C, dorsal view. 1D, phallus.

in ventral view narrowly separate basally, tapering and diverging apically, each bearing a long dorso-lateral seta basally; in lateral view somewhat club-shaped, narrowest in middle, apico-dorsal corner rounded. Phallus with basal portion tapering to bulblike apex, bearing short paramere; distal portion triangular basally with ejaculatory duct protruding apically.

Female.—Unknown.

Etymology.—Latin "around the bay," referring to the species occurrence around Mobile Bay.

Holotype.—Alabama, Baldwin County, Pine Log Creek at Hwy. 59, 11 May 1982, S. C. Harris (USNM).

Paratypes.—Alabama, same as above, 6 ♂ (INHS); Nelson Branch, 3 mile east Gateswood, 23 June 1982, 2 ♂, S. Harris and P. O'Neil (UA); Sandy Creek, at Hwy. 98, 23 June 1982, 22 ♂, S. Harris and P. O'Neil (USNM); Mobile County, Indian Grave Creek, 7 mile east Citronelle, 24 June 1982, 6 ♂, S. Harris and P. O'Neil; Little Creek, 4 mile southeast Citronelle, 31 March 1982, 11 ♂, P. O'Neil and M. Mettee (INHS); same as above, but 12 May 1982, 6 ♂, S. Harris; same as above, but 20 September 1982, 5 ♂, S. Harris and P. O'Neil.

Discussion.—The male genitalia of *H. circangula* is similar in many aspects to that of *H. carolae* Holzenthal and Kelley. The structure of the subgenital plate and inferior appendages are similar in both species. The two species can be readily separated, however, on the appearance of the phallus. In *H. carolae* the basal portion of the phallus is long and tubular with the distal portion thin and styletlike with no paramere, while in *H. circangula* the phallus tapers both basally and dorsally, and possesses a short paramere.

Hydroptila paralatosa Harris, New Species

Fig. 2

This species is another member of the *H. consimilis* group with similarities to *H. quinola* and *H. latosa* Ross in the overall plan of the male genitalia. However, the structure of the inferior appendages and shape of the subgenital plate render it distinct.

Male.—Length 2.1–2.5 mm. Antennae 24-segmented, last 11 segments light, particularly 14–16. Color brown in alcohol. Venter of abdominal segment VII with short, apico-mesal process. Segment VIII generally quadrate in lateral view, narrowing posterio-mesally, clump of long hairs dorso-laterally. Segment IX approximately half width of VIII and extending anteriorly into that segment, tapering to a rounded posterio-ventral point. Segment X in dorsal view with flared lateral extensions and membraneous median lobe rounded at apex; in lateral view somewhat club-shaped. Subgenital plate shorter than inferior appendages; in ventral view rounded baso-laterally, with wide distal point bearing two divergent setae. Inferior appendages in ventral view narrowly separate basally, nearly parallel sided over much of length and slightly diverging apically, baso-laterally with a short, thumblike projection bearing a long seta; in lateral view straight and parallel sided, rounded distally, basal projection less than ¼ length of appendage. Phallus long and slender, basal portion gently tapering to bulblike apex; distal portion gently curved to sharp apex.

Female.—Unknown.

Etymology.—Latin, referring to the similarity with *H. latosa*.

Holotype.—Alabama, Tuscaloosa County, Hurricane Creek at Old Mill Trace, 1 mile south Cottondale, 11 August 1983, S. Harris and P. O'Neil (USNM).

Paratypes.—Same as above, 44 ♂ (USNM, INHS); same as above, but 18 August 1982, 2 ♂, S. Harris (UA); Turkey Creek at Hwy. 69, 26 July 1984, 8 ♂, S. Harris and P. O'Neil; same, but 11 August 1981, 1 ♂; Keeple Creek at mouth, 3 miles south Coaling, 6 August 1984, 1 ♂, P. O'Neil and R. Smith; same, but 7 June 1984, 5 ♂.

Discussion.—Many of the genitalic structures of *H. paralatosa* appear to be intermediate in character between those of *H. quinola* and *H. latosa*. The inferior appendages, particularly in ventral view, are similar to those of *H. quinola*, in being divergent apically, although not to the extent seen in *H. quinola*, and in the possession of a short baso-lateral thumb. In contrast, the inferior appendages of *H. latosa* are convergent apically with a long, fingerlike, baso-lateral process. In lateral view, the inferior appendages of *H. quinola* and *H. paralatosa* are straight, while in *H. latosa* they curve ventrally. In common with *H. latosa*, *H. paralatosa*

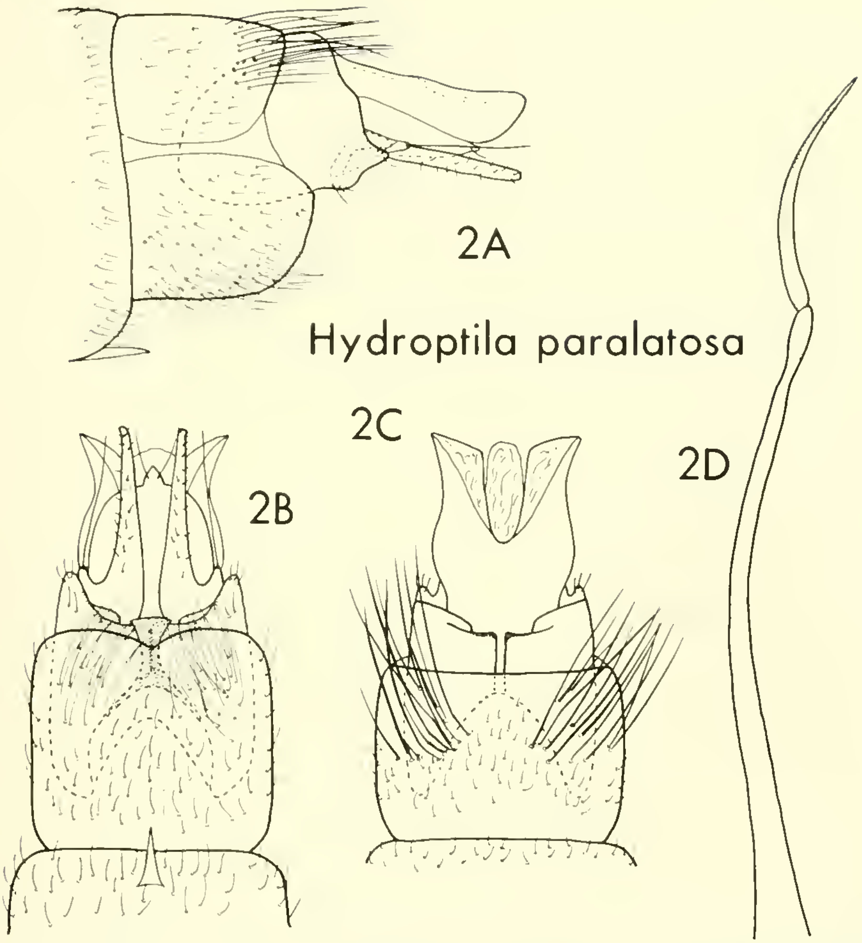

Fig. 2. *Hydroptila paralatosa* n. sp., male genitalia. 2A, lateral view. 2B, ventral view. 2C, dorsal view. 2D, phallus.

has a rounded, distally pointed subgenital plate. By contrast, the subgenital plate of *H. quinola* is triangular in shape. *Hydroptila latosa* is a coastal plain endemic, restricted to sand bottom streams and rivers on the lower coastal plain in Alabama, while *H. quinola* is widespread in the state. *Hydroptila paralatosa* is presently only known from several streams on the lower Cumberland Plateau.

Hydroptila choccolocco **Harris, New Species**

Fig. 3

This is a third new species to be placed in the *H. consimilis* group. The distinctive, sinuate inferior appendages, however, render it unique.

Male.—Length 2.8–3.0 mm. Antennae 26-segmented. Color brown in alcohol. Venter of abdominal segment VII with short, apico-mesal process. Segment VIII generally quadrate in lateral view; clumps of long setae laterally both dorsally and ventrally. Segment IX equal in width to segment VIII and extending anteriorly

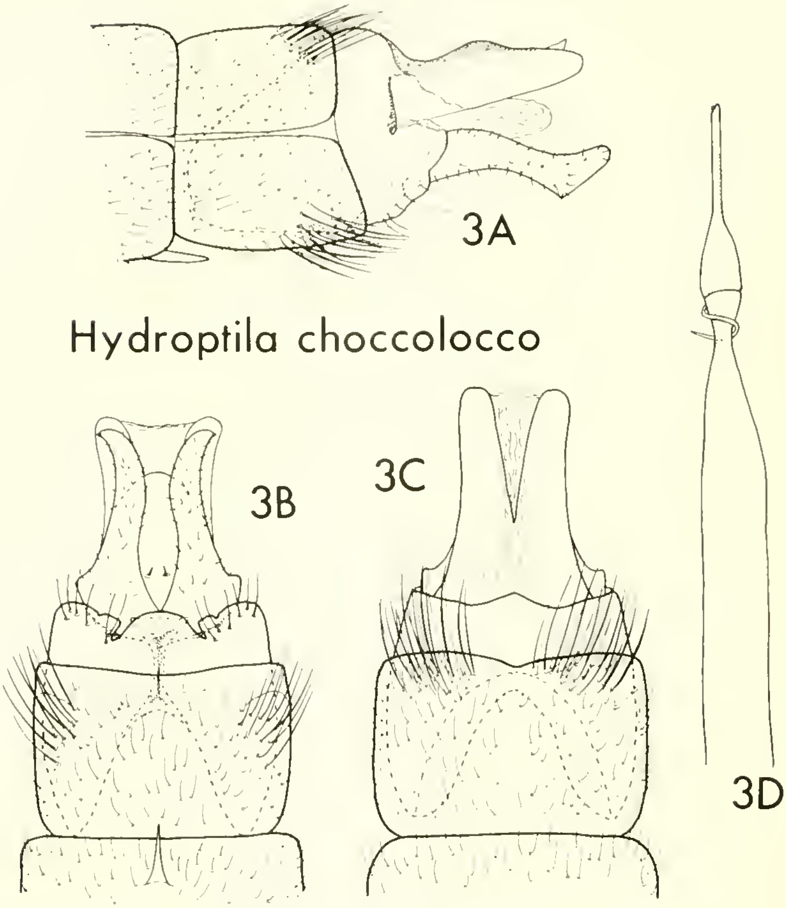

Fig. 3. *Hydroptila choccolocco*, n. sp., male genitalia. 3A, lateral view. 3B, ventral view. 3C, dorsal view. 3D, phallus.

into that segment, fused with segment X. Segment X in dorsal view truncate apically, lateral sclerotization forming two, long diverging lobes, lightly membraneous between lobes; in lateral view dome shaped, lightly sclerotized dorsally. Subgenital plate in ventral view rounded with pair of peglike setae baso-mesally; tonguelike in lateral view. Inferior appendages in ventral view narrowly separate basally, sinuate, tapering and diverging apically, with slightly hooked, sclerotized apex; boot shaped in lateral view, wide basally, upturned apically. Phallus with basal portion long and tubular, narrowing apically and bearing long paramere encircling shaft; distal portion triangular at base, thin and parallel sided apically with ejaculatory duct slightly protruding.

Female.—Unknown.

Etymology.—Named for Choccolocco Creek.

Holotype.—Alabama, Calhoun County, Choccolocco Creek, unmarked county road, 1.5 miles east Jenkins, 23 May 1981, S. Harris and P. O'Neil (USNM).

Paratypes.—Alabama, same as above, 229 ♂ (USNM, INHS, UA).

Discussion.—This species is only known from the headwaters of Choccolocco Creek, a small, gravel bottom Piedmont stream. Collections in nearby streams and in other sections of Choccolocco Creek have yielded no additional specimens.

Hydroptila fuscina Harris, New Species

Fig. 4

This species appears to be a member of the *H. waubesiana* group on the basis of the elongate tenth tergum. The short, angled inferior appendages and trifid nature of tergum X serve to distinguish the species.

Male.—Length 2.0–2.4 mm. Antennae 26-segmented. Color brown in alcohol. Venter of abdominal segment VII with short, apico-mesal process. Segment VIII deeply incised dorsally, bearing several thick setae intermixed with long thin setae along posterior margin; ventro-lateral margin with several thickened setae. Segment IX rounded in lateral view, completely retracted within segment VIII. Segment X in dorsal view, three pronged, the lateral prongs with acute apex, the inner prong rounded at apex; in lateral view scissor shaped, with lateral prongs projecting ventrally. Inferior appendages in ventral view short and angled laterally, in lateral view gently bending ventrad and tapering to apex. Phallus tubular, wide basally, and thickened in midsection; ejaculatory duct protruding at apex; thin paramere encircling shaft.

Female.—Unknown.

Etymology.—Latin "trident," referring to the appearance of the tenth tergum.

Holotype.—Alabama, Tuscaloosa County, Turkey Creek at Hwy. 69, 11 August 1981, S. Harris and P. O'Neil (USNM).

Paratypes.—Alabama, same as above, 17 ♂ (USNM, INHS, UA); same as above, but 26 July 1984, 4 ♂.

Discussion.—This species is only known from Turkey Creek, a small, rocky bottom stream of the lower Cumberland Plateau. Extensive collecting throughout this region has failed to yield additional specimens.

Hydroptila cretosa Harris, New Species

Fig. 5

In overall appearance, this species is similar to *H. tridentata* Holzenthal and Kelley and *H. lonchera* Blickle and Morse. However, details of the genitalia, including the appearance of the tenth tergum, serve to differentiate the two species.

Male.—Length 2.3–2.5 mm. Antennae 25-segmented. Color brown in alcohol. Venter of abdominal segment VII with short, apico-mesal process. Segment VIII incised dorsally about one-half length, quadrate ventrally. Segment IX short and completely retracted within segment VIII. Segment X in dorsal view deeply cleft, each side rounded posteriorly, apex twisted forming a small lobe, in lateral view gently tapering posteriorly to upturned apex. Inferior appendages nearly contiguous in ventral view, tapering gently distally, bearing sclerotized point apically and subapically, in lateral view nearly straight and parallel sided over length, with sclerotized points apically and subapically on ventral surface. Phallus long and narrow, widest at base and center, thin paramere encircling the shaft at midlength.

Female.—Unknown.

Etymology.—Latin "abounding in chalk," referring to the geology of the region of Alabama where the species occurs.

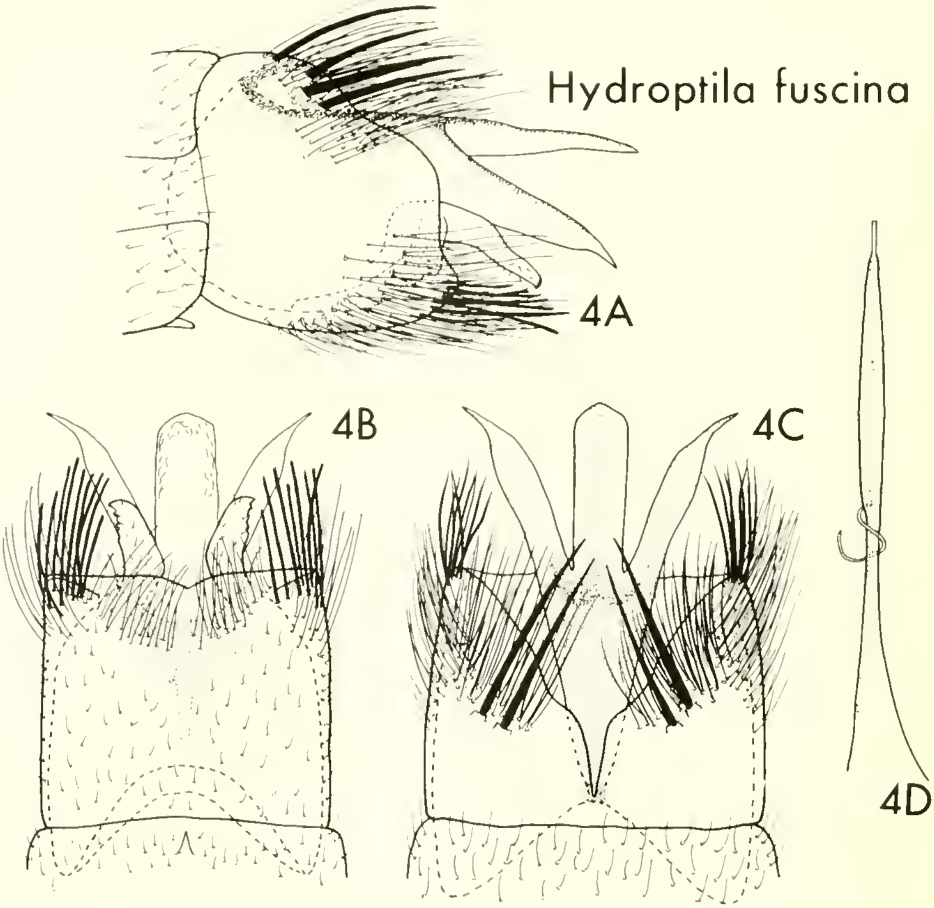

Fig. 4. *Hydroptila fuscina* n. sp., male genitalia. 4A, lateral view. 4B, ventral view. 4C, dorsal view. 4D, phallus.

Holotype.—Alabama, Greene County, Trussels Creek at Co. Hwy. 23, 22 June 1983, S. Harris and P. O'Neil (USNM).

Paratypes.—Alabama, same as above, 1 ♂ (INHS); Brush Creek at Co. Hwy. 14, 22 June 1983, S. Harris and P. O'Neil, 4 ♂ (USNM, INHS, UA).

Discussion.—In many respects *H. cretosa* resembles *H. lonchera,* particularly in the appearance of segment X and the inferior appendages. However, *H. cretosa* lacks the prominent dorso-lateral spines on segment IX of *H. lonchera. Hydroptila cretosa* is only known from several small, sand bottom streams in west-central Alabama. This region is characterized by extensive outcropping of the Selma Chalk formation.

***Hydroptila oakmulgeensis* Harris, New Species**

Fig. 6

Although closely resembling *H. poirrieri* Holzenthal and Kelley, of the *H. waubesiana* group, this species is distinguished by the structure of the tenth tergum, and by the truncate distal end of the inferior appendages.

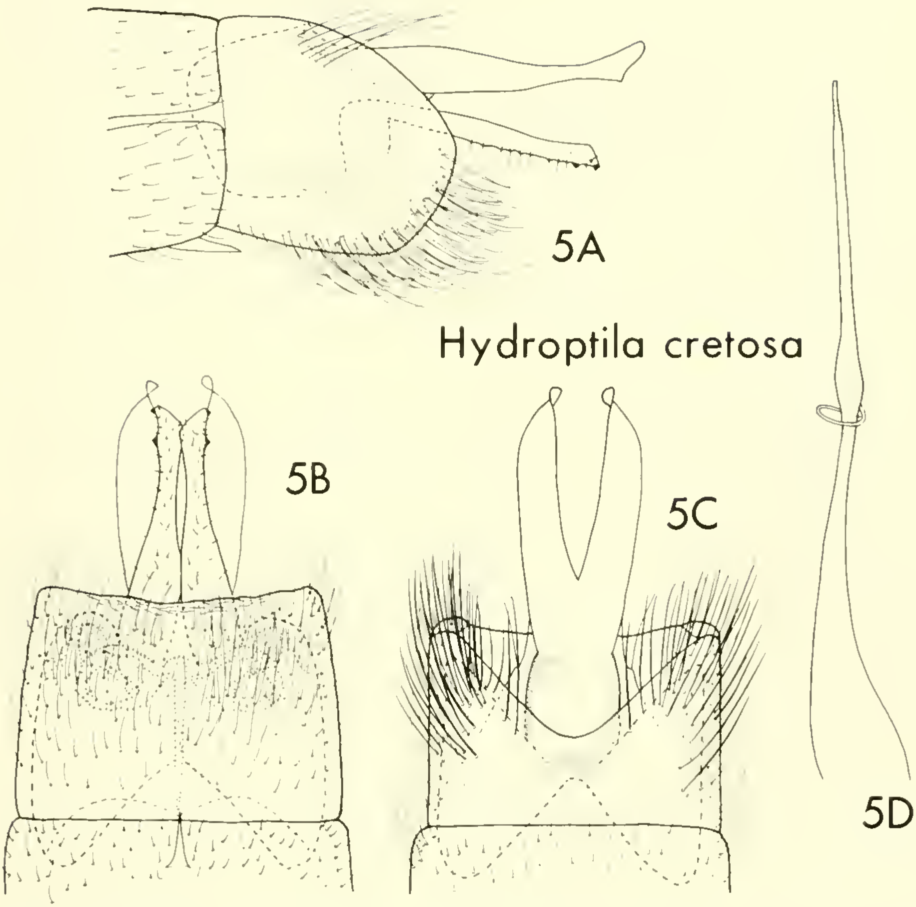

Fig. 5. *Hydroptila cretosa* n. sp., male genitalia. 5A, lateral view. 5B, ventral view. 5C, dorsal view. 5D, phallus.

Male.—Length 2.2–3.0 mm. Antennae 26-segmented. Brown in alcohol. Venter of abdominal segment VII with short, apico-mesal process. Segment VIII generally trapezoidal in lateral view with posterior margin about half width of anterior margin, dorsally with rounded, mesal excision, ventrally with square mesal excision on posterior margin. Segment IX short and completely retracted within VII and VIII, generally hexagonal in ventral view, with a narrow meso-dorsal excision anteriorly, and meso-ventral apodeme. Segment X in dorsal view narrowly rounded at base, deeply forked to midlength, each arm narrowing to a laterally rounded apex; intermediate appendages sclerotized and narrow, arising from venter of segment and extending beyond posterior margin of segment VIII; in dorsal view curving dextrally in preserved specimens, apex acute and slightly angled. Inferior appendages in ventral view narrowly separated, and roughly rectangular in shape, truncate at apex, lateral fingerlike projection basally; in lateral view mostly enclosed by segment VIII, parallel sided, rounded distally with sclerotized ventral point subapically. Phallus long and generally tubular; basal portion

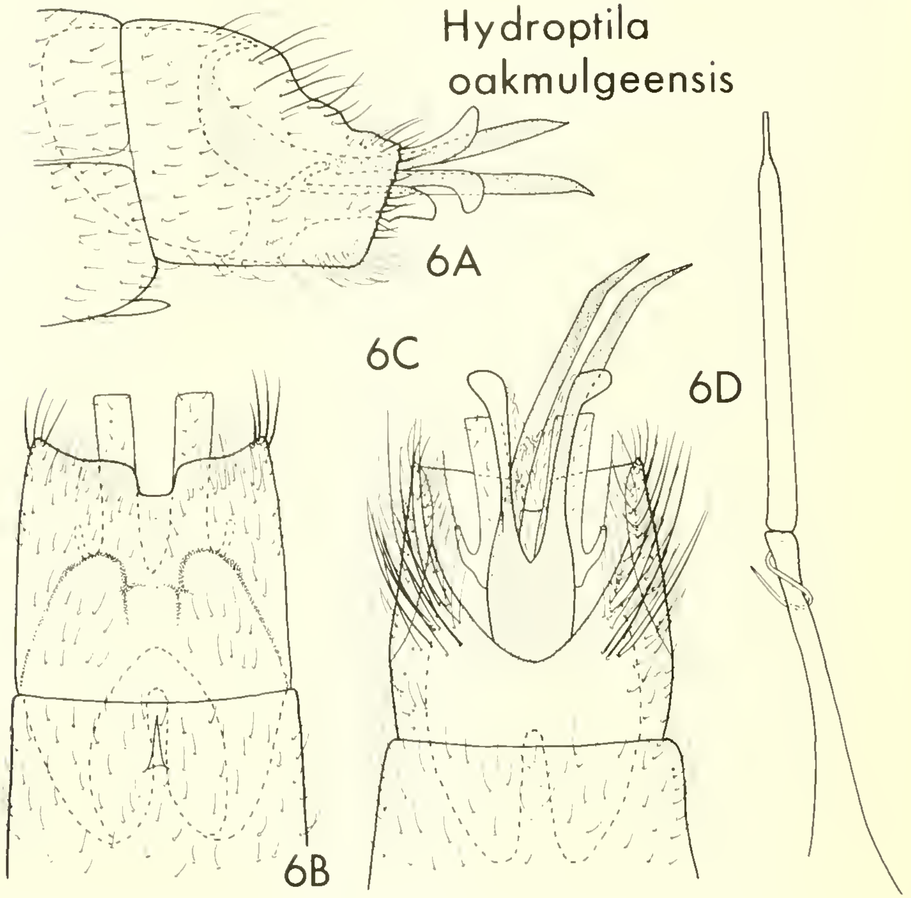

Fig. 6. *Hydroptila oakmulgeensis* n. sp., male genitalia. 6A, lateral view. 6B, ventral view. 6C, dorsal view. 6D, phallus.

tapering, bearing thin paramere encircling shaft; distal portion parallel sided with ejaculatory duct protruding at apex.

Female.—Unknown.

Etymology.—Named for Oakmulgee Creek where the species is common.

Holotype.—Alabama, Choctaw County, Tallawampa Creek at Co. Hwy. 23, 16 May 1982, S. Harris (USNM).

Paratypes.—Alabama, same as above, 8 ♂ (USNM), Bogueloosa Creek at Co. Hwy. 9 near Toxey, 16 May 1982, S. Harris, 3 ♂ (INHS); Perry County, Oakmulgee Creek at Hwy. 219, 5 June 1981, S. Harris and P. O'Neil, 198 ♂ (USNM, INHS, UA); same as above, but 4 April 1982, 24 ♂ (UA); Little Oakmulgee Creek at Co. Hwy. 30, 4 April 1982, S. Harris and P. O'Neil, 6 ♂; Marion County, Buttahatchee River off Hwy. 278, 9 miles east of Hamilton, 29 May 1983, S. Harris, 2 ♂; same as above, but 28 June 1983, 28 ♂ (USNM, INHS); Monroe County, Beaver Creek at Hwy. 41, 15 May 1982, S. Harris, 1 ♂; Tuscaloosa County, Wallace Branch, 5 miles southeast of Berry, 15 June 1982, S. Harris and P. O'Neil, 1 ♂; Winston

County, Sipsey Fork at Sipsey Fork Recreation Area, Bankhead National Forest, 23 May 1983, S. Harris, 1 ♂.

Discussion.—*Hydroptila oakmulgeensis* might be confused with *H. poirrieri* on overall appearance. However, in *H. poirrieri,* segment X is reduced to a pair of long, sickle shaped intermediate appendages, while in *H. oakmulgeensis* segment X is more complex with a long, forked dorsal portion and ventral intermediate appendages. The two species also differ in the appearance of the inferior appendages, particularly in ventral view. In *H. oakmulgeensis,* the inferior appendages are thinly rectangular and truncate at apex, while in *H. poirrieri,* the posterior end of the inferior appendages are acute with a large subapical spine.

Hydroptila talladega **Harris, NEW SPECIES**

Fig. 7

This species, a member of the *H. tineoides* group, closely resembles *H. spinata* Blickle and Morse in the presence of ventral spines on abdominal segment VIII. The structure of the phallus and appearance of the tenth tergum, however, serve to distinguish *H. talladega.*

Male.—Length 2.6–3.0 mm. Antennae 26-segmented. Color brown in alcohol. Venter of abdominal segment VII with short, apico-mesal process. Segment VIII quadrate in lateral view, with ventral sclerite extending posteriorly to an acute point bearing several heavy spines; in ventral view this sclerite appearing sinuate posteriorly, and bearing numerous mesal spines. Segment IX square in dorsal view; in ventral view, incised deeply anteriorly and slightly posteriorly, internally with a bilobed process; laterally with narrow lobe bearing setal clusters both ventrally and dorsally, narrowing anteriorly and extending to midlength of segment VIII. Segment X in dorsal view emarginate posteriorly and fused anteriorly with segment IX, in lateral view slightly upturned with lightly sclerotized ventral lip. Inferior appendages short and sharply curved ventrad in lateral view, with dorsal tubular process bearing a long seta near apex; in ventral view contiguous along meson, fused basally with tubular arm arising midlaterally. Phallus tubular basally, posteriorly divided into two processes of equal length; one flaplike, the other narrowing to a rattlelike apex, with protruding ejaculatory duct; bearing short paramere at midlength making half revolution of shaft.

Female.—Unknown.

Etymology.—Named for Talladega National Forest.

Holotype.—Alabama, Cleburne County, unnamed tributary to Coleman Lake, ¾ mile northeast of Choccolocco Ranger Station (R10E, T14S, S27), Talladega National Forest, 25 May 1984, S. Harris and P. Lago (USNM).

Paratypes.—Alabama, same as above, 5 ♂ (USNM, INHS); same, but 21 May 1984, 1 ♂; Calhoun County, unnamed tributary to Choccolocco Creek along Bain Gap Road, ¾ mile east of Bain Gap Gate on Ft. McClellan Military Reservation, 26 June 1984, 1 ♂, S. Harris and P. O'Neil (UA).

Discussion.—While *H. talladega* generally resembles *H. spinata,* it can be distinguished on the basis of several characters of the genitalia. The phallus of *H. talladega* is divided into two apical processes, while in *H. spinata* the phallus has three apical processes. Segment IX in *H. talladega* narrows anteriorly and extends to the middle of segment VII, while in *H. spinata* the anterior portion of segment IX is truncate, and only extends anteriorly to the middle of segment VIII. In

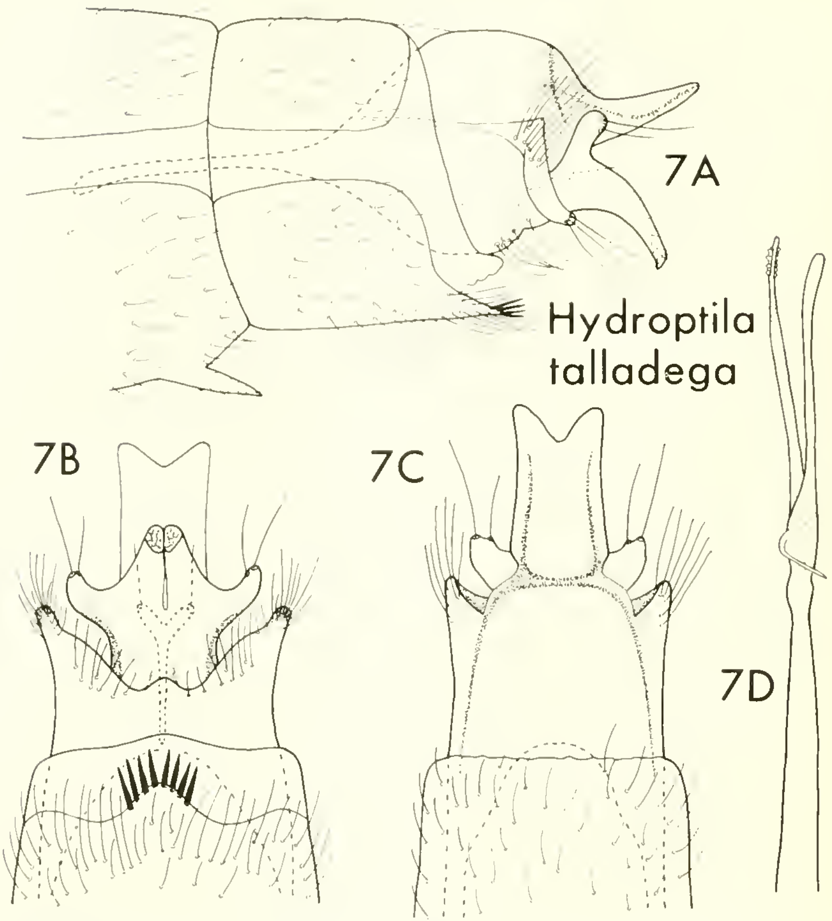

Fig. 7. *Hydroptila talladega* n. sp., male genitalia. 7A, lateral view. 7B, ventral view. 7C, dorsal view. 7D, phallus.

dorsal aspect, segment X in *H. spinata* is deeply cleft apically while in *H. talladega* segment X is emarginate at apex. In Alabama, *H. talladega* has only been collected in small, headwater tributaries, while *H. spinata* seems to occur in larger streams of the Appalachian Plateau.

Hydroptila paramoena **Harris, New Species**

Fig. 8

This species, another member of the *H. tineoides* group, is similar to *H. amoena* Ross, but is easily differentiated on the basis of segment X in dorsal profile and the structure of the phallus.

Male.—Length 2.0–2.5 mm. Antennae 27-segmented. Color brown in alcohol. Venter of abdominal segment VII with long, apico-mesal process extending to middle of segment VIII. Segment VIII generally quadrate in lateral view. Segment IX square in dorsal view; incised deeply anteriorly and gently posteriorly in ventral view, internally with short forked process; laterally with narrow lobe bearing dorsal

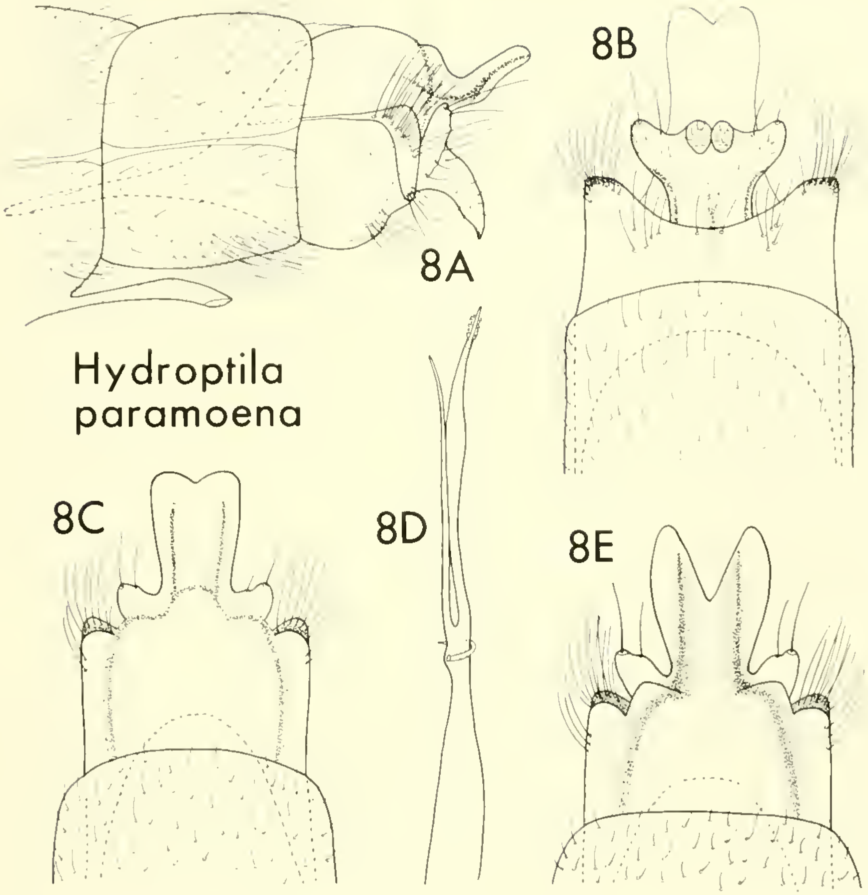

Fig. 8. *Hydroptila paramoena* n. sp., male genitalia. 8A, lateral view. 8B, ventral view. 8C, dorsal view. 8D, phallus. 8E, *H. amoena* Ross, dorsal view (redrawn from paratype).

and ventral setal clusters, narrowing anteriorly and extending into segment VIII. Segment X slightly emarginate posteriorly in dorsal view, fused anteriorly with segment IX; in lateral view sharply upturned with lightly sclerotized ventral ridge. Inferior appendages short and sharply curved ventrad in lateral view, with dorsal thumblike projection bearing long setae at apex; in ventral view inferior appendages fused along meson, with winglike lateral extentions. Phallus wide at base, split into two processes apically; one slender and acuminate; the other thick and sinuate, rattlelike at apex with protruding ejaculatory duct; short paramere below division making half revolution of shaft.

Female.—Unknown.

Etymology.—Latin, referring to the similarity with *H. amoena.*

Holotype.—Alabama, Bibb County, Six Mile Creek at Hwy. 25, 29 October 1982, S. Harris (USNM).

Paratypes.—Alabama, same as above, but 13 May 1982, 1 ♂; same, but 25 August 1981, 17 ♂ (USNM, INHS, UA); Schultz Creek, 4 miles north of Centreville, 13 April 1982, 11 ♂, S. Harris (INHS); Tuscaloosa County, Blue Creek at Hwy. 69, 11 August 1981, 2 ♂, S. Harris and P. O'Neil; North River at Co. Hwy. 38, 25 September 1981, 1 ♂, S. Harris; Cripple Creek at Cripple Creek Church, 3 miles northeast of Samantha, 11 August 1981, 1 ♂, S. Harris and P. O'Neil; Tyro Creek, 4.5 miles east of New Lexington, 25 September 1981, 1 ♂, S. Harris (USNM); Cherokee County, Terrapin Creek at Hwy. 278, 6 September 1981, 6 ♂, S. Harris and R. Handley; Cleburne County, Tallapoosa River, 3.5 miles east of Fruithurst, 6 September 1981, 1 ♂, S. Harris and R. Handley; Shoal Creek at Shoal Creek campground, Talladega National Forest, 6 September 1981, 4 ♂, S. Harris and R. Handley.

Discussion.—*Hydroptila paramoena* shares in common with *H. amoena* the character of having a phallus divided into two apical processes. However, *H. paramoena* differs in having the one process tipped with a rattlelike structure which is not present in *H. amoena*. The tenth tergum which is deeply cleft in *H. amoena* (Fig. 8E) while only slightly emarginate in *H. paramoena* (Fig. 8C), most readily separates the two species. In addition, *H. amoena* is a somewhat larger species (3 mm in length) than is *H. paramoena*. In Alabama, *H. amoena* is rarely collected, and primarily on the Appalachian Plateau, while *H. paramoena* is more abundant, particularly in the lower Appalachian mountains.

***Hydroptila oneili* Harris, New Species**

Fig. 9

A third new member of the *H. tineoides* group, this species resembles the preceding species as well as *H. amoena* and *H. hamata* Ross. The species is differentiated, however, on the appearance of the tenth tergum and structure of the phallus.

Male.—Length 2.0–2.4 mm. Antennae 27-segmented. Color brown in alcohol. Venter of abdominal segment VII with long, apico-mesal process extending to near posterior margin of segment VIII. Segment VIII generally quadrate in lateral view. Segment IX square dorsally; incised slightly posteriorly and deeply anteriorly in ventral view, internally with bilobed process; laterally with narrow lobe bearing dorsal and ventral setal clusters, narrowing anteriorly and extending to near anterior edge segment VIII. Segment X in dorsal view slightly emarginate at apex, flaring subapically before narrowing basally; in lateral view only slightly upturned with lightly sclerotized ventral ridge. Inferior appendages short and sharply curved ventrad in lateral view, with thick tubular process dorsally bearing long setae subapically; in ventral view contiguous along meson, fused basally with small winglike extensions baso-laterally. Phallus wide at base, divided into two processes apically; one thin and filamentlike; the other thicker and bearing ejaculatory duct, which protrudes and bends at apex.

Female.—Unknown.

Etymology.—Named for Patrick O'Neil for his assistance in many of the Alabama collections.

Holotype.—Alabama, Bibb County, spring at Schutlz Creek Church, 2.5 miles southwest of West Blocton, 12 September 1982, S. Harris (USNM).

Paratypes.—Alabama, same as above, 5 ♂ (USNM); same, but 12 May 1982, 1 ♂; Little Ugly Creek, upstream crossing Co. Hwy. 24, 4 April 1982, 1 ♂, S. Harris (USNM, INHS); Calhoun County, Ohatchee Creek at Co. Hwy. 23, 7 September

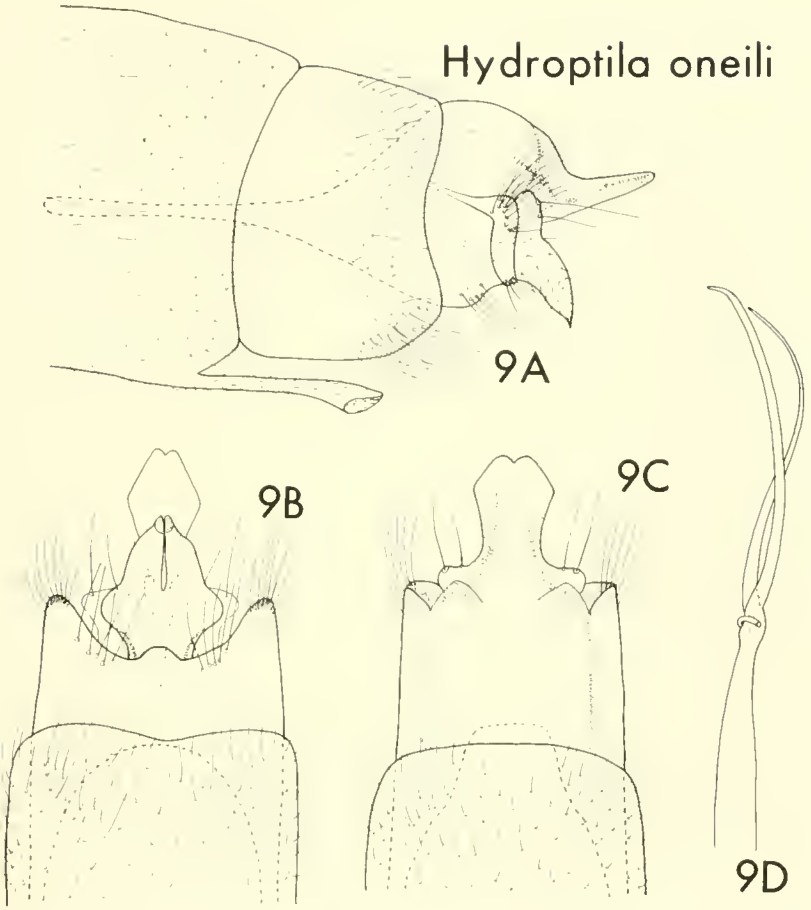

Fig. 9. *Hydroptila oneili* n. sp., male genitalia. 9A, lateral view. 9B, ventral view. 9C, dorsal view. 9D, phallus.

1981, 2 ♂, S. Harris and R. Handley; Cleburne County, Shoal Creek at Shoal Creek campground, Talladega National Forest, 6 September 1981, 2 ♂, S. Harris and R. Handley; Etowah County, Line Creek at Egypt Road, 1 mile west of Rockledge, 17 July 1982, 3 ♂, S. Harris; Little Canoe Creek at Rocky Hollow Road, 3 miles northeast of Steele, 9 July 1982, 35 ♂, S. Harris; Fayette County, Tyro Creek, 2.5 miles southeast of Berry, 25 September 1981, 8 ♂, S. Harris (INHS); same, but 25 July 1983, 1 ♂; same, but 24 August 1983, 2 ♂ (USNM); Jackson County, Little Coon Creek off Hwy. 54 at Cave Spring Church, 21 June 1981, 2 ♂, S. Harris; Jefferson County, Cahaba River at Trussville, Co. Hwy. 132, 25 July 1981, 4 ♂, S. Harris and P. O'Neil; same, but 13 September 1981, 2 ♂; Tuscaloosa County, Tyro Creek, 4.5 miles east of New Lexington, 20 June 1983, 4 ♂, S. Harris and P. O'Neil (USNM); Tyro Creek, 3.5 miles southeast of Berry, 26 May 1983, 1 ♂, S. Harris and P. O'Neil; same, but 20 June 1983, 4 ♂ (INHS); same, but 25 July 1983, 13 ♂; same, but 23 August 1983, 72 ♂; same, but 27 September 1983, 27 ♂; Wallace Branch, 5 miles southeast of Berry, 23 August

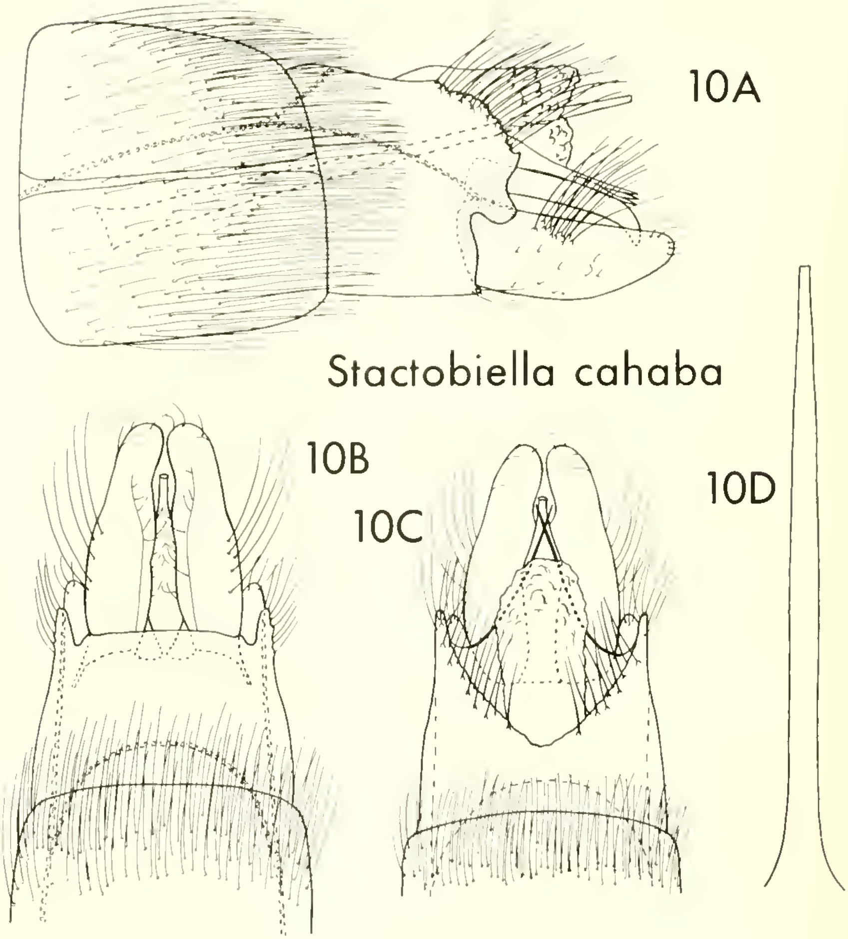

Fig. 10. *Stactobiella cahaba* n. sp., male genitalia. 10A, lateral view. 10B, ventral view. 10C, dorsal view. 10D, phallus.

1983, 5 ♂, S. Harris and P. O'Neil; Turkey Creek at Hwy. 69, 19 October 1982, 1 ♂, S. Harris; Mill Creek at Gristmill, Tannehill State Park, 9 May 1982, 16 ♂, S. Harris.

Discussion.—As with *H. amoena*, *H. paramoena*, and *H. hamata*, *H. oneili* shares the character of the phallus being divided into two apical processes. The tenth tergum of *H. oneili* is similar in appearance to *H. hamata*, but while the phallic process in *H. hamata* is sharply angled at apex, in *H. oneili* the apex of this process is only slightly bent.

Stactobiella cahaba **Harris, New Species**
Fig. 10

In many respects, this species resembles *S. delira* Ross. It differs in the structure and shape of the inferior appendages, in the possession of dorsal rods associated with the intermediate appendage, and in the simple phallus.

Male.—Length 1.9–2.0 mm. Antennae 16-segmented. Color brown in alcohol. Segment VIII quadrate in lateral and dorsal views. Segment IX deeply incised dorsally, the margins serrate and bearing numerous long setae; ventrally with distal margin square and lacking setae, with apical lobes laterally; in lateral view with mesal excision posteriorly, serrate dorsally; long apodemes extending anteriorly. Segment X membraneous; in dorsal view narrow and short, rounded apically; in lateral view appearing generally truncate apically. Inferior appendages in lateral view boat shaped, wide basally, gently tapering to rounded apex, cluster of setae dorsally near midlength; in ventral view widest at base, slightly tapering to rounded apex, mesal margins sinuate and nearly contiguous. Intermediate appendage in dorsal view wide basally and at midlength, apically narrow and tubular; thin, sclerotized rodlike apparatus arising laterally and crossing intermediate appendage dorsally; in lateral view intermediate appendage tubular over much of length, curving ventrally apically, dorsal sclerotized apparatus with three apical spines. Phallus simple and generally tubular, wide basally, generally parallel sided over much of length, tapering to a truncated apex.

Female.—Unknown.

Etymology.—Named for the Cahaba River of which Schultz Creek is a tributary.

Holotype.—Alabama, Bibb County, Schultz Creek, 4 miles north of Centreville, 13 April 1982, S. Harris (USNM).

Paratypes.—Alabama, same as above, 3 ♂ (USNM, INHS).

Discussion.—This species is only known from Schultz Creek, a swift, rocky bottom stream situated on the fall line at the boundary of the lower Appalachian Mountains and the coastal plain. Extensive collecting throughout the Cahaba River basin, has failed to yield additional specimens. Also collected at this locality were *S. delira* Ross, *S. martynovi* Blickle and Denning, and *Dibusa angata* Ross.

ACKNOWLEDGMENTS

The Geological Survey of Alabama provided facilities and supplies during the course of the study and are gratefully acknowledged. I also wish to thank Jack Unzicker for providing the paratypes of *H. amoena*; Ralph Holzenthal for providing a second opinion on several identifications and reviewing the manuscript; Sabra Rager for typing the manuscript; Ruth Turner for photographing the figures; and Patrick O'Neil and Paul Lago for assisting in the collecting.

LITERATURE CITED

Harris, S. C. 1985. New Hydroptilidae (Trichoptera) from Alabama. J. Kans. Entomol. Soc. (in press).

Marshall, J. E. 1979. A review of the genera of the Hydroptilidae (Trichoptera). Bull. British Mus. (Nat. Hist.) Entomol. 39: 135–239.

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87(3), 1985, pp. 622–633

NUPTIAL FEEDING IN *SEPEDON* SPP. (DIPTERA: SCIOMYZIDAE)

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Abstract.—Courting males of *Sepedon fuscipennis fuscipennis* Loew, *S. f. floridensis* Steyskal, and *S. aenescens* Wiedemann release a nearly clear liquid anally that the females feed on during copulation. Other observers have indicated that an opaque, semi-solid nuptial food is secreted orally by males of *S. aenescens*, *S. senex* Wiedemann, *S. plumbella* Wiedemann, and *S. ferruginosa* Wiedemann. Males of *S. f. fuscipennis* also attract and nourish potential mates with foods (e.g. dead snails) that they discover and defend, and some *Sepedon* males mate without offering females anything. These systems are compared with other insect mating systems in order to suggest fruitful avenues for future research.

Reports in the literature suggest that mating in most species of Sciomyzidae (Diptera: Acalyptratae) is simple and direct. Published observations on a number of species in the genera *Antichaeta*, *Dictya*, *Elgiva*, *Perilimnia*, *Pherbellia*, *Shannonia*, and *Tetanocera* (see papers cited by Berg and Knutson, 1978, p. 240) all indicate that the males exhibit no distinctive courtship behavior. They simply leap onto females and quickly establish genitalic contact.

Neff and Berg (1966) observed that premating behavior in some species of *Sepedon* is far more elaborate than that indicated above. We have confirmed and extended their observations by studying one species that they also studied and two taxa not included in their report. In all three taxa, the male liberates an almost clear liquid anally that the female feeds on during copulation.

Our observations and those of others indicate that the use of attractive and/or nutritive substances, secreted anally or orally by the male, may be widespread in *Sepedon* and related genera. They also suggest differences in sites of origin of the nuptial food, and in nuptial uses of foods other than secretions, and indicate that matings sometimes occur without any food being transferred.

This paper is written to present our observations on the sequence of premating acts of *Sepedon fuscipennis fuscipennis* Loew, *S. f. floridensis* Steyskal, and *S. aenescens* Wiedemann, to enter some contrasting observations of others into the published record, to discuss and try to explain the obvious diversity and puzzling paradoxes reported, and to note the remarkable convergence in mating systems between *Sepedon* and *Panorpa* scorpionflies.

COURTSHIP OF *SEPEDON FUSCIPENNIS FLORIDENSIS*

Although described as a subspecies (Steyskal, 1951), *S. f. floridensis* is easily distinguished from *S. f. fuscipennis*, and it probably should be recognized as a distinct species. Our observations of the courtship of this little-known taxon are based on a rearing of flies collected at Highlands Hammock State Park, Highlands County, Florida.

The essential steps in the premating sequence of *S. f. floridensis* are illustrated in Figs. 1–6. Photographic prints were made from a strip of motion picture film of a pair that mated while standing on the side of a glass breeding jar. However, resolution was lost when selected frames of this 16-mm color motion picture film were greatly enlarged and reproduced in black and white. Therefore, the prints were traced, and obscured details were filled in by studying the original color frames on the stage of a dissecting microscope. The motion picture sequence was taken through the glass, so all pictures are ventral views.

The male initiated precopulatory behavior by touching the substrate with the tip of his abdomen and depositing a droplet of clear, transparent fluid (Fig. 1). This colorless droplet, presumably expelled through the anus, can easily be overlooked. It shows well on our film only because a floodlight was positioned so that the droplet reflected its light into the camera lens.

The male then lifted the tip of his abdomen, extended his wings laterally at right angles to his body axis, and vibrated them rapidly for a few seconds (Fig. 2). His wings were then returned to their resting position over his abdomen, but he repeated the wing vibration movement several times before a female was attracted. During this time, his abdomen bobbed up and down conspicuously, and his forelegs were frequently raised, waved about, and lowered.

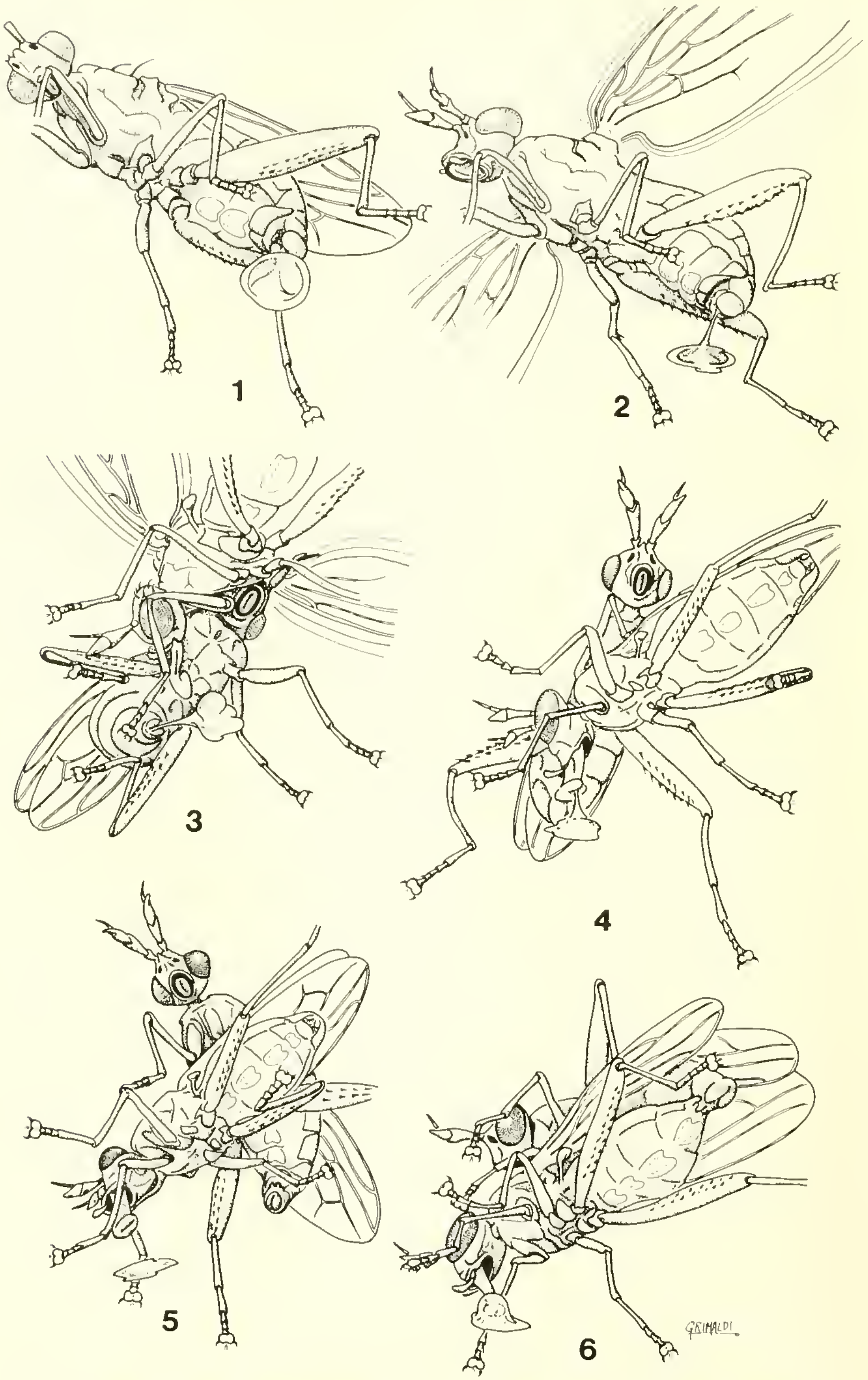
At this point in the sequence illustrated, the male noticed a female approaching from the upper right. He quickly shifted his position, facing her and placing himself between her and the droplet, so that she would have to crawl under him to reach it. The female approached in a crouching posture, with her labellum extended. For brief intervals, her wings were extended laterally and vibrated rapidly, apparently responding to the signal of the male (Fig. 3).

When the female started to feed, the male stepped onto her. They were still facing in opposite directions (Fig. 4). He rotated his body to align himself for copulation, temporarily distracting her from feeding (Fig. 5). When he attained the proper position, genitalic contact was quickly established. The female resumed feeding and continued to feed as long as copulation continued (Fig. 6).

Other matings of *S. f. floridensis* have followed the general pattern outlined above. In all instances that we have witnessed, the males have released the nuptial food anally, permitted the females to reach it only by crawling under them, mounted as they did so, and rotated their bodies to align themselves for copulation after mounting. We have never seen them whip the nuptial food into a froth with their mouthparts, as males of *S. aenescens* characteristically do, nor utilize other foods to attract females, as males of *S. f. fuscipennis* often do.

COURTSHIP OF *SEPEDON FUSCIPENNIS FUSCIPENNIS*

Sepedon f. fuscipennis has been studied intensively since it was involved in the discovery that sciomyzid larvae are predatory on snails (Berg, 1953). It is therefore better known biologically than any other taxon of Sciomyzidae (see papers by Arnold, Barnes, Eckblad, Eckblad and Berg, and Neff and Berg (1966) cited by Berg and Knutson (1978); and the recent study of sciomyzid phenology (Berg et al., 1982)). Our observations of its premating behavior are based on a laboratory



Figs. 1–6. Steps in the premating sequence of *S. f. floridensis*. (See text for full explanation.)

rearing started with flies collected in Tilden Township, Berks County, Pennsylvania.

This behavior is similar to that of *S. f. floridensis* in the anally deposited liquid that is fed upon by the female during copulation and in actions of the wings, abdomen, and forelegs of the male while trying to attract her to it. It differs from *S. f. floridensis* in the direction of approach when the male mounts the female, and the use of foods other than their own secretions to attract females may also be different. Instead of interposing himself between the droplet and the female so that she must crawl under him to reach it, the male of *S. f. fuscipennis* usually leans or steps back to give her free access to the droplet. Then, after she has started to feed, he walks around behind her and mounts, already properly aligned for copulation.

Males of this sub-species sometimes utilize other foods to attract a female and keep her occupied during copulation. Our breeding and oviposition jars are routinely supplied with a small pellet of a honey-yeast mixture and a freshly killed snail for supplementary protein. If a male is the first to find either of these foods, he may frequently interrupt his feeding on it to bob his abdomen up and down, raise and wave his forelegs, and rapidly vibrate his extended wings. He permits the attracted females that give the proper wing signal to approach and feed. Then they mate and usually remain in copula as long as she continues to feed.

Whether standing guard over droplets they have produced or food materials they have discovered, males prevent other males and often prevent females from reaching the food by raising their forelegs in a threatening pose and, if necessary, charging toward them. Females apparently are permitted to reach the food material only if they vibrate their wings to signal their willingness to mate. We have not seen this signal every time we have witnessed copulation, but it is given briefly and can easily be overlooked.

This affirmative or submissive signal must be distinguished from another wing signal that has almost the opposite meaning. If a fly flicks her wings several times in quick, lateral, scissors-like movements, other flies of both sexes take this as a warning not to come any closer. This signal is especially characteristic of females that have found a food mass and are already feeding on it. However, it may help them to defend choice oviposition sites as well as food resources.

Feeding of the female during copulation is so commonly observed in *S. f. fuscipennis* that it almost appears prerequisite to mating. We have watched many matings that continued for 9 to 21 minutes in which the females fed almost continuously throughout the process. There were only a few interruptions of less than 5 seconds to groom their mouthparts. When such prolonged matings occurred on a freshly killed snail or a fresh honey-yeast pellet, the female carried the male around freely and fed over the entire surface of the food mass. A male that managed to mate 11 times in about 50 minutes accomplished this by remaining on a freshly killed snail most of that time.

Whenever the female abandoned her food source, mating was promptly terminated. The male appeared to raise up as if signalled to do so, and the female walked out from beneath him. This orderly behavior was in contrast to what we commonly observed in *Dictya* spp. (Valley and Berg, 1977), where females had to dislodge males by shaking their bodies vigorously.

The great frequency of matings in the first few minutes after flies are introduced into new breeding jars—a phenomenon that mystified us for years—also is explained by the requirement of supplying the females with acceptable nuptial food. In jars more than a day old, impenetrable crusts form over the dead snails. The honey-yeast pellets also tend to dry and harden. In new breeding jars, both types of food are moist, soft, and readily accessible. Males who find them have more than enough food and excellent opportunities to mate.

Males were never observed to produce their nuptial fluid in new breeding jars, nor to place it on freshly killed snails or honey-yeast pellets, but they frequently deposited it on crushed snails that were old and dry. Females attracted to such dried snail remains fed only in the area moistened by the droplet.

Courtship of *Sepedon aenescens*

Sepedon aenescens was introduced into Hawaii from Japan several years ago to aid in a program of biological control of the snail host of the giant liver fluke of cattle. Harry Nakao, then State Entomologist of Hawaii, kindly sent us 30 puparia of this species. The 12 pairs of adult flies (plus three extra males) obtained from these puparia afforded many opportunities to observe courtship, mating, and oviposition.

Eight days after the first flies emerged, we discovered two pairs in copula. One of the females was eating from a frothy mass of opaque, white material that was fully as large as her head (cf. Fig. 7), stuck on the side of the plastic observation cell. She seemed to pull hard every time she leaned back to tear off more material. After ingesting that, she leaned forward again to get another portion. She continued to feed throughout the process of copulation.

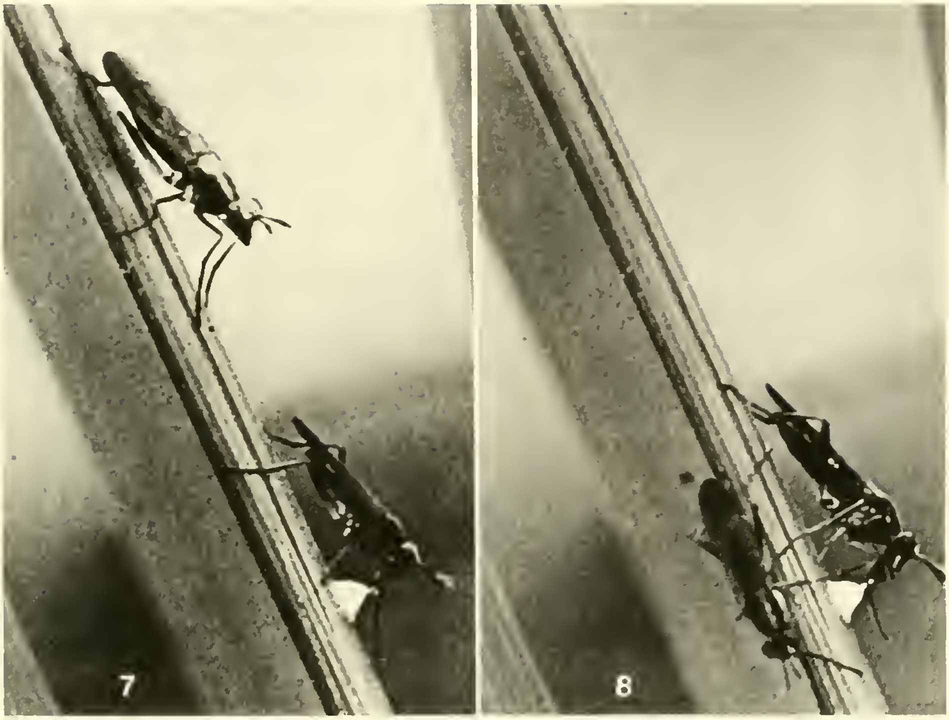
The other mating female clearly was not eating. There was no white, frothy material near her, and she did not extend her labellum to the substrate during the 12 minutes she was observed in copula.

A courtship and mating act observed two days later convinced us that the nuptial food of this species also is secreted from the tip of the male's abdomen. A fly was holding the end of its abdomen on the substrate in a posture suggesting oviposition. However, this individual was a male, and the substance being deposited was a low, flat droplet only about half the diameter of the fly's head. He lifted the tip of his abdomen two or three times and touched it down again, as if to deposit more of this transparent, faintly whitish fluid.

A minute later, he turned and began to work this material with his labellum. The mass quickly became much more conspicuous—larger in diameter and in height and opaque white instead of almost completely clear and colorless. A female fly approached, stopped about 3 cm from the mass, and stood still, evidently watching (cf. Fig. 7).

After about three minutes, the female walked forward (cf. Fig. 8). The male leaned away from her, as if to get out of her way so she could make contact with the white mass. As soon as she did he stepped up onto her, and they copulated almost immediately.

When her tarsi apparently slipped, the mating pair fell to the moss covering the bottom of the observation cell. She walked, carrying the male, back up the vertical wall of the cell (about 4 cm), found the white mass about a minute later,



Figs. 7, 8. A male of *S. aenescens* whips the nuptial food into an opaque, white froth and attracts a female to it. (Both from S.-Y. Lee, in Green, 1977).

and resumed feeding. Sexual contact apparently was not broken during this episode.

A male fly approached the mating pair and fed on the white mass with the mating female. Then he stepped up onto the mating pair and apparently tried to copulate with the copulating male. The white mass was now reduced to about half the size of a fly's head. The second male again joined the female in feeding on it. About five minutes after his first approach, he tried again to mate with the mounted male, then walked away.

About 12 minutes after the female started to feed and mating began, we could no longer see any nuptial food. However, continued labellar action of the female indicated that she tried for two more minutes to get more food. The pair then sat still, but we observed five minutes later that they were no longer in copula, and a minute after that (18 minutes after copulation began) the male dismounted.

Observations of the mating of *S. aenescens* show great variability in nuptial feeding. We have seen just as many mating pairs in which the female clearly was not eating anything as pairs in which female feeding was involved. The behavior lacks uniformity and predictability also because the male frequently eats the secreted nuptial food himself. This sometimes happens after a male has whipped it into a frothy mass and tried to attract a female, but males also have been observed to deposit the clear liquid anally, then promptly turn and eat it.

We have not observed males of either *S. aenescens* or *S. f. floridensis* using other foods (e.g. dead snails) to attract receptive females. However, we have spent less time watching those species and we were not specifically looking for it. *Sepedon f. fuscipennis* almost certainly is not the only taxon of *Sepedon* utilizing this mating system; a slide showing the female of *S. sphegea* (Fabricius) (Palearctic) feeding on a dead snail during copulation suggests that it may be used in that species.

Observations of Others on Asiatic Species of *Sepedon*

Observations of courtship and mating of *Sepedon* have been made by others on four palearctic species. Sung-Yang Lee (in Green, 1977) observed and photographed a "sciomyzid fly" on Taiwan that he did not further identify. His excellent color pictures (reproduced here in black and white as Figs. 7 and 8) identify the subject positively to the genus *Sepedon* and suggest strongly that it is *S. aenescens*. Ookeow Beaver (unpublished) observed courtship and mating of *S. senex* Wiedemann and *S. plumbella* Wiedemann in Thailand, and K. Durga Prasad (presumably unpublished) observed these activities of *S. aenescens*, *S. plumbella*, and *S. ferruginosa* Wiedemann in India.

Those observations were made several years ago, and further publication of them now appears unlikely. However, observations of such significance should be recorded and preserved. By differing from ours in fundamental ways, they pose important questions that should be raised. We are therefore taking the liberty of summarizing the observations of Mr. Prasad and Dr. Beaver and of quoting excerpts from the research notes they kindly sent us.

Lee reported that the male of what appears to be *S. aenescens* exudes a white, frothy substance orally and that this material is eaten by the female during copulation (Figs. 7, 8). Prasad corroborated this in observations recorded under *Sepedon sauteri* Hendel, a junior synonym of *S. aenescens* (Knutson and Orth, 1984). He added that he has "many times" observed production of the "white mass" in nature, with several female flies and "sometimes even male flies" congregating within a radius of 15 cm "in an excited condition."

In a section entitled, "Origin of the White Mass," Prasad recounted the dissection of flies of both sexes without identifying the species involved. He found "long, coiled salivary glands reaching almost the tip of the abdomen" in males. In females, those glands were "much shorter, smaller in diameter," and only "half the size" of the male salivary glands. He concluded that the male salivary glands enlarged as they assumed the added function of producing the nuptial food.

Beaver first saw the "viscous, white material" on the mouthparts of a male *S. senex*. She watched him place it on the substrate, saw mating occur as the female consumed it, then saw that "more of the substance oozed out from his proboscis." Although we had told her of our conviction that *S. aenescens* produces the nuptial food anally, she remains convinced, after watching this and several other matings of *S. senex*, that this species produces it orally.

Both Prasad and Beaver reported production of the "white mass" as an important element in the mating behavior of *S. plumbella*. Prasad stated that it is secreted "through its labellum," and Beaver's wording is "from his proboscis." Prasad indicated that the male "guards it aggressively by lifting its forelegs and swiping at the incoming female." Both recounted "pseudofights" between the male and female, a term[1] that Beaver applied also to premating activities of *S. senex*.

Both stated that males of *S. plumbella* produced more white material while mating. This is another phenomenon that Beaver also observed in *S. senex* and another indication of great similarity in the courtship and mating activities of these two species. Prasad mentioned watching a male *S. plumbella* produce the "white mass" five times in about 15 minutes, finally attracting a female and mating with her. While still mounted, it produced a sixth issue of nuptial food, finally dismounting with "a big white mass sticking to its labellum." It placed this material on a leaf, manipulated it with its mouthparts until the female was attracted again, and mated again.

In *S. ferruginosa*, Prasad believes that nuptial food functions more to pacify females during copulation than as a lure to get them to mate.[2] Although males of that species sometimes produce this material before mating and use it to attract the female, he saw several matings that started without any evidence of nuptial food. The males simply jumped onto the females.

However, he saw much evidence of its production after mating was in progress, with males producing it one, two, or three times during a mating process. These males produced the white material orally, and it came out "in the form of coils." They placed it on the antennae of their female partners, and some females removed it with their forelegs and devoured it while mating. Others removed it, but left it on the substrate in front of them. In such instances, the male usually ate this material after he dismounted.

DISCUSSION

Extent of Nuptial Feeding in Sciomyzidae and Other Diptera.—Nuptial feeding is known in the dipterous families Empididae (Downes, 1970, and references therein), Micropezidae (Wheeler, 1924), Platystomatidae (McAlpine, 1973, and papers cited therein), Sciomyzidae (Green, 1977, and this paper), Tephritidae (reviewed by Friedberg, 1982), and Asteidae (Friedberg, 1984).[3]

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[1] This term evidently refers to the state of strife when a female tries to feed without signalling her willingness to mate, and the male seems determined to prevent this. Probably because it is followed quickly in many instances by the ultimate gesture of amiability, Beaver and Prasad evidently concluded that it is not a real fight. However, males that defend a rich food resource in order to attract mating partners assault all intruders except *receptive* females with surprising vigor. Until a female signals her receptivity, she is, like other intruders, just stealing the male's valuable resources and giving nothing in return.

[2] Neither he nor Beaver mentioned its possible value in nourishing the female for greater egg production.

[3] Consideration of the foods and feeding habits of these flies raises serious doubts concerning the proposition of Kessel (1955, p. 98) and others, that nuptial feeding serves to protect the lives of courting males from predatory and potentially cannibalistic females. Only the Empididae and the Micropezidae are predatory, and the Micropezidae prey only on much smaller insects. Thus, lives of the males are in no jeopardy in five of the six families. Even in the Empididae, where cannibalism of males by females is known to occur, closer observation has indicated that the males thus victimized probably were newly emerged and teneral. Downes (1970, p. 790) wrote that he could not "find any record in the literature of the eating of the male by the female *at the time of mating* (our italics) either in the three genera in question or in other Empididae." In the robber flies (Asilidae), where the

In the Sciomyzidae, there are indications that nuptial feeding is widespread not only in species of *Sepedon,* but also in two closely related genera. *Sepedomerus* was split off from *Sepedon* (Steyskal, 1973) to receive Neotropical species having relatively minor differences from the taxa retained in *Sepedon.* The Neotropical genus *Thecomyia* is not quite so close to *Sepedon,* yet far more similar to it than are most genera of the Tetanocerini. Steyskal (1973) placed it in the "*Sepedon* group," a distinctive assemblage of genera that Steyskal and Verbeke (1956) had earlier called the Sepedoninae.

Neff and Berg (1966) were reporting observations made primarily on *Sepedomerus caeruleus* (Melander) when they wrote: "Prior to mating, the male . . . forelegs are raised and lowered nervously and a bobbing motion of the abdomen occurs. His wings are extended laterally from their resting position over the abdomen, vibrated rapidly for several seconds, and then returned to the resting position. The frequency of these wing vibrations increases as long as the female remains still and presumably receptive; however, if she backs away and flicks her wings several times in quick scissors-like movements, the male ceases his display. If the female remains still and gives no wing motion, the male circles behind her slowly and mounts her from behind."

Concerning *Thecomyia limbata* (Wiedemann), Abercrombie and Berg (1975) wrote: "Prior to mating, the male frequently stands about 5–7 cm in front of the female, waving his forelegs while resting on his mid- and hindlegs. At the same time, he holds his wings obliquely upward and outspread."

Although neither quotation mentions the inconspicuous droplet of nuptial food, and the latter does not even stipulate that the male's outstretched wings were vibrating, a detailed reexamination of courtship probably would reveal that nuptial feeding is involved in both species. It is far more significant that certain male actions associated only with the sciomyzid species known to employ nuptial feeding were observed than that other actions associated with those males were not. We often fail to see what we are not looking for, even when it is clearly visible.

An Oral or Anal Secretion?—The contrasting observations of courtship and mating reported here suggest fundamental differences that are not easily explained. Before we saw the research notes of Beaver and Prasad, we felt comfortable with the conclusion that *Sepedon* males secrete the nuptial food anally. This is unquestionably true in *S. f. fuscipennis* and *S. f. floridensis,* where male mouthparts never contact this material unless the male decides to eat it.

Opinions that it is secreted orally seemed accountable to incomplete observations of courtship in *S. aenescens.* The small, clear droplets secreted anally by males of that species are not easily seen, and Lee (in Green, 1977) presumably never looked for them. He probably did not suspect that premating activity had begun until after the male turned and got his labellum into this material. Therefore, he drew the logical but erroneous conclusion, "To woo his chosen mate, this six-legged lover exudes a white froth from his mouth . . . ."

However, we cannot conclude that Beaver and Prasad were overlooking an anal origin of nuptial food when they saw it appear on the mouthparts of males that

assertion that nuptial feeding protects the lives of courting males (Cloudsley-Thompson, 1961, p. 89) may seem completely credible, female feeding while *in copula* evidently does not result from nuptial feeding, but from opportunistic males pouncing on females with prey! Dennis and Lavigne (1975, p. 49) stated, "There is no evidence to suggest that males offer females food . . . ."

were already in copula. Since copulating males could not turn to recover an anally secreted substance, oral secretion seems evident in the three species concerned, *Sepedon senex, S. plumbella*, and *S. ferruginosa*.

It may seem unlikely that closely related species are producing this material in totally different parts of their bodies. However, Alcock (1981) has reported both oral and anal secretion of nuptial food in closely related species of Australian thynnine wasps. Perhaps the course of evolution of nuptial feeding in *Sepedon* may suggest an explanation of this puzzling situation.

The Evolution of Nuptial Feeding in *Sepedon*.—The ability of *Sepedon* males to secrete a nuptial food probably evolved by a gradual, step-wise process. As indicated above, males of *S. f. fuscipennis* often take possession of food items that they have found, defend them against other flies, and use them both to attract a willing female and to occupy her attention during a prolonged mating process. When they find dead snails that have dried and formed hard surface crusts, they deposit droplets of the nuptial food on them, soften the crust, and render them accessible for hungry females.

This suggests that the first step in the evolution of nuptial food deposit may have been the habit of placing a droplet of liquid from the hind gut onto any dried animal matter found in nature. Males secreting this liquid would have had positive selective advantages, even if it contained no nutritive substances nor volatile pheromones. By simply moistening bits of dried animal matter, they made them valuable to the females as food, hence valuable to themselves as female attractants.

Pheromones and other additives may have evolved later in some species of *Sepedon*, either incorporated into the nuptial food or released in association with it. Courting males of several insect species combine nuptial feeding with pheromone production, and the *Sepedon* habit of rapidly vibrating their wings after depositing this material suggests a pheromone-dispersing function. Pheromone dispersal is the demonstrated or suggested function of rapid wing vibrations following the eversion of abdominal glands and/or the extrusion of visible droplets by courting males of a drosophilid and two tephritids (Spieth, 1974, p. 397; Féron, 1962, p. 37–45; Friedberg, 1982).

However, the "nuptial food" deposited anally may still be nothing more than hind gut contents. When the male of *S. aenescens* turns and whips the anal secretion into an opaque froth, he may be adding salivary secretions to supply nutrients, pheromones, and substances to partially solidify this material. This would suggest why the male salivary glands may be enlarged even in a species that begins by depositing a droplet anally. It might also suggest an evolutionary link between a primitive practice of simply moistening existing food with a droplet of gut contents and an advanced condition of relying solely on the salivary glands to supply semi-solid, and perhaps nutritious and pheromone-impregnated nuptial food.

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Males of *Sepedon f. fuscipennis* that find a freshly killed snail[4] advertise its availability to potential mates by conspicuous movements of their wings, abdo-

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[4] *Sepedon* larvae are voracious snail predators that abandon their prey when satiated. Since the weak-flying adults remain in larval breeding sites, snails killed by their larvae may be their major

mens, and forelegs. Males of this and other species of *Sepedon* also attract receptive females by similar displays after releasing oral and anal secretions. These probably consist chiefly of snail tissues digested and transformed to varying degrees. *Sepedon* males that do not offer their potential mates either secretions or a snail often jump onto females and sometimes succeed in mating.

Like males of other species that can monopolize a rich food resource, *Sepedon* males that either "possess" a snail or release secreted nuptial food have something of value to offer to receptive females. They may therefore have unusual reproductive success relative to other males in their populations. Mating systems in which males find and defend resources to which females will be attracted (oviposition sites as well as foods) are discussed informatively by Thornhill and Alcock (1983, p. 248–252).

Our objectives in publishing this preliminary report are to stimulate someone to make a far more thorough study of this intriguing subject, to lay some groundwork for launching that study, and to suggest some profitable avenues of investigation. Unanswered questions that merit further research are suggested or implied throughout. Other questions very worthy of study are suggested by the striking degree of convergence between *Sepedon* and *Panorpa* (Mecoptera: Panorpidae) (Thornhill, 1981; Thornhill and Alcock, 1983, p. 271–272). The three alternative techniques utilized by males of *Panorpa* to obtain a mating closely resemble the three listed above for males of *Sepedon*.

In some species of *Panorpa*, males defend rich food resources (e.g. dead crickets) and enjoy disproportionate reproductive success. Others, if sufficiently well fed, offer salivary masses to females, who will accept them if there are no carrion defenders at the site. Still others, less well fed, attempt to mate without offering females anything. Sometimes, although rarely, they succeed in doing so.

Would a quantitative study of *Sepedon* and related genera reveal that the reproductive success of males is proportional to the resources they control, with males on freshly killed snails doing better than secretion producers, which in turn do better than those without a gift? Would it also show that female fecundity and the interval between this and the next mating are proportional (as in *Panorpa*) to the food ingested during each mating? In short, does the male that offers a nuptial gift gain the advantage that his mate will lay more eggs fertilized by him than by a male that cannot offer anything?

ACKNOWLEDGMENTS

Ookeow Beaver, Department of Biology, Chiangmai University, Chiangmai, Thailand, and K. Durga Prasad, then a biology student at the College of Agriculture, Hebbal, Bangalore, India, kindly sent us their unpublished research notes, then corresponded repeatedly with us to try to explain the contrasts between their observations and ours. Sung-Yang Lee, entomologist and expert insect photographer of Taiwan, made the photographs reproduced here as Figs. 7 and 8. David Grimaldi made the drawings (Figs. 1–6) and counselled with us concerning the manuscript and pertinent literature. R. E. Orth checked our voucher specimens

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source of protein (Berg and Knutson, 1978, p. 246). The importance of this rich food resource is now seen to extend beyond their own nourishment to play crucial roles in reproductive success of the males and in essential nourishment that the females translate into egg production.

of *S. f. fuscipennis* and *S. f. floridensis*, confirmed our identifications, and returned this material for deposit in the Cornell University Insect Collection. He and B. A. Foote, L. Knutson, and S. E. Neff read and suggested improvements in the manuscript. We are especially grateful to John Alcock, whose special interest in insect mating systems and broad knowledge of them made his comments uniquely valuable.

LITERATURE CITED

Abercrombie, J. and C. O. Berg. 1975. Natural history of *Thecomyia limbata* (Diptera: Sciomyzidae) from Brazil. Proc. Entomol. Soc. Wash. 77: 355–368.

Alcock, J. 1981. Notes on the reproductive behavior of some Australian thynnine wasps (Hymenoptera: Tiphiidae). J. Kans. Entomol. Soc. 54: 681–693.

Berg, C. O. 1953. Sciomyzid larvae that feed on snails. J. Parasitol. 39: 630–636.

Berg, C. O. and L. Knutson. 1978. Biology and systematics of the Sciomyzidae. Ann. Rev. Entomol. 23: 239–258.

Berg, C. O., B. A. Foote, L. Knutson, J. K. Barnes, S. L. Arnold, and K. Valley. 1982. Adaptive differences in phenology in sciomyzid flies. Mem. Entomol. Soc. Wash. 10: 15–36.

Cloudsley-Thompson, J. L. 1961. Animal behavior. Oliver and Boyd, Edinburgh. 162 pp.

Dennis, S. D. and R. J. Lavigne. 1975. Comparative behavior of Wyoming robber flies II (Diptera: Asilidae). Univ. Wyo. Agric. Exp. Stn. Sci. Monogr. 30: 1–68.

Downes, J. A. 1970. The feeding and mating behavior of the specialized Empidinae (Diptera); observations on four species of *Rhamphomyia* in the high arctic and a general discussion. Can. Entomol. 102: 769–791.

Féron, M. 1962. L'instinct de reproduction chez la mouche Méditerranéenne des fruits *Ceratitis capitata* Wied. (Dipt. Trypetidae). Comportement sexuel.—Comportement de ponte. Rev. Pathol. Végétale Entomol. Agr. Fr. 41: 1–129.

Friedberg, A. 1982. Courtship and post-mating behaviour of the fleabane gall fly, *Spathulina tristis* (Diptera: Tephritidae). Entomol. Gener. 7: 273–285.

———. 1984. The mating behavior of *Asteia elegantula* with biological notes on some other Asteidae (Diptera). Entomol. Gener. 9: 217–224.

Green, T. 1977. A man's obsession reveals the riches of a hidden world. Smithsonian 8(8): 80–87 (November 1977).

Kessel, E. L. 1955. The mating activities of balloon flies. Syst. Zool. 4: 97–104.

Knutson, L. and R. E. Orth. 1984. The *Sepedon sphegea* complex in the Palearctic and Oriental Regions: identity, variation, and distribution (Diptera: Sciomyzidae). Ann. Entomol. Soc. Am. 77: 687–701.

McAlpine, D. K. 1973. Observations on sexual behaviour in some Australian Platystomatidae (Diptera, Schizophora). Rec. Aust. Mus. 29: 1–10.

Neff, S. E. and C. O. Berg. 1966. Biology and immature stages of malacophagous Diptera of the genus *Sepedon* (Sciomyzidae). Va. Agric. Exp. Stn. Bull. 566: 1–113.

Spieth, H. T. 1974. Courtship behavior in *Drosophila*. Ann. Rev. Entomol. 19: 385–405.

Steyskal, G. C. 1951(1950). The genus *Sepedon* Latreille in the Americas (Diptera: Sciomyzidae). Wasmann J. Biol. 8: 271–297.

———. 1973. A new classification of the Sepedon group of the family Sciomyzidae (Diptera) with two new genera. Entomol. News 84: 143–146.

Steyskal, G. C. and J. Verbeke. 1956. Sepedoninae (Sciomyzidae, Diptera) from Africa and southern Arabia. Bull. Inst. R. Sci. Nat. Belg. 32(7): 1–14.

Thornhill, R. 1981. *Panorpa* (Mecoptera: Panorpidae) scorpionflies: systems for understanding resource-defense polygyny and alternative male reproductive efforts. Ann. Rev. Ecol. Syst. 12: 355–386.

Thornhill, R. and J. Alcock. 1983. The evolution of insect mating systems. Harvard University Press, Cambridge, Massachusetts, and London, England. 547 pp.

Valley, K. and C. O. Berg. 1977. Biology, immature stages, and new species of snail-killing Diptera of the genus *Dictya*. Search, Cornell Univ. 7(2): 1–44.

Wheeler, W. M. 1924. The courtship of the calobatas. J. Hered. 15: 485–495.

PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 634–640

OXYBELUS (ANOXYBELUS) MAIDLII KOHL, AN *OXYBELUS* WITH UNUSUAL FEATURES (HYMENOPTERA: SPHECOIDEA: CRABRONIDAE)

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Abstract.—The previously unknown male of the Indian *Oxybelus (Anoxybelus) maidlii* Kohl is described from Sri Lanka, and additional descriptive notes are given for the female. Males exhibit allometric growth. Females have a pair of processes on the posterior surface of the head that may function in prey carriage or nest construction. *Anoxybelus* Kohl is revalidated as a subgenus with two included species, *O. maidlii* from the Indian subcontinent and *O. stevensoni* Arnold from Zimbabwe.

Oxybelus maidlii Kohl (1924: 274–277, figs. 9, 10) has been a puzzle for years. Described from a single female from Abu, it was so unusual that Kohl proposed the new subgenus *Anoxybelus* for its reception. The anomaly was that this female lacked a mucro on the propodeum, whereas both sexes of all previously described *Oxybelus* possessed such a process. Subsequent aculeate hymenopterists were conservative in their treatment of the taxon, perhaps suspecting that Kohl described an aberrant specimen. Pate (1937: 387) retained *Anoxybelus* as a provisional subgenus, noting that the lack of a mucro appeared to be the only distinguishing character. Bohart and Menke (1976: 46) did not recognize any subgenera in *Oxybelus*, placing all genus-group names in synonymy.

During one of my trips to Sri Lanka I collected at Kondachchi, Ma Villu, Mannar District, 11–12 April 1981. This large area is being developed as a cashew plantation but substantial tracts of monsoon scrub jungle still remain. I obtained seven males of a distinctive species of *Oxybelus*. The species was unusual because of the variation in size coupled with an allometric development of several structures. It had a well developed mucro (Fig. 8). I placed it (1983: 38) as an unidentified species of Ceylonese *Oxybelus*, speculating that it might be the opposite sex of a species described from an Indian female.

In 1984 I received three *Oxybelus* that were collected in 1976 in Malaise traps at two sites near Padaviya, Anuradhapura District, by P. B. and S. Karunaratne and D. W. Balasooriya during field work for the Smithsonian Insect Project. A pair was collected 13–22 March in one trap and a single female 13–20 March in the other trap. The male is identical with my series from Kondachchi. The females agree perfectly with Kohl's description of *O. maidlii* including the lack of a propodeal mucro. There is excellent concordance between the females and males in the unusual coloration and in the surface sculpture, leaving no doubt that these are opposite sexes of the same species.

DISTRIBUTION AND ECOLOGY

Kohl gave the type locality of *O. maidlii* as Abu, Baluchistan, now the westernmost province of Pakistan. Abu, however, is in the extreme southwestern part of Rajasthan, India. The type in the British Museum (Natural History) bears only one of Nurse's typed labels, "Abu." Nurse (1903: 393) noted that his specimens were collected by a native at Mount Abu in 1901. He said the climate at Deesa "about 40 miles distant" was hot and dry with an average annual rainfall "from 25 to 30 inches." The area around Mt. Abu is similarly xeric, and presumably has the same amount of rain, an annual average of 635–760 mm.

Ma Villu at Kondachchi is 5 km from the northwest coast, a few meters above sea level, and a short distance from Adams Bridge between Sri Lanka and India. Padaviya is about 100 km east of Ma Villu at an altitude of about 55 m. Both localities are in the Dry Zone and receive most of their average annual rainfall of 965 and 1490 mm respectively from October to December during the northeast monsoon.

The meager available data suggest that *O. maidlii* probably is restricted in Sri Lanka to the most xeric areas in the northwest at low altitudes, and perhaps also in similar xeric areas in the southeast. Presumably it may be found in similar situations in India and perhaps even as far as western Pakistan.

I collected the males at Ma Villu along a trail in the scrub jungle in a small area of a few square meters open to the sun. They were making short flights, frequently perching momentarily on desiccated, disintegrated strawy elephant dung. They were quite fresh and were probably awaiting the emergence of females from the sandy loam. The Padaviya specimens were captured in Malaise traps set at two sites in scrub jungle. Both sexes have a well developed pecten on the fore tarsi. Undoubtedly the females nest in the soil and the males dig resting burrows therein.

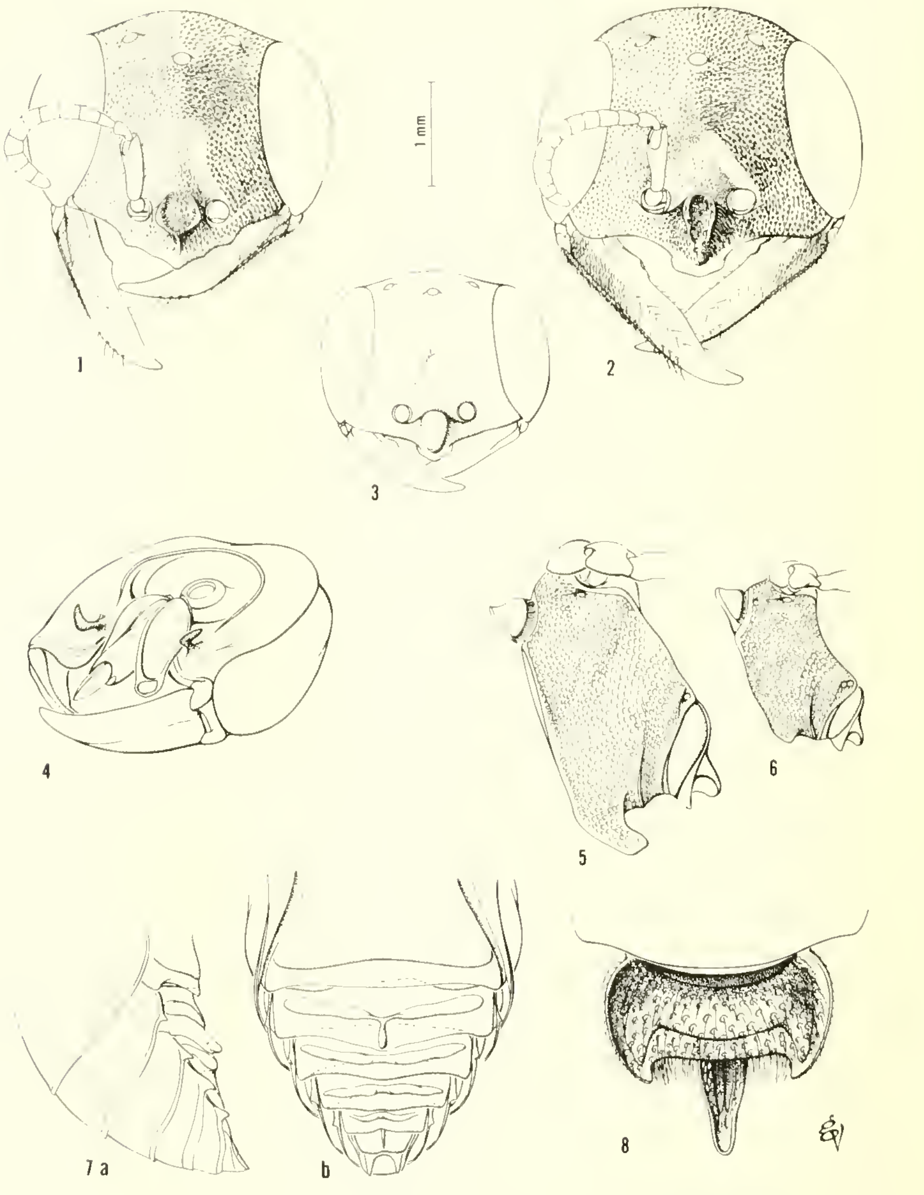
SYSTEMATICS

Oxybelus maidlii exhibits several unusual characteristics that distinguish it from most species in the genus. Although the male has a mucro on the propodeum (Fig. 8) as do both sexes of other species in the genus, this peculiar feature is not present in the female. Both sexes have a light red scutum, seemingly a trivial character but actually of some significance at the subgeneric level.

The female has a pair of stout, angled, outwardly and obliquely directed processes on the posterior surface of the head (Fig. 4). The basal half of the clypeus in both sexes is strongly raised medially with curved or oblique lateral ridges that meet or almost meet below (Figs. 1–3).

The males vary greatly in size, the body length ranging from 5.8 to 8.7 mm. Allometric growth associated with increasing size is manifested in mandible length (Figs. 2, 3) and development of a ventral lamella on the mesopleuron (Figs. 5, 6). Allometric growth is also present on sterna III–VI of the male (Fig. 7) which have a series of transverse rounded ridges across the middle, decreasing in magnitude posteriorly, that on II with a median digitate process whose apex lies above but does not extend beyond the translucent apical third of the sternum.

Color and Vestiture.—Black, flagellum beneath and scutum light red as are the fore femur and tibia beneath of the female, the following white: basal two-thirds



Figs. 1–8. *Oxybelus (Anoxybelus) maidli* Kohl. 1, Female head, anterior aspect. 2, Head of large male, *idem*. 3, Head of small male, *idem*. 4, Female head, oblique view of posterior aspect, palpi omitted. 5, Mesopleuron of large male (pronotal lobe, tegula and wing base above; mid coxa at lower right). 6, Small male, *idem*. 7, Male abdominal segments II–VIII (a, lateral; b, ventral). 8, Male metanotum and propodeal mucro.

of mandible, scape beneath, short lateral stripe on pronotal collar, pronotal lobe, lateral spot on scutellum, squama and posterior half of metanotum except lateral and posterior margins colorless and transparent, small apical spot on femora, stripe on outer surface of anterior tibia, stripe beneath on posterior tibia of female, posterior tarsus of female, narrow stripes on posterior third of terga I–IV decreasing in width posteriorly and narrowly separated along midline, female with large median blotch of variable extent merging with narrow line posteriorly on sternum II, and narrow median line on III, male with narrow stripes across the middle of sterna II–IV or V decreasing in width posteriorly, that on II broadened laterally, posterior third or less of sterna II–V (♀) or VI (♂) in both sexes translucent. Vestiture moderately dense on head, appressed on clypeus, front and gena, erect on ocellar area and vertex; median cell more sparsely setose on posterior half; sterna III–VII of male with brushes of longer erect cinereous setae.

Male.—Length 5.8–8.7 mm, forewing 4.1–5.9 mm. Head in frontal view (Figs. 2, 3), mandible disproportionately longer and vertex more arched above eyes in larger specimens; clypeus with basal prominence in middle margined by curved, occasionally obsolescent ridges, apical margin with rounded median lobe, edentate; front and vertex with close small punctures except scapal basin mostly smooth; ocellar tubercles and genal carina lacking.

Thorax with pronotal margin absent at angle, stronger on lobe than medially; mesonotum more strongly arched in larger specimens, median groove lacking; scutellum with median carina weak, present only posteriorly if at all; metanotum (Fig. 8) without median carina, squama evenly incurved and without inner lobe; mesopleuron in larger specimens with a large lamella anteroventrally (Fig. 5) which is reduced disproportionately in smallest specimens to a slight projection (Fig. 6); propodeal mucro (Fig. 8) tapering toward apex, basal width slightly less than half length.

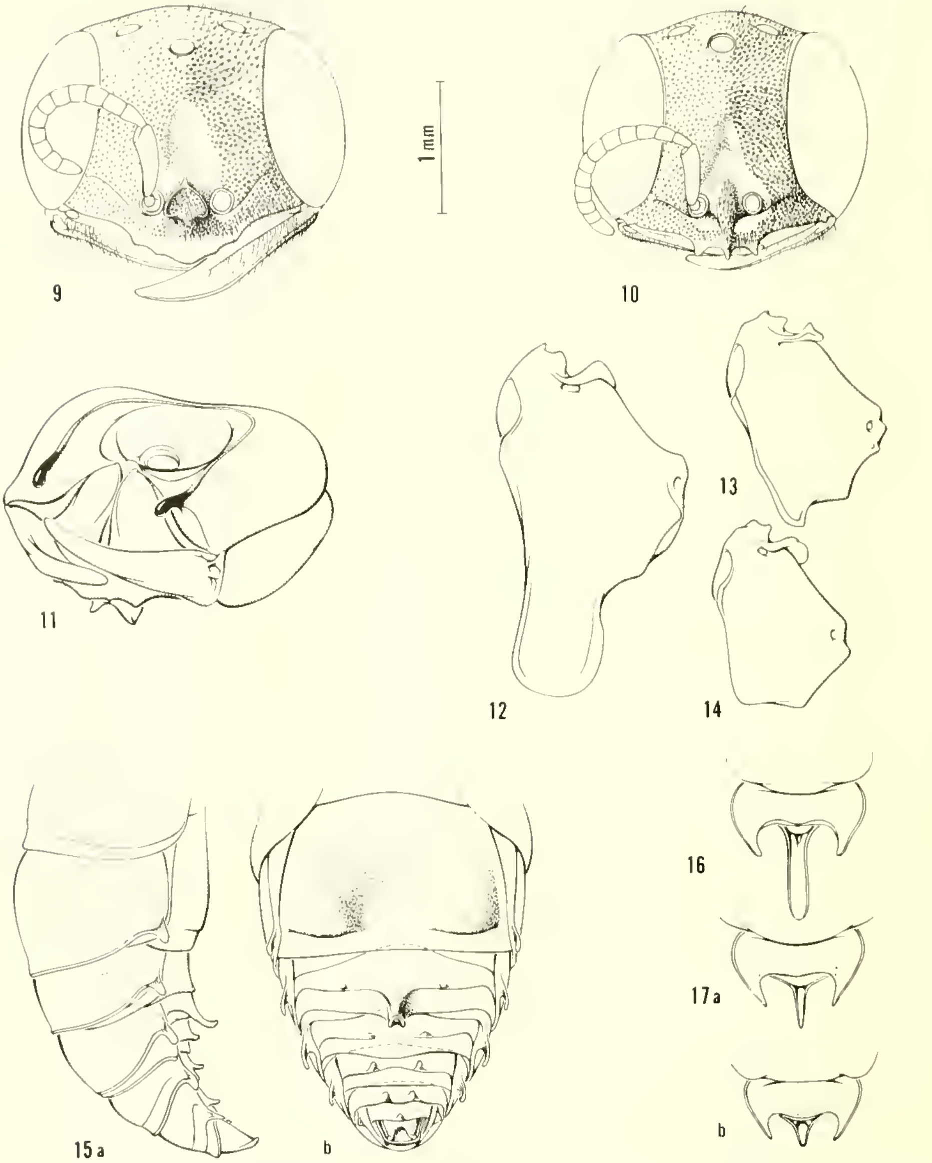
Apical fourth of abdominal terga slightly depressed below anterior part; terga III–VI with posterolateral tooth, that on III smaller; tergum VII with lateral margins weakly carinate and converging slightly posteriorly; sterna III–VI with strong, rounded transverse ridges, that on III with a median digitate process that is reduced to a tubercle in smallest specimens, narrow area behind ridges with brushes of erect setae; sternum VII with median longitudinal ridge weak or obsolescent.

Female.—Length 8.2–8.7 mm (Kohl states 9 mm for type), forewing 5.8–5.9 mm. As in male except as follows: head in frontal view (Fig. 1); clypeus with basal prominence more strongly ridged laterally, ridges sometimes meeting below, area below prominence with weak median ridge almost to apex, apical margin quinquedentate, tooth between median and lateral teeth very weak; head posteriorly (Fig. 4) with a pair of stout, angled, outwardly and obliquely directed processes on gena, separated from both occipital and hypostomal carinae though quite close to former; mesopleuron without anteroventral projection; propodeal mucro absent; terga without posterolateral tooth; pygidium with decumbent golden setae; sterna without ridges or brushes of erect setae.

Discussion

The combination of the processes on the posterior surface of the head in the female, the occurrence of allometric growth of the mesopleuron and sterna III–VII of the male, and the red scutum in both sexes distinguish *O. maidlii* of the Indian subcontinent and *O. stevensoni* Arnold, 1927, of Zimbabwe from other known species of the genus. To these characters may be added the absence of a propodeal mucro in the female of the former species and the noticeable reduction of the mucro in the female of the latter (Figs. 17a, b).

Cephalic Processes of Female.—The pair of processes on the posterior surface



Figs. 9–17. *Oxybelus (Anoxybelus) stevensoni* Arnold. 9, Female head, anterior aspect. 10, Male head, *idem*. 11, Female head, oblique view of posterior aspect, palpi omitted. 12–14, Mesopleuron of successively smaller males. 15, Male abdominal segments II–VIII (a, lateral; b, ventral). 16, Male metanotum and propodeal mucro. 17a, b, Metanotum and mucro of the two females.

of the female head was not noted by Kohl or Arnold. The head is held close to the forelegs in pinned specimens and the silvery vestiture on the gena also tends to obscure the processes. The processes are separated from the hypostomal and occipital carinae in *O. maidlii* but the hypostomal carina extends to the process in *O. stevensoni*. The function of the processes is unknown but I suspect that they could be used either in transporting slender prey or in removing soil from the nests. Published data on other *Oxybelus* indicate that all prey upon Diptera and transport their prey either by impaling it on the sting or by carrying it with the mid and/or hind legs. Alternately, the processes could be grasped by the male during mating. The male fore tarsi, however, are not especially modified and are like those of other *Oxybelus*.

Females of both species have a strong median prominence at the base of the clypeus unlike the conformation of this area in other species. The sides are strongly ridged laterally, curved and meeting below or almost so in *O. maidlii* (Fig. 1), angulate and not meeting below in *O. stevensoni* (Fig. 9). The male clypeus is somewhat similarly modified in *O. maidlii* (Fig. 2), but in *O. stevensoni* (Fig. 10) the clypeus has a broad median process tapering to a point apically and overlying the median tooth of the thickened tridentate apical margin.

Allometric Growth in Male.—The males of *Anoxybelus* exhibit allometric growth on several parts of the body.The mandibles are disproportionately enlarged as the body size increases in *O. maidlii* (Figs. 2, 3), but not in *O. stevensoni* (Fig. 10).

The mesopleuron also demonstrates this kind of growth, the anteroventral area lacking a projection or having only a barely perceptible one in the smallest specimens of both species. As the body size increases there is a disproportionate enlargement of this area to form a lamelliform process extending downward (cf. Figs. 5, 6, 12–14).

A gradual arching of the top of the head is associated with the longer mandibles in *O. maidlii*. Undoubtedly this accommodates the increased musculature required to manipulate the mandibles. Presumably males with larger mandibles may be able to compete for females more successfully than their smaller conspecifics.

Concomitant with the overall increasing body size is gradual arching of the scutum. Doubtless this reflects the enlarged musculature needed for flight in heavier-bodied individuals.

Sternal Armature of Male.—Transverse rounded ridges on abdominal sterna III–VI are more strongly developed in *Anoxybelus* (Figs. 7a, b and 15a, b) than in other *Oxybelus*. A feature peculiar to the former subgenus is the presence of a digitate process on the middle of the ridge on sternum III that is reduced to a tubercle in small specimens or may be lacking in some *O. stevensoni* including the type. Larger specimens of *O. stevensoni* have a swollen rounded ridge toward the side of sternum II, not an oblique carina as Arnold stated. The transverse rounded ridges of sterna IV–VI in *O. stevensoni* are produced into a tubercle on either side of the midline in larger specimens, and there is a small median tooth on sternum VII; these modifications are not present in *O. maidlii*.

Coloration.—The two species of *Anoxybelus* are the only *Oxybelus* in which the scutum is light red. This sclerite is sometimes partly red in the North American *O. cornutus* Robertson but the erythrism is of a different character. If present, it does not cover the entire scutum but leaves a black area of variable extent posteriorly. Furthermore, the scutum may be entirely black, more frequently so in males than in females.

The two species differ from each other in that the pale maculations are white in *O. maidlii*, lemon yellow in the male of *O. stevensoni* and whitish yellow in that female. Also, the last two (♀) or three (♂) abdominal segments are light red in the latter species and black in *O. maidlii.* There is a size difference also, males of *O. maidlii* being 5.8–8.7 mm long, those of *O. stevensoni* 4.5–7.0 mm, and their respective females being 8.2–8.7 mm and 6.5–7.2 mm.

Status of *Anoxybelus.*—Kohl justified separating *Anoxybelus* only by the lack of a propodeal mucro in his unique female of *O. maidlii.* The subgeneric validity cannot be based on this character, for a well-developed mucro is present in males of that species and of *O. stevensoni* and a much reduced mucro in the female of the latter. The other differentiating characters discussed above, however, do permit revalidation of *Anoxybelus* as a subgenus.

The two known *Anoxybelus* may be relict species apparently now occupying only a part of their former ranges or there may be related uncollected species in intervening areas. Certainly, each is quite rare. *Oxybelus maidlii* has been collected only three times at three localities in Sri Lanka and India. I visited the former country a dozen times, collecting in several localities in the Dry Zone during each visit, and obtained *O. maidlii* only once. *Oxybelus stevensoni* (2 ♀, 16 ♂) has been collected several times at two localities in Bulawayo District, Zimbabwe.

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LITERATURE CITED

Arnold, G. 1927. The Sphegidae of South Africa, Part VIII. Ann. Transvaal Mus. 12: 55–131, 45 figs.

———. 1934. New African Hymenoptera, No. 2. Occas. Papers Rhodesian Mus. 3: 18–28, 6 figs.

Bohart, R. M. and A. S. Menke. 1976. Sphecid wasps of the world: A generic revision. University of California Press, Berkeley, CA. 695 pp., 190 figs.

Kohl, F. F. 1924. Die Hymenopteren-Gattung *Belomicrus* A. Costa (Schluss). Konowia 2: 258–278, 1 pl.

Krombein, K. V. 1983. Biosystematic studies of Ceylonese wasps, X: Taxonomic and biological notes on some Oxybelinae (Hymenoptera: Sphecoidea, Crabronidae). Internatl. J. Entomol. (India) 1: 31–39, 3 figs.

Nurse, C. G. 1903. New species of Indian aculeate Hymenoptera. Ann. & Mag. Nat. Hist. (7) 11: 393–403, 511–526, 529–549.

Pate, V. S. L. 1937. The oxybeline wasps of the Philippines, with a synonymic catalogue of the Oriental species (Hymenoptera: Sphecidae). Philippine J. Sci. 64: 375–395, 1 pl.

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87(3), 1985, pp. 641–655

OMMATIUS (DIPTERA: ASILIDAE) IN THE LESSER ANTILLES

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Abstract.—The species of *Ommatius* of the Lesser Antilles are revised. Five new species, *Ommatius* ***prolongatus***, *O.* ***dimidiatus***, *O.* ***villosus***, *O.* ***emarginatus*** and *O.* ***infractus***, are described and their genitalia illustrated. Only *O. infractus* ranges onto the South American continent and into Panama while the remaining species are endemic to the Caribbean. A key to the known species of the Lesser Antilles is included.

This paper is the fourth of a series that will eventually cover all the neotropical species of *Ommatius* Wiedemann. Earlier papers (Scarbrough and Rutkauskas, 1983; Scarbrough, 1984a, b, 1985) treated the fauna of the Greater Antilles and the Bahamas. The present paper covers the species in the Lesser Antilles (Fig. 1). Species found on the islands south of Grenada are mainland species and will be covered in a later paper. Included here are six species, five of them new to science. Of these, four are endemic to the Lesser Antilles and one species, *O. infractus* Scarbrough, is widespread, ranging onto the South American continent southward to southern Brazil and Paraguay and northward into Panama. Although formerly reported from the Caribbean (Williston and Aldrich, 1896; Martin and Papavero, 1970), *O. tibialis* Say is probably limited to eastern United States (Bullington and Lavigne, 1984) and is not included in this paper.

The genus *Ommatius* is well represented in the Caribbean with a total of 27 known species. Presently most species are limited in their distribution to one or two islands, with *O. infractus* and *O. dimidiatus* Scarbrough being the exceptions. Surprisingly the faunas of eastern United States, the Greater Antilles, and the Bahamas do not share a single species, and only one species is common to the faunas of the Lesser Antilles and South America. Thus, the Caribbean faunas are almost entirely insular, forming one large heterogeneous assemblage of related species. They may, however, be divided into at least 4 groups based upon genitalic characters, color of the femur, presence or absence of scutellar and anepimeral bristles in both sexes, and presence or absence of a dilated costa in males. Further study is necessary to determine whether or not these characters are indicative of natural groups.

Specimens used in this study are in the following museums and private collections: Museum of Comparative Zoology (MCZ), American Museum of Natural History (AMNH), Ohio State University (OSU), National Museum of Natural History (NMNH), Mike Ivie (MI), Eric Fisher (EF), California Academy of Sciences (CAS), British Museum of Natural History (BM(NH)), and Instituto de Zoologia Agricola, Universidad de Central Venezuela, Maracay (IZA).

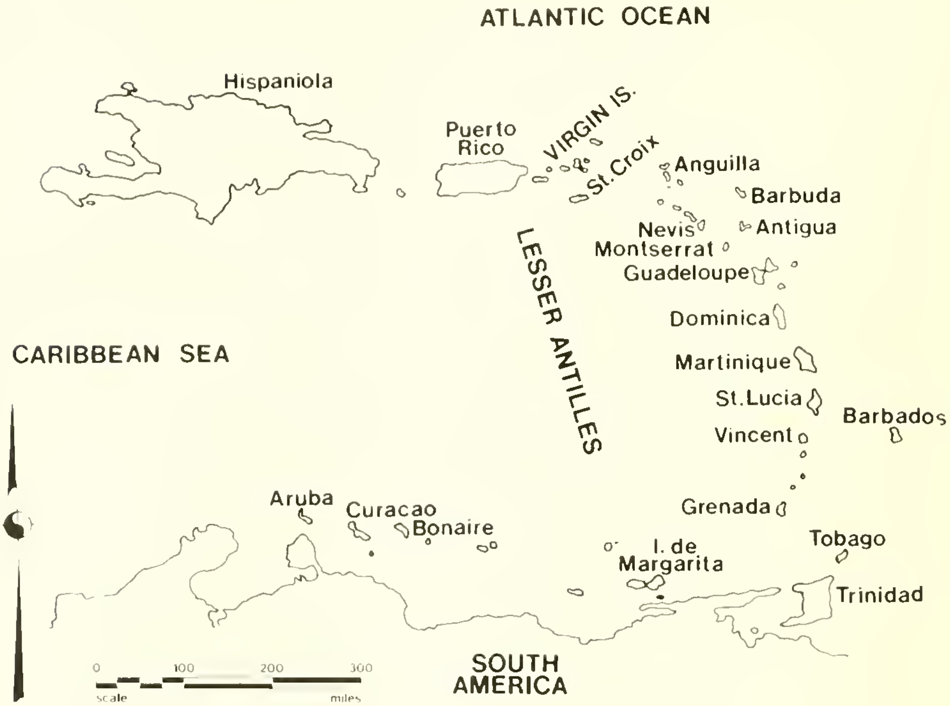


Fig. 1. The Lower Antilles.

Most illustrations were made from dissected genitalia that had been cleared in KOH for 24–48 hours, washed in alcohol and held in glycerine. When included, bristles and hairs indicate relative sizes and distribution, and are not intended to show actual numbers of individuals.

Key to *Ommatius* Species in the Lesser Antilles

1\. Scutellar margin with short, thin, brown hairs or strong bristles 2

– Scutellar margin without short, thin, brown hairs or bristles 3

2\. Scutellar margin with 2–3 thin brown hairs, not longer than dorsal pile; 8–10 pairs of short, thin, dorsocentrals posteriorly; hairs between rows of dorsocentrals similarily short, thin and abundant; 3rd antennal segment short, only slightly longer than wide (Montserrat) .... *O. prolongatus* n. sp.

– Scutellar margin with 2 strong bristles, much longer than dorsal pile; 2–4 pairs of long, strong dorsocentrals posteriorly, hairs between rows of dorsocentrals sparse and whitish; 3rd antennal segment length twice its width; genitalia as in Figs. 2–4, 5–6 (Lesser Antilles, Venezuela, British Guyana, Brazil, Paraguay, Panama) .... *O. infractus* n. sp.

3\. Third antennal segment as long as wide; male with hindfemur slightly enlarged, apical ⅓ or more of posteroventral row of bristles curved dorsad (Fig. 13) 4

– Third antennal segment length longer than wide; male with hindfemur not enlarged, apical ⅓ of posteroventral row of bristles wholly ventral, not curved dorsad (Fig. 10b) 5

4. Style about 2× length of 3 basal antennal segments combined; hindfemur with 3 bristles anteriorly; narrow apical margin of hypandrium with short pale pile (Puerto Rico and Virgin Is.) .... *O. marginellus* (Fabricius)
- Style about same length as 3 basal antennal segments combined; hindfemur with 4 bristles anteriorly (Fig. 13a); apical ½ or more of hypandrium with abundant long, thin, pile (Dominica) .... *O. villosus*, n. sp.

5. Basal ⅓ of hindfemur with at least 3–4 yellowish bristles in both ventral rows; 3rd antennal segment long, at least twice its width; male with abdomen slightly constricted, epandrium apically truncate (Fig. 11) and costal margin strongly dilated (Dominica, St. Lucia, Martinique) .... *O. dimidiatus* n. sp.
- Hindfemur with all or most bristles in both ventral rows dark brown or black; 3rd antennal segment short, length about 1¼ times its width; male without an abdominal constriction, epandrium broadly emarginated apically (Fig. 7) costal margin not strongly produced (St. Vincent) .... *O. emarginatus* n. sp.

***Ommatius infractus* Scarbrough, NEW SPECIES**

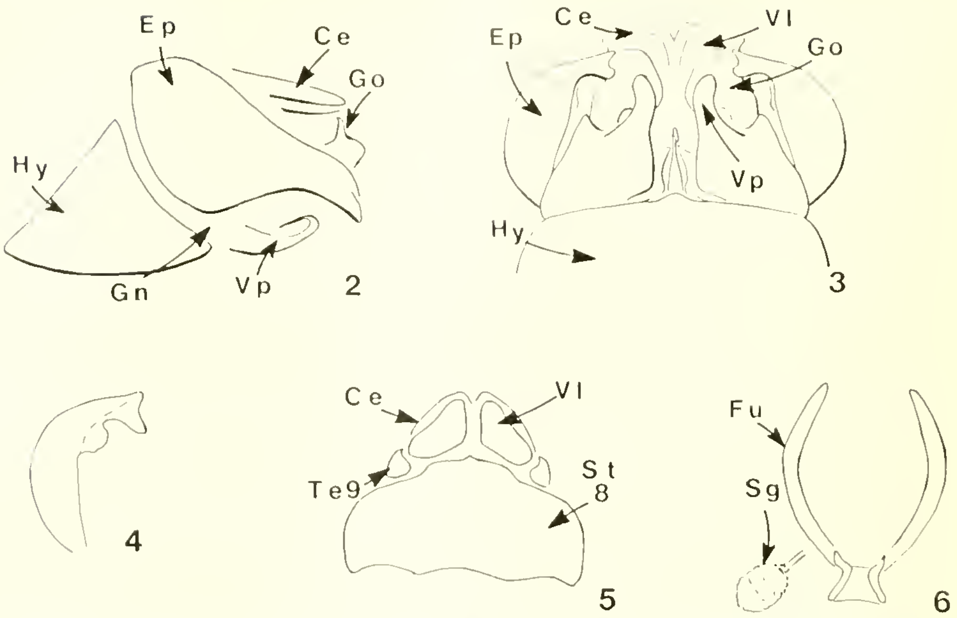
Figs. 2–6

Diagnosis.—*Ommatius infractus* is easily recognized by a 3rd basal antennal segment twice as long as wide, strong scutellar and dorsocentral bristles, the ventral rows of bristles of the hindfemur wholly or almost wholly brown; sternite 8 of females with scattered, long, brownish hairs basally, none forming V-shaped pattern, the apical margin moderately produced and with a low, median point; males with slender femora, a slightly produced costal margin; the apical ⅓ of the epandrium moderately curved behind, the apex with a V-shaped notch; a flat, somewhat rectangular gonostylus and an elongated, pilose, gonocoxal process.

Ommatius infractus is similar to *O. barbiellinii* Curran (Curran, 1932) but males are easily distinguished by the external parts of the genitalia. The females of the two species are almost inseparable in external characters and usually require dissection of the genitalia for accurate identification. The female of *O. infractus* has a narrow furcal base, the spermathecal gland is oval with a wrinkled surface and tergite 9 extends slightly below the cercus.

Description.—*Male:* Length 13.0 mm. Head and palpus brown. Head mostly pale brassy yellow pollinose, front brownish in frontal view, dull brassy yellow from above. Face with yellowish hairs and 8 brown bristles, occipital pile white; 5–6 dorsal postocular, 2 ocellar, antennal and palpal bristles brown; palpal hairs mostly brown; inner 2–3 dorsal postocular bristles moderately proclinate. Antenna brown, 3rd segment twice as long as wide, style length 1½ that of 3 basal segments combined.

Scutum dark brown with mostly brown pollen, yellowish to pale brownish gray behind humeri, in grooves, above wings, and in prescutellar area. Pleuron mostly grayish pollinose, kat- and anepisternum brownish to yellowish. Scutal bristles dark brown, 2 notopleurals, 1 supraalar, 1 postalar, 3 prominant pairs of dorsocentrals, their lengths almost that of alar bristles. Scutellum brown pollinose basally, gray apically, scattered pale pile dorsally and 2 strong marginal bristles. Pleuron pile and bristles whitish.



Figs. 2–6. *Ommatius infractus* n. sp., genitalia. 2, Male, lateral view. 3, Same, ventral view. 4, Epandrium, dorsal view. 5, Female, ventral view. 6, Same, furca and spermathecal gland. Terms: Ce = cercus, Ep = epandrium, Fu = furca, Ho = hook of gonocoxite, Go = gonostylus, Gn = gonocoxite, Hy = hypandrium, Sg = spermathecal gland, St = sternite, Te = tergite, Vp = ventral process of gonocoxite, Vl = ventral lamella or plate.

Coxae brown with gray pollen and whitish pile and bristles. Legs mostly yellow to yellowish amber, fore- and midfemora with apical fourth or more brownish, hindfemur and hindtibia with apical third to half brown, fore- and midtibiae with brownish shadow apically. Tarsi mostly dark brown, the fore- and midtarsi with basal segments somewhat yellowish. Femora slender, midfemur below with row of 4–5 rather long, slender yellowish hairs posteriorly, 4 anteroventral brown bristly hairs or bristles on basal half, 3 brown bristles on anterior surface of which 2 are on apical half, usual posteroapical bristle absent. Hindfemur with 2 rows of rather short, brown, setigerous bristles, both rows extending full length of segment, 6 bristles anteroventrally, 5 posteroventrally; anterior surface with 1 amber (basally) and 2 brown bristles. Most bristles of foretibia, 2–3 on midtibia and 1 on foretarsus yellowish, the remaining tibial and tarsal bristles brown; fore- and midtibiae with a ventral row of thin amber hairs.

Wings hyaline, anterior cells slightly yellowish, ribs weak and yellowish; costal margin slightly produced. Veins brown, r-m crossvein before middle of discal cell, 1st medial cell slightly narrowed (by ⅓) beyond middle. Halter yellowish brown, knob brown.

Abdomen without a constriction, dark brown with brown pollen, the pollen light brown on sides and below, sides of tergite 1 and base of tergite 2 brownish to yellowish gray. Pile and hairs yellowish, tergites with brown setae medially, a few brown bristly hairs on apical 2–3 segments.

Genitalia (Figs. 2–4) dark brown with mostly yellowish or amber hairs apically, stronger and brown basally; cercal pile whitish. Epandrium with apical ⅓ tapered abruptly below, curved behind moderately and flattened dorsoventrally, inner margin incised mesally with a prominant lobe; apex of epandrium flared with a slight notch. Hypandrium with a thick patch of fine, yellowish, pile apically, and scattered hairs basally. Gonocoxal process elongate and flattened, the apex rounded, the inner margin with abundant hairs; the base with a short, acute, process medially. Gonostylus flat, somewhat rectangular, with a short apical point.

Female: Similar to male but with the following differences: length 12.4 mm, halter reddish brown. Wing without costal dilation, yellow in anterior cells or ribs; r-m crossvein beyond middle of discal cell, constriction of 1st medial cell less prominant than in male; midtarsus slightly brownish basally. Tibial and tarsal bristles brown except 2 yellowish ones on foretarsus. Midfemur with postapical bristle brown. Hindfemur with 2 long yellowish bristles in posteroventral row basally, each about 1½ times or more the length of brown bristles. Eighth and ninth abdominal segments dark brown to black, the tergites with mostly dark hairs, apical corners of tergite 9 curved slightly below cercus. Sternite 8 (Fig. 5) with short yellowish pile apically, scattered brown hair basally, none forming a discrete V-shaped row; apical margin noticeably produced, the middle only slightly swollen and with a low point or ridge. Genitalia as in Fig. 6.

Holotype ♂. St. Vincent, W.I. 1906, H. H. Smith. Allotype with name data. The holotype is in the NMNH and the allotype in the BM(NH).

Paratypes. 54 ♂♂ and 60 ♀♀ from the following countries and cities; *St. Vincent Island*; *Canal Zone* (Barro Colo. Island, Tobago Island, Corozal, Punta Patilla); *British Guyana* (Georgetown, Kartabo, Bartica District); *Venezuela* (San Esteban, Apupau Villa, Barinas, Akuriman Gran. Sabana); *Brazil* (Cavinna, Parana, Santa Caterina, Piedras, Chapadas, San Sabastiao, Sao Paulo, Maracaju, Piraja, Bahia); *Trinidad* (Port-of-Spain, Maquiripe Bay, Arima Valley, Maraval, Northern Mt. Range); *Tobago* (Mt. Irvine); *Little Tobago Island*; *Paraguay* (Bella Vista, Belem, Villarica, Alto Parana, Molinescue). Paratypes are in the following museums and private collections: CMZ, AMNH, CAS, USNM, MI, OSU, EF, BM(NH) and IZA.

Variation.—Major differences include: ♂ 10.6–16.5 mm, ♀ 8.5–15.0 mm. Face usually pale brassy yellow pollinose with pale yellowish hairs and 5 to 7 brown bristles, rarely 4 or 8. The front is typically brassy yellow pollinose from above. The postocular bristles range from 4–8 and the palpal bristles may be either wholly yellow or brown, sometimes combined. The palpal hairs are usually yellowish although brown hairs are not uncommon, especially dorsally, the knob of the halter ranges from yellow to reddish. Most specimens usually have the apical third to half of the fore- and midfemora and hindtibia and the apical two-thirds to three-fourths of the hindfemur dark brown to black. Some specimens in the southern most part of its range have reddish femora anteriorly and dorsally rather than yellow. The basal half or more of the foretarsomere is usually yellowish with 1–4 yellowish bristles, rarely brownish yellow with only dark bristles. The basal midtarsal segment is sometimes brownish.

Etymology.—The specific name, *infractus*, refers to the apical third of the epandrium being sharply bent or curved behind the male genitalia.

Ommatius emarginatus Scarbrough, New Species

Figs. 7–8

Diagnosis.—*Ommatius emarginatus* is readily recognized by an absence of scutellar bristles, the presence of a slightly produced costal margin, wholly pale yellow hindfemoral bristles, the 3rd basal antennal segment slightly longer than wide, a slender epandrium with the apex broadly notched, and a gonocoxite with a flat, elongated, somewhat apically flared process and 2 strong basal bristles.

Ommatius emarginatus is similar to *infractus* but can be identified easily by a lighter brown body, the absence of scutellar bristles, and the genital characters listed above.

Description. *Male:* Length 14.0 mm, brown. Head gray pollinose with a slight tint of yellow along the eye margin, most bristles and hairs whitish or white; 3–4 on upper face, antennal, 2 ocellar and 2–3 postocular bristles brown. Dorsal postocular bristles generally short with 3–4 curved forward for about half their lengths. Third antennal segment slightly darker than other segments and slightly longer than wide; style about 1½ times length of the 3 basal segments combined.

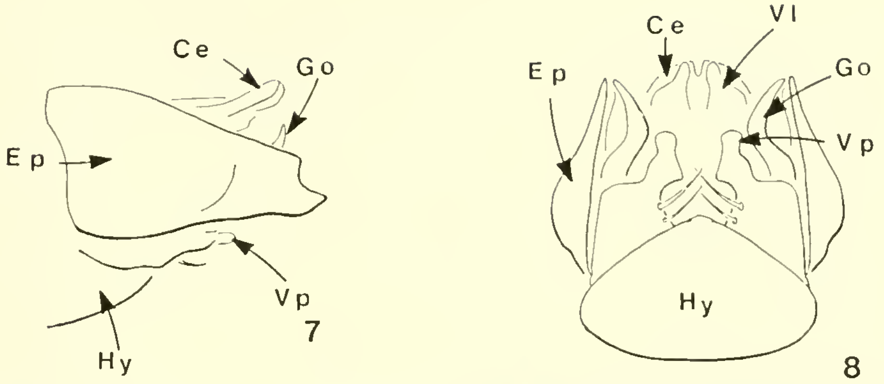
Scutum dark brown with mostly brown pollen, yellowish to brownish gray in grooves, on sides, behind humeral callus and posteriorly. Pleuron mostly gray with some pale yellow, anepisternum partly brown pollinose. Pleural pile sparse and pale, bristles yellowish. Scutal bristles black, 2 notopleural, 1 supra-alar, 1 postalar and 3 pairs of rather strong dorsocentrals posteriorly; several scattered, weak, brown hairs on sides above wings, pile or weak hairs absent between dorsocentrals. Scutellum brownish gray pollinose, marginal bristles absent.

Coxae brown with gray pollen, bristles and hairs white. Femora slender and mostly yellow; apical fourth of anterior 2 femora and extreme apices of midtibia light brown to brown; apical half of hindfemur and hindtibia dark brown, basal half of hindtibia dull yellowish brown; anterior surface of midtibia slightly darker brown than posteriorly. Basal segments of fore- and midtarsus mostly yellow with remaining segments of all tarsi dark brown. Femora with hairs and bristles mostly pale yellow; forefemur with 1–2 and midfemur witih 2–3 rather strong ventral bristles basally, midfemur with 2 strong brown bristles in anteroventral row and 2 weaker pale hairs basally, 2 brown bristles on apical half anteriorly and 1 posteroapical. Hindfemur with bristles somewhat brownish yellow, 3 anteriorly, 2 extra setigerous bristles slightly posterior to anterior row (9), posterior row extending two-thirds length of segment with basal 2 1½ times longer than others. Fore- and midtibiae with a ventral row of weak yellow hairs and 3 bristles; foretarsus with 1 yellowish bristle, remaining bristles black.

Wing hyaline, somewhat yellowish or brownish with marginal and submarginal cells darkest. Veins dark brown anteriorly, slightly reddish brown basally, costal margin slightly dilated, r-m crossvein before the middle of discal cell. Halter knob reddish brown.

Abdomen brown with apical borders slightly lighter, pollen mostly brownish gray to yellowish on sides and below. Hairs mostly light yellow, tergite 1 with 4 pale brownish bristles, hairs of tergite 6–8 and those along apical margin of sternite 8 dark brown.

Genitalia (Figs. 7–8) dark brown basally with dark hairs, yellowish brown apically with yellowish ones. Epandrium elongate, length slightly more than twice width, basal two-thirds slightly swollen, apical third flat, slightly tapered ventrally,



Figs. 7–8. *Ommatius emarginatus* n. sp., genitalia. 7, Male, lateral view. 8, Same, ventral view.

dorsoapical margin slightly flattened on apical fifth or so, apex notched dorsally, anteroventral corner slightly projecting more than above. Hypandrium triangularly rounded apically with narrow patch of dense yellow pile and scattered brownish to yellowish hairs basally. Gonocoxite with a flat, elongated, somewhat wavy apical margin and flared, 2 strong bristles basally. Gonostylus slender, slightly triangular in cross section, almost straight on apical two-thirds, base narrowly joined to gonocoxite.

Female unknown.

Holotype ♂. St. Vincent, W.I. windward side, 1907, H. H. Smith. The holotype is in the BM(NH).

Etymology.—The specific name of the species refers to the notch in the apex of the epandrium.

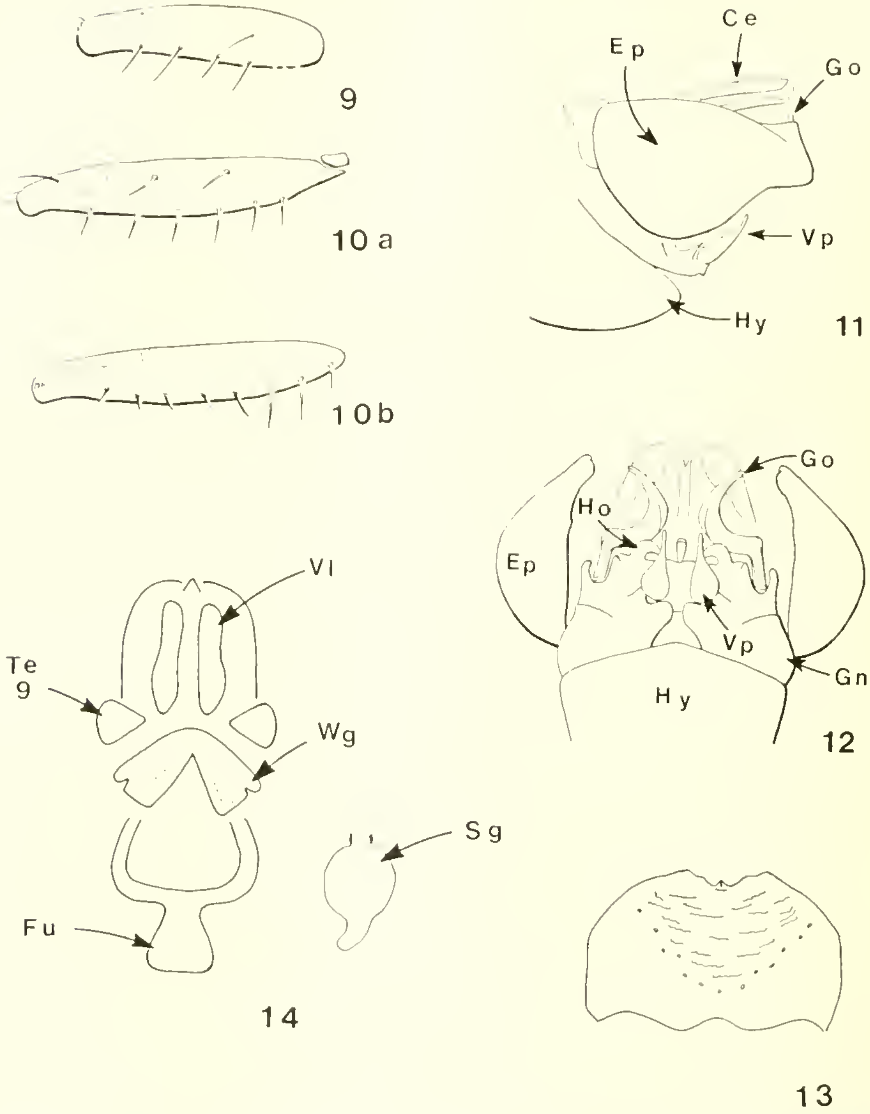
Ommatius dimidiatus Scarbrough, New Species

Figs. 9–14

Diagnosis.—*Ommatius dimidiatus* is recognized by the first antennal segment usually having only black hairs, palp brownish yellow basally, face with light yellowish gray pollen and several yellowish to brown bristles, an absence of scutellar bristles, femora and hindtibia with apical third brown, anteroventral row of hindfemur usually with 1–2 black apical bristles; male with costal margin produced strongly, abdomen constricted moderately, posteroventral row of hindfemur with apical 6–7 bristles black, the row extending almost entire length of segment with bristles in a straight line; apical margin of epandrium truncate with basal margin broadly rounded; gonostylus sickleshaped with base inserted in a U-shaped gonocoxal cavity; gonocoxite with a flat dorsal hook, an elongated urnshaped basal process with asymmetrical margins, and a transverse groove basally.

Ommatius dimidiatus is most closely related to *villosus* but the male may be easily identified by the genital characters, a long 3rd antennal segment, the posteroventral row of bristles on the hindfemur do not curve dorsad apically, the anteroventral row of bristles are usually all or almost all yellowish.

Description.—*Male:* Length 18.5 mm. Head dark brown, palp brownish yellow basally, dark brown apically, basal 2 antennal segments light brown. Face light pollinose, front brownish yellow in frontal view; occiput gray, somewhat yellowish



Figs. 9–14. *Ommatius dimidiatus* n. sp. 9, Male midfemur, anterior view. 10a, Male hindfemur, anterior view. 10b, Male hindfemur, posterior view. 11, Male genitalia, lateral view. 12, Same, ventral view. 13, Female, sternite 8. 14, Same, ventral view of genitalia with sternite 8 removed.

along eye margin. Ocellar, 6 pairs of postoculars and all antennal bristles dark brown, several remaining postoculars and palpal hairs yellowish; most occipital pile white. Face with 4 strong bristles and hairs creamy white, 6 long bristles yellowish to light brown. Antennal segments of equal lengths, 3rd basal segment length about twice its width, style length slightly more than 1½ times the 3 segments combined.

Scutum dark brown to black with mostly brown pollen dorsally, bright brownish golden to brownish yellow behind humeral callus, light brownish white in grooves, on sides and posteriorly. Scutal bristles black, 2 notopleurals, 1 supra-alar, 1 postalar and 2 pairs of moderately strong dorsocentrals; scattered pile on sides and along rows of dorsocentrals. Scutellum brown pollinose with grayish borders and scattered long pale pile; bristles absent. Pleuron gray pollinose with some yellow or brown, anepisternum brown to brownish gray, pleural bristles slightly yellowish. Halter dull brownish yellow.

Wings hyaline, costal and basal cells yellowish, R_1 and $R_2 + R_3$ broadly bordered with brown and ribbed; costal margin strongly produced, r-m crossvein before middle of discal cell, 1st medial cell slightly constricted.

Legs. Coxae grayish pollinose with a trace of yellow, forecoxal bristles slightly yellowish. Femora slightly swollen, primarily honeycomb yellow with apical third brown; fore- and midtibiae with slight shadow of brown apically, hindtibiae with apical third brown. Tarsi with apical 4 segments brown, basal segments of fore- and midtarsi mostly yellowish to light brownish yellow. Legs with mostly short, yellowish, hairs; some setaceous, the latter usually black in dark areas of femora, scattered on tibiae and tarsi. Forefemur with 2 short, anterior black bristles, 1 anteroventral, ventral bristles yellowish; midfemur (Fig. 9) with 5 anterior black bristles, 1 postapical and 2 anteroventral yellowish bristly hairs basally. Hindfemur (Fig. 10) with 2–3 yellowish bristles anteriorly, 1 black apically; ventral 2 rows with bristles more or less evenly spaced, forming a straight line, anterior row with 5–6 light yellowish bristles plus an apical 1 black, posterior row with 3–4 yellow bristles basally, 6–7 black apically. Fore- and midtibiae with 3 yellowish bristles, the remaining bristles black, both tibiae with a ventral row of long, slender, black hairs. Foretarsus with 4 yellowish bristles.

Abdomen moderately constricted, narrowest at segment 3, segments brown with margins of several segments lighter, light yellow pollen on sides and ventrally, light brown dorsally. Dorsal setae mostly yellow, a few black medially on basal tergites, longer setae in apical corners, brown to black on last 3–4 segments, 2–3 pale brownish bristles on tergite 1; pile yellowish and abundant on basal segments.

Genitalia (Figs. 11–12) brown, somewhat lighter apically, with strong black hairs basally, weaker and yellowish apically. Cercus somewhat truncate apically, ventral plates elongated triangularly, separated along inner margins. Epandrium swollen most of its length, apical fourth to fifth strongly tapered ventrally and thin, margin truncate, ventroapical corner broadly rounded. Gonostylus sickle-shaped with a narrow basal arm inserted into a U-shaped gonocoxal cavity laterally, the apical half somewhat flat in cross section, rotated about 90° and directed forward. Gonocoxite with a flat, hooked, process dorsally, an elongated U-shaped process of which the outer margin protrudes somewhat laterally, a pronounced asymmetrical urn-like process, and a transverse groove basally. Hypandrium with apical margin almost straight and scattered dark pile basally.

Female: The allotype differs only slightly from the holotype male: size 14.5 mm; 7 facial, 2 foretibial, all midtibial bristles dark brown; 2 foretarsal bristles yellowish. All bristles in posteroventral row of hindfemur yellowish, 2 bristles on basal half of latter row stronger and longer than remaining. Venation typical of females, wing surface slightly yellowish, subcostal cell brownish. Costal bulge and constriction of 1st medial cell and abdomen absent. Tergites 8–9 shiny black, apical corners not noticeably projecting posteriorly. Cercus pale brownish yellow. Sternite 8 (Fig. 13) black basally, yellowish brown apically, cordate-shaped, the latter surface shiny, with low transverse ripples and numerous reddish hairs posteriorly; anterior margin of sternite with a noticeable notch, the surface slightly thick with a low ridge. Genitalia as in Fig. 14.

Holotype ♂. *Dominica,* Clarke Hall, Cocoa Trail, 11.16.1965, W. W. Wirth. Allotype ♀ same location, III.21–31,1965,W. W. Wirth. Paratypes: 2 ♀, 2 ♂ nr. Clarke Hall, Mannett's Gutter, IV.28, V.1–3.1964, III.21–31.1965, O. S. Flint, Jr.; ♂, 3 ♀ Clarke Hall, 11.16, III.21–31.1965, W. W. Wirth; ♀ Clarke Hall, Layon Vall. 11.4.1965 H. E. Evans; ♀, 3 ♂ Clarke Hall Est., III.29, IV.20–21, V.23,1966, R. J. Gagné; ♀, South Chiltern, V. 25–27,1965, D. R. Davis. *Martinique,* ♂ Tivoll, 20.VII.1945, H. Stehle, ♀ St. Pierre, 23.VI.1965, D. R. Davis, 2 ♀ no data. *St. Lucia,* ♀ Soufriere, VII.1963, J. Maldonado. The holotype, allotype and 17 paratypes are in the USNM; 2 paratypes are in the MCZ.

Variation.—Lengths ♂ 18.5 mm. ♀ 14.5–16.5 mm. The brown coloration of the leg segments is sometimes dark brown apically and may extend as a yellowish brown slightly beyond the apical third on the hindfemur. The usual yellowish leg bristles may be reddish, rarely black, in dark specimens. The anterior surface of the hindfemur usually has 3 bristles, rarely 4, and 1 is noticeably shorter; the preapical bristle is always black. Two males have only yellowish bristles in the anterior row of the hindfemur. The bristles of the basal antennal segment, hindtibia, midfemur, face and postocular region are sometimes yellowish.

Etymology.—The specific epithet *dimidiatus* refers to the one-sided or asymmetrical base of the urn-shaped gonocoxal process.

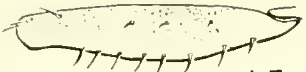
***Ommatius villosus* Scarbrough, New Species**

Figs. 15–17

Diagnosis.—*Ommatius villosus* is easily recognized by its blackish body, the brassy yellow facial pollen, 3rd antennal segment only slightly longer than wide, scutellar and dark facial bristles absent, a moderately constricted abdomen, a strongly produced costal margin, a black palp; midtarsus with basal tarsomere reddish brown to brown, fore- and midfemora with long black streaks anteriorly, posterior row of bristles on the hindfemur extend about two-thirds length of segment, the apical 3–4 bristles curved in a line posteriorly, most bristles in posterior row black and spaced unusually close for most of its length; the apical margin of the epandrium oblique, the ventroapical corner with an acute angle; gonostylus triangular in cross section, lateral arm attached above base; and gonocoxal cup with an elongated bladelike process; and the presence of abundant long, weak, hairs on the hypandrium.

Ommatius villosus is somewhat similar to *dimidiatus* but is readily identified by the blackish body, brassy facial pollen, a short 3rd antennal segment, the black fore- and midfemoral dark streaks, the reddish brown to brown midtarsus, the closely spaced bristles in the posterior row on the hindfemur, and the abundant weak hairs on the hypandrium.

Description.—*Male:* Length 18.0 mm. Head and palp black, face and front brassy yellow pollinose in frontal view, occiput gray to pale yellow gray. Ocellar, 7 dorsal postocular and most antennal bristles black; 1st antennal segment with several pale yellow hairs. Face and palp with bristles or hairs pale yellow to yellow, occipital hairs white. Antennal segments of equal lengths, 3rd segment only slightly longer than wide; style about twice combined length of all segments.



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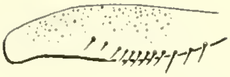

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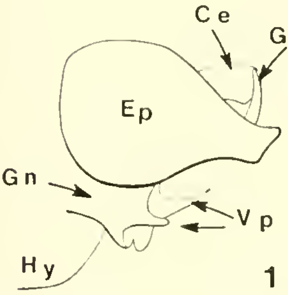

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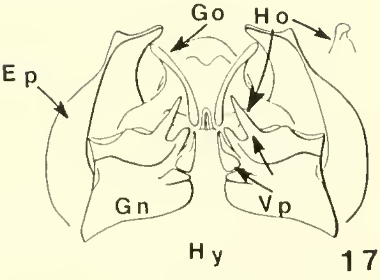


17

Figs. 15–17. *Ommatius villosus* n. sp., hindfemur and genitalia of male. 15a, Anterior view. 15b, Posterior view. 16, Lateral view. 17, Ventral view.

Thorax black, scutum with mostly brown pollen, humeral callus and spot behind brassy yellow to brownish yellow; oblique grooves, side above wing, prescutellar region and scutellum pale yellowish gray to gray pollinose. Scutal bristles black, 2 notopleurals, 1 or 2 supra-alars, 1 postalar and 4–5 moderately long dorsocentrals; scattered short hairs on side and between dorsocentrals posteriorly. Scutellum with scattered weak, pale pile; bristles absent. Pleuron yellowish gray to gray pollinose, anepisternum brown to yellowish gray, bristles and pile pale yellow. Halter knob reddish brown, stalk pale.

Wings hyaline, somewhat yellowish, veins reddish basally, dark brown anteriorly, R_1 and R_{2+3} broadly margined with a brown, costal cell yellow. Costal margin strongly produced anteriorly, r-m crossvein before middle of discal cell, 1st medial cell slightly constricted before middle.

Legs with coxae yellowish to gray pollinose, yellowish bristles and white hairs. Fore- and midfemora with black streaks extending almost entire lengths anteriorly and dorsally, forefemoral streak wide, covering almost entire anterior surface, about twice width of that on midfemur; hindfemur black except for basal fifth. Femoral bases reddish, forefemur somewhat lighter and more brownish. Hindtibia black on apical fourth, midtibial apex and all tarsi brown to dark brown, basal tarsomeres of fore- and midtarsi slightly contrasting in color but clearly not yellowish basally; fore- and midtibiae with anterior surfaces slightly brownish, tibiae otherwise yellowish. Femora and tibiae with mostly short, fine, yellowish hairs, some setaceous antero- or posteroventrally, often black; bristles mostly black, forefemur with 1 short, anteroventral, black bristle and 2–3 slightly strong yellow ones ventrally. Midfemur with 5 black bristles anteriorly, 1 black posteroapically, anteroventral row with 2 weak, pale, hairs basally. Hindfemur with 4 yellowish or amber bristles anteriorly, anteroventral row with 4 yellowish bristles basally and 4 black apically, each more or less evenly spaced the entire length of the segment; posteroventral row (Fig. 15) with 2 yellowish bristles basally and 10 black bristles apically, the latter somewhat closely spaced with the apical 3–4 curving in a line behind the segment, the entire row extending about two-thirds the length of the segment. Fore- and midtibiae and tarsi with 2 yellowish bristles, the remaining black. Fore- and midtibiae with a ventral row of weak, black, hairs.

Abdomen dark brown to black, moderately constricted with segment 3 being narrowest, brown pollen dorsally with yellowish gray on sides of tergites and on sternites, lateral margins of apical segments 3–5 with some bright yellow pollen. Tergites with mostly yellowish setae, brown dorsally on apical 2–3 tergites, the margins with 2–3 long bristles; 5 pale brownish bristles on tergite 1; pile long and whitish basally.

Genitalia (Figs. 16–17) mostly dark brown with yellowish or amberish hairs apically, scattered blackish hairs basally. Epandrium swollen on basal three-fourths or more, apical third somewhat reddish and abruptly narrowed ventrally, ventroapical corner angle acute, apical margin oblique. Gonostylus slender, slightly bent forward, triangular in cross section on apical 3rd, immediate base free from lateral arm. Gonocoxite with dorsal, apically projecting, hooked process; a wide cuplike process with a long bladelike tooth on the outer rim; and a long, canallike basal process with a flared base. Hypandrium simple, apical margin rounded, with abundant long, weak, yellowish hairs. Plates below cercus fused along inner margins.

Female unknown.

Holotype ♂. *Dominica,* W. I., Clarke Hall Est., VI.11.1966, G. Steyskal (Bredin-Archbold, Smithsonian Bio. Surv. of Dominica). Paratypes. *Dominica,* 2 ♂ Grande Savane, V.30.1965, D. R. Davis; ♂ same location, IX.15.1964, T. J. Spilman; 2 ♂ Clark Hall, VI.3.1964, O. S. Flint, Jr. All specimens are in the USNM collection.

Variation.—The males differ in length 16.5–17.5 mm; two males have mostly brownish gray pollen on the scutum and the anterior row of ventral bristles on the hindfemur are entirely yellowish. The basal 2–3 bristles in the posterior row are usually yellowish. The basal segments of the midtarsi are somewhat light brown on 3 paratypes. The face and front are usually pale brassy yellow.

Etymology.—The specific name of *villosus* refers to the abundant, long, weak, hairs on the hypandrium.

***Ommatius marginellus* (Fabricius)**

Asilus marginellus Fabricius, Species Insectorum, II., p. 464, 1781; Mantisse Insectorum, II., p. 178, 1787; Type locality Virgin Islands, St. Croix. Type ♂, Kieler Collection, Copenhagen, Denmark.

Dasyopogon marginellus; Wiedemann, Diptera Exotica, I., p. 213, 1821.

Ommatius marginellus; Coquillett, 1910; 579. Designated type species; Wolcott, 1948, vol. 32, p. 435; Hull, 1962, Bull. 224, pt. 2, pp. 434–436; Farr, 1965: 19–25. Removed from list of asilids from Jamaica; Martin and Papavero, 1970: 59.

Distribution.—Puerto Rico and the Virgin Islands.

Although *O. marginellus* was not found in this region of the Caribbean, its range probably extends into the northern islands of the Lesser Antilles.

Diagnosis.—*Ommatius marginellus* is recognized by the absence of marginal scutellar hairs or bristles, the presence of yellowish to orangish facial bristles, face and abdomen yellow pollinose, 1st antennal segment with pale yellow hairs below, 3rd segment as long as wide, hindfemoral bristles mostly yellowish to orangish; male with costal margin produced moderately, posteroventral row of hindfemur with 4–8 black bristles apically, apical ⅓ or more of row slightly curved dorsad, epandrium subtruncate apically, gonostylus base narrowly joined to lateral arm; female with apical corners of tergite 9 slightly produced, and sternite 8 with mostly brown bristles and a prominent median notch and 2 mediolateral protuberances apically.

Ommatius marginellus is somewhat similar to the female of *O. prolongatus* n. sp. in the short 3rd antennal segment, the pale facial hairs and bristles, and pale yellowish bristles on the hindfemur, but differs by the absence of weak scutellar hairs, abundant posterior dorsocentrals and the slightly brownish facial bristles.

Ommatius prolongatus **Scarbrough** NEW SPECIES

Figs. 18–19

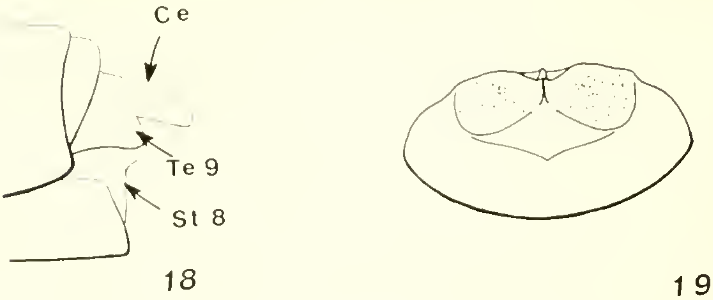
Diagnosis.—*Ommatius prolongatus* is recognized by the presence of a few pale brownish bristles on the upper face, a 3rd antennal segment about as long as wide; numerous weak brown hairs between the dorsocentrals posteriorly, 2–3 weak brown scutellar hairs on margin of about same length as dorsal pile; 8–10 pairs of weak dorsocentrals posteriorly; hindfemur and sternite 8 with only pale yellowish hairs and bristles; apical corners of tergite 9 greatly produced; apical margin of sternite 8 slightly produced medially, moderately thickened with a protruding rounded point; and the apical surface of sternite 8 smooth with 2 deep depressions laterally.

The female of *O. prolongatus* is similar to *O. marginellus* (Fabricius) (Scarbrough, 1984b). *Ommatius prolongatus* differs in the presence of pale brownish facial bristles, the weak scutellar and dorsocentral hairs, the abundant weak brown hairs between the dorsocentrals posteriorly and a protruding rounded point on the apical margin of sternite 8.

Description.—*Female:* Length 13.2 mm, head brown. Face, front and occiput gray pollinose, front with a trace of yellow. Most bristles and hairs whitish, a few on upper face with some brown; antennal, 2 ocellar and 7 postocular bristles dark brown. Occipital pile white. Antennal style twice length of 3 basal segments combined, 3rd segment, short, about as long as wide.

Thorax black, scutum brown pollinose, brownish gray to gray in grooves, on sides and in prescutellar region, area behind humeral callus dull yellow; pleuron and scutellum gray pollinose. Scutal bristles black, 2 notopleurals, 1 supra-alar, 1 postalar and a row of abundant, dorsocentrals extending most or entire length of scutum, 8–10 pairs of unusually short, weak, brown hairs posteriorly; side above wing and between rows of posterior dorsocentrals with numerous weak, brown hairs. Scutellum with long white pile and 2 thin, brown, marginal hairs. Pleuron pile sparse, short and whitish; bristles yellowish. Halter yellow.

Coxae dark brown with grayish pollen and whitish bristles. Femora and tibiae primarily yellowish; apical half of anterior surfaces of fore- and midfemora and apical two-thirds of hindfemur brown. Fore- and midtibia with narrow apical bands, hindtibia brown on apical third. Tarsi brown, basal segments of fore- and midtarsi brownish yellow. Bristles and hairs of femora mostly yellow; forefemur



Figs. 18–19. *Ommatius prolongatus* n. sp., female genitalia. 18, Lateral view. 19, Sternite 8.

with 1–2 anteroventral, short, yellowish setae, ventral row and posteroventral row of midfemur with rather strong, long, bristly hairs; midfemur with 6 strong black bristles (1 postapical, 3 on anterior surface, 2 in anteroventral row). Hindfemur with 2 rows of yellowish setigerous bristles extending almost entire length of segment, apical 2–3 in both rows and basal 1 in anterior row short, basal 3 in posterior row long, 3 yellowish bristles anteriorly. Tibial and tarsal bristles mostly black, basal tarsomere of foretarsus and foretibia with 1–2 yellowish bristles. Foretibia with a ventral row of long, thin, yellowish hairs.

Wing hyaline, r-m crossvein beyond middle of discal cell, anterior cells without brownish tint. First medial cell without a noticeable constriction beyond middle.

Abdomen brownish with light borders, pollen light reddish brown dorsally, yellowish on sides and ventrally. Bristles and hairs mostly yellowish, brown on tergites 5–8, most abundant and longer posteriorly. Tergite 9 (Fig. 18) with apical corners greatly produced. Sternite 8 (Fig. 19) with pale yellow bristles basally, apical margin slightly produced, the middle greatly thickened with a rounded point and ridge in lateral view, the apical surface of the sternite shiny and smooth with 2 depressions laterally. Genitalia not dissected.

Male unknown.

Holotype ♀. Plymouth, Montserrat, W.I., 11.17.1937, S. T. Danforth. The holotype is in the USNH.

Etymology.—The name *prolongatus* is in reference to the elongated apical corners of tergite 9 in the female.

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LITERATURE CITED

Bullington, S. W. and R. J. Lavigne. 1984. Review of the genus *Ommatius* Wiedemann (Diptera: Asilidae) in Eastern United States with descriptions of five new species. Ann. Entomol. Soc. Am. 77: 372–392.

Coquillett, D. W. 1910. The type-species of the North American genera of Diptera. Proc. U.S. Natl. Mus. 37: 499–647.

Curran, C. H. 1928. New Species of *Ommatius* from America, with key (Diptera: Asilidae). Am. Mus. Novit. 327: 1–6.

———. 1953. The Asilidae and Mydaidae of the Bimini Islands, Bahamas, British West Indies (Diptera). Am. Mus. Novit. 1644: 5–6.

Fabricius, J. C. 1781. Species Insectorum exhibentes eorum differentias specificas symonyma, auctorum, locanatalia. II. Hamburgi et Kilonii. 2: 464.

———. 1787. Mantissa Insectorum sisten species nuper detectas. II. Hafniae. 2: 178.

Farr, T. H. 1965. The robber-flies of Jamaica (Diptera: Asilidae). Pt. 2. Bull. Inst. Jam. Sci. Ser. 13: 5–36.

Hull, F. H. 1962. Robber-flies of the world. The genera of the family Asilidae. U.S. Natl. Mus. Bull. Pt. 2. 224: 434–436.

Martin, C. H. and N. Papavero. 1970. Family Asilidae, pp. 58–60. *In* Catalogue of the Diptera of the Americas South of the United States. Mus. Zool. Univ. São Paulo. 35b: 1–139.

Scarbrough, A. G. 1984a. Synopsis of *Ommatius* Wiedemann from Hispaniola. J. N.Y. Entomol. Soc. 92: 131–149.

———. 1984b. Four species of *Ommatius* Wiedemann (Diptera: Asilidae) from Puerto Rico and the Virgin Islands. Proc. Entomol. Soc. Wash. 85: 610–629.

———. 1985. New species *Ommatius* Wiedemann (Diptera: Asilidae) from Cuba and the Bahamas. N.Y. Entomol. Soc. Submitted for publication.

Scarbrough, A. G. and R. Rutkauskas. 1983. A new species of *Ommatius* (Diptera: Asilidae) from San Salvador, the Bahamas. Proc. Entomol. Soc. Wash. 85: 144–151.

Wiedemann, C. R. W. 1821. Diptera exotica. Kiliae 1: 213.

Williston, S. W. and J. M. Aldrich. 1896. On the Diptera of St. Vincent (West Indies). Trans. Entomol. Soc. London 1896: 304.

Wolcott, G. N. 1948. The insects of Porto Rico. J. Agric. Univ. P.R. 32: 453.

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FIRST DESCRIPTION OF THE FEMALE OF *PARASIMULIUM STONEI* PETERSON (DIPTERA: SIMULIIDAE), WITH NOTES AND A DISCUSSION ON COLLECTION SITES

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Abstract.—The female of *Parasimulium stonei* Peterson is described and illustrated for the first time and is distinguished from the female of *P. crosskeyi* Peterson. This is only the second species of the genus for which females are known. Notes and a discussion on the collection sites of both species are given.

A synoptic review of the genus *Parasimulium* Malloch was published by Peterson (1977). At that time, only eight specimens were known for the genus, all of which were males representing four species distributed in two subgenera. More recently, Wood and Borkent (1982) collected many additional males and a small number of females of *P. crosskeyi* Peterson, and added one more locality to the previous eight known collection sites. Since the publication of the latter paper, two females and one more male of *P. stonei* Peterson have been found. The female specimens are the first known for *P. stonei* and are described and illustrated below.

DESCRIPTION

Fig. 1

Female (preserved in alcohol).—General body color yellowish brown. Length: body, 1.82 mm; wing, 1.82 mm.

Head.—Dark brown, shiny; eye rather small, black; stemmatic bulla paler than rest of head capsule. Frons noticeably broader than clypeus, moderately covered with pale yellow setae; postocular setae pale yellow. Clypeus rather long and slender, nearly twice as long as wide, slightly paler than frons, sparsely covered with moderately long, dark setae. Antenna almost translucent, pale yellow, with pale yellowish pubescence that is longer than normal for family, and seemingly without short, stiff, coarse pubescence of other black flies; with 8 flagellomeres, all subequal in length and width except apical flagellomere slightly longer; pedicel distinctly longer and slightly wider than scape or individual flagellomeres. Palpus pale brownish yellow; third palpomere darkest, distinctly enlarged and somewhat

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globose, palpomeres 3 and 4 subequal in length, palpomere 5 somewhat longer. Sensory vesicle situated centrally in palpomere 3, slightly less than ½ as long as palpomere, opening to exterior through a perpendicular pore that widens dorsally to ⅔ length of vesicle. Mandible pale, weakly sclerotized, shorter but broader than lacinia, bluntly rounded apically, without serrations, one minute, nipple-like convexity present apically (this is difficult to accurately discern in available specimens). Lacinia pale, weakly sclerotized, somewhat cleaver-shaped but rather short, slender and pointed apically, with about 12–15 seta-like processes on apex and along margin. Proximal (dorsal) arms of cibarium relatively long and nearly uniform in width, somewhat truncate apically.

Thorax.—Yellowish brown dorsally, lobe of antepronotum slightly darker than scutum; scutellum and postnotum darker yellowish brown, but median area of postnotum paler brown. Lobes of antepronotum widely separated, connected by a very slender median rod-like strip that is situated under anterior margin of scutum; each lobe with a series of moderately long and stout yellow setae (there also are about 15 larger and conspicuous setal bases on each lobe that presumably held the longer, stouter black setae described by Wood and Borkent (1982) for *P. crosskeyi*; neither specimen at hand had any of these bristle-like setae). Postpronotal lobe small, weakly defined, slightly paler yellow than adjacent area of scutum, sparsely covered by yellow setae that are scarcely longer than sparse yellow setae of anterior portion of scutum; setae mid-dorsally on scutum yellow, but distinctly shorter than anterior marginal setae; prescutellar area of scutum with a sparse series of rather stout, yellow setae, in addition there is a series of large setal bases presumably from large, stout, black setae as described for *P. crosskeyi* by Wood and Borkent (1982). Dorsal margin of supra-alar declivity with a few moderately long, dark setae and with 3 or 4 shorter dark setae present anterodorsal to point where base of wing joins thorax. Scutellum sparsely covered with moderately long and stout, yellow setae, also present are a number of larger setal bases probably from large, stout, black setae as described by Wood and Borkent (1982) for *P. crosskeyi*. Postnotum shiny, brownish yellow, mottled with patches of darker brown. Pleuron brownish yellow, mottled with whitish yellow patches; anepisternal membrane white, specimens at hand each with a single tiny white seta at anterodorsal corner of membrane. Anepimeral tuft absent.

Legs whitish yellow, distalmost tarsomere slightly darkened, about apical ½ of mid and hind femora, in dorsal view, appearing brownish and corresponding in position with brown of abdominal tergites 3 and 4, this brownish tinge much less evident in lateral view; legs generally covered with pale whitish yellow setae, anteroventral surface of each femur with 1 to several longer dark setae, and posterior margin of basal ½ of hind tibia with 2 to 3 long, dark setae and several shorter, more distal, black setae; distal ¼ or slightly more of posterior surface of hind tibia with a patch of short, yellow setae that can be seen, in lateral view, as a slight bulge on inner posterior surface; basal ½ of first hind tarsomere with a similar nearly contiguous patch of short, yellow setae. Hind femur only slightly longer than tibia; hind basal tarsomere 6 times as long as wide, and slightly longer than combined lengths of tarsomeres 2–5. Tarsal claw simple at base, relatively long, slender and rather straight, slightly curved near tip; empodium plumose.

Wing essentially as described for male by Peterson (1977, 1981) except about proximal ½ of stem vein with short yellow to yellow and black bicolored setae,

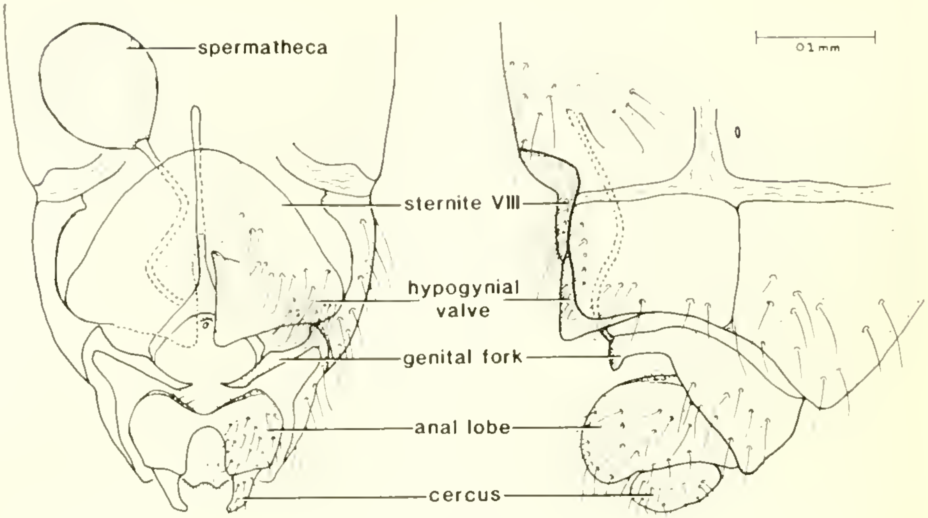

Fig. 1. Female terminalia of *Parasimulium stonei* Peterson. Left side showing ventral view. Right side showing left lateral view.

and distal ½ with about 6 very much longer, black, coarse, stiff, bristle-like setae that readily abrade; alar lobe and calypter fringed with fine, pale yellow setae. Halter whitish yellow, with a slight brownish tinge on stem near base.

Abdomen.—Segments 1 and 2 entirely whitish yellow except for a small tubercle-like brown spot below middle of posterior margin of pleural membrane of segment 2; tergite 1 (basal scale) slightly smaller and yellow fringe more sparse and shorter than in other female black flies; tergites 3–9 sclerotized and distinguishable from pleural membrane and sternites; tergites 3–6 brown, tergites 7, 9 and 10 paler brown, mottled with whitish yellow patches, tergite 8 paler whitish yellow; tergites 2–7 with sparse, short, yellow setae dorsocentrally, and with longer, sparse, dark setae laterally; tergites 8 and 9 with mixed short, yellow and dark setae. Sternites 3–5 whitish yellow, remaining sternites brown. Terminalia as in Fig. 1. Anal lobe with a short, slender, dorsal portion, and an enlarged ventral portion that projects nearly horizontally beneath cercus, ventroapical margin broadly rounded; moderately covered with short setae. Cercus relatively small, about twice as wide as long, hind margin curved and rounded ventroapically; moderately covered with short setae. Cercus not noticeably hidden or concealed in concavity of anal lobe in specimens at hand. Sternite 8 broadly U- or V-shaped, its central portion sclerotized, shiny, and bare, each side narrowly bare laterodorsally along anterior margin, posterior ½ or slightly more with both short and longer setae. Posterior margins of hypogynial valves slightly oblique or subtruncate, weakly sclerotized, pale and narrowly bare; inner margins of valves nearly straight, folding inwardly, weakly sclerotized, pale and bare; valves narrowly separated from each other; each moderately covered by setulae. Genital fork (sternite 9) with stem about twice as long as arms, slender, nearly straight and moderately heavily sclerotized; each arm slender basally, expanding distally into a rather narrow, rectangular plate with a posteromedial curved process that is pointed apically and heavily sclerotized along inner margin, tips of processes of

Table 1. Characters separating females of *Parasimulium crosskeyi* and *P. stonei.*

crosskeyi	*stonei*
—Frontal and postocular setae dark, scarcely paler than dark integument.	—Frontal and postocular setae pale yellow, contrasting with dark integument.
—Lobes of antepronotum dark brown.	—Lobes of antepronotum paler brownish yellow.
—Pleuron yellow except for triangular pale brown spot on mesepimeron.	—Pleuron brownish yellow, mottled with whitish yellow patches. Anterodorsal angle of anepisternal membrane with a single tiny white seta.
—Mid femur entirely pale yellow.	—Mid femur, in dorsal view, with about apical ½ appearing brownish.
—Tergites and sternites weakly sclerotized, scarcely distinguishable from adjacent pleural membrane.	—Tergites 3–9 and, at least, sternites 6–8 sclerotized and distinguishable from adjacent pleural membrane.
—Slender curved medial process of each arm of genital fork apparently not heavily sclerotized along inner margin, the tips of the two processes almost meeting at midline behind opening of spermathecal duct (Figs. 4 and 5 in Wood and Borkent (1982)).	—Slender curved medial process of each arm of genital fork heavily sclerotized along inner margin, the tips of the two processes rather broadly separated medially behind opening of spermathecal duct (Fig. 1).

both arms rather widely separated medially; each arm broadly united with tergite 9 dorsolaterally. Spermatheca nearly spherical, moderately sclerotized, with a small, clear, circular area at junction with spermathecal duct.

REMARKS

Since only two alcohol preserved females of *P. stonei* are known, it is difficult to distinguish them reliably from females of *P. crosskeyi.* On careful perusal of the description of *P. crosskeyi* given by Wood and Borkent (1982), and by comparisons of actual specimens, several differences are apparent. These differences are listed in Table 1. The features of the genital fork are probably the best characters for separating these species.

DESCRIPTION OF COLLECTION SITES

Parasimulium stonei has been collected at five North American localities. The species was originally found by A. L. Melander at Viento, Oregon, on July 1, 1917. The male holotype is from the Bolling Park area, Humboldt Co., in northern California, and one male is known from Mt. Hood, Oregon. Three adults were found in emergence trap samples collected in 1982 from Mack Creek and Grasshopper Creek on the west side of the Cascade Mountains of Lane Co., Oregon. These are third order streams with similar altitude (800–900 m), aspect (north facing watersheds), gradient (about 10%), and substrates (primarily boulder-cobble). The latter two sites differ most noticeably in riparian vegetation. Mack Creek flows through an old-growth coniferous forest with Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) (Pinaceae) dominating the canopy. Streamside vegetation includes red alder (*Alnus rubra* Bong.) (Betulaceae), bigleaf maple (*Acer macrophyllum* Pursh) (Aceraceae), and devilsclub (*Oplopanax horridus* (J. E. Smith) Torr. & Gray ex Miq.) (Araliaceae). Grasshopper Creek is located in an area that was clear-cut in 1976. Riparian vegetation is dominated by mountain alder (*Alnus incana* (L.) Moench), vine maple (*Acer circinatum* Pursh), willow (*Salix* (L.) sp.) (Salicaceae), and numerous herbaceous species including an abundance of coltsfoot (*Petasites frigidus* (L.) Fr.) (Compositae).

A male of *P. stonei* was collected at Mack Creek on June 29, and a female on August 7. Both specimens were taken in a trap located in a fast riffle directly below a waterfall plunge pool. The stream current velocity exceeded 1 m/s throughout much of the sampled area. Water temperatures during this period ranged from 9°C to 14°C. A second female was collected at Grasshopper Creek on July 22. It was taken from a trap placed in a depositional zone about 115 m downstream from the clear-cut boundary. Above this was old-growth coniferous forest. The trap was situated in a pool adjacent to a fast riffle, but was protected from the current by several boulders. The water temperatures for July ranged from 9°C to 13°C.

Discussion

The ecology of *Parsimulium* species is poorly known due, in part, to a lack of information about the immature stages. The only detailed account of adult bionomics was given by Wood and Borkent (1982). Their discussion pertained to *P. crosskeyi* and, primarily, the Wahkeena Creek site in the Columbia River gorge. There seems to be a tendency for *P. crosskeyi* to inhabit streams with waterfalls (e.g. Wahkeena, Eagle, Starvation creeks). The presence of a waterfall might reflect some ecological requirement, such as a marker for adult swarming behavior. The Mack Creek collection site is directly below a waterfall, but the height of the falls is much less than that of Wahkeena Falls, or others in the Columbia River gorge. However, if this feature serves only as a marker, the relative height may be inconsequential. Grasshopper Creek contains no waterfalls per se, but does have numerous high-gradient, cascading sections. The cascades of these sections might also serve as swarm markers.

It is difficult to explain why the immature stages of *Parasimulium* have not been found. Certainly, most habitats have been examined by a number of blackfly collectors. One habitat that may have been insufficiently explored is the hyporheic zone (i.e. the aquatic habitat in deep gravels beneath and lateral to the stream bed). At Wahkeena Creek the hyporheic zone is extensive, particularly along the reach where most of the adult *Parasimulium* have been collected. Mack and Grasshopper Creeks contain relatively little hyporheic habitat. Still, if immature stages inhabit this zone, its extent need not be great to support the seemingly low abundances of *Parasimulium* at these sites.

Parasimulium crosskeyi has been reported from Corvallis, which is about 145 km south-southeast of the Columbia River gorge. The Corvallis area is dramatically different from other *P. crosskeyi* sites, both topographically and floristically. Aquatic systems in the general vicinity of Corvallis are predominantly large, low-gradient rivers, with relatively high sediment loads. The specimen of *P. crosskeyi* taken by Melander, might actually have been collected in the nearby foothills of the Coast Range, where ecological conditions may approach those of other *Parasimulium* localities. An alternate explanation is that adult *Parasimulium* can travel long distances, a behavior observed in several other black fly taxa. As a final possibility, *Parasimulium* may inhabit larger stream systems, such as the Willamette and Columbia Rivers. The biota of these are poorly known, especially in terms of the black fly fauna. More effort in collecting simuliids in these large rivers might prove rewarding.

Unlike the *P. crosskeyi* collection sites, Mack and Grasshopper creeks are far removed from any large, silty rivers. Our collections provide strong evidence that *P. stonei* inhabits relatively cold, clear, high-gradient streams. The teneral condition of our specimens further suggests that they emerged nearby. Future examination of these streams, and others, should concentrate on isolating the microhabitat of immature *Parasimulium*. Unfortunately, for the present, the enigmatic problem of where these stages occur remains unsolved.

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LITERATURE CITED

Peterson, B. V. 1977. A synopsis of the genus *Parasimulium* Malloch (Diptera: Simuliidae), with descriptions of one new subgenus and two new species. Proc. Entomol. Soc. Wash. 79: 96–106.

———. 1981. Simuliidae, pp. 355–391. *In* McAlpine, J. F. et al., Coords., Manual of Nearctic Diptera. Vol. 1. Res. Branch, Agric. Can., Ottawa, Mono. No. 27.

Wood, D. M. and A. Borkent. 1982. Description of the female of *Parasimulium crosskeyi* Peterson (Diptera: Simuliidae), and a discussion of the phylogenetic position of the genus. Mem. Entomol. Soc. Wash. 10: 193–210.

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THE *EUPITHECIA* (LEPIDOPTERA: GEOMETRIDAE) OF TEXAS, WITH THE DESCRIPTION OF A NEW SPECIES

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Abstract.—Twenty-three species of *Eupithecia* (Geometridae: Larentiinae) are listed from Texas. Nineteen of these are illustrated with figures of the adult male, male genitalia, inflated vesica, and sclerotizations of the eighth abdominal segment. One new species, ***Eupithecia fredericki***, is described from western Texas. Ten of the included species represent new state records.

Eupithecia Curtis is a huge, cosmopolitan genus of small, usually obscurely colored geometrid moths. Most of the described species occur in the palearctic and nearctic regions, with over 160 species occurring in America north of Mexico, predominantly in forested areas in northern and western U.S.A. and in Canada. The moths are all similar in appearance, with elongate forewings and small rounded hindwings, usually colored gray or brown with obscure transverse markings. Many species are indistinguishable, or nearly so, in color and pattern and genitalic dissection is required for accurate species determination. The life history is unknown for most North American species, but the larvae so far known feed on foliage, buds, and flowers of many kinds of plants, including conifers. Many are host specific. Much interest was aroused by the recent discovery of several predatory species in Hawaii, in which the larvae are highly modified, enabling them to capture fruit flies and other small insects (Montgomery, 1983).

Eupithecia and related genera were last revised for North America by James H. McDunnough (1949). Since this revision, additional species have been described by Roger L. Heitzman and Wilbur R. Enns (1977), and Frederick H. Rindge (1952, 1956, 1963, 1985), who found also several of McDunnough's (1949) determinations to be in error. The authors' interest in this genus was aroused in April 1977, when the senior author succeeded in inflating the vesica of *E. prostrata* McDunnough (slide AB 4061), using the technique described by Charles L. Hogue (1963), with a few minor modifications. The results were so interesting that we felt all available species should be studied in the same manner. Over 100 vesica inflations were performed on Texas examples, showing great differences between species, including those quite similar in other respects, although there appeared to be little variation within each species. We felt, therefore, that this information would make a valuable contribution to the study of these moths. Prior publications have usually figured only portions of the male genitalia and not inflated vesica. Because much significance has been attached to the size and shape of the sclerotized structures within the aedeagus, it is obvious that vesica inflation best demonstrates these structures.

By mid 1984, 18 of the 22 species of *Eupithecia* known by us to occur in Texas had been successfully dissected, including inflation of the vesica. Of the remainder, insufficient material was at hand. Presented here are illustrations of these 18 species, including the adult male, male genitalia, inflated vesica, and eighth abdominal segment sclerotizations. Additionally, a new species of *Eupithecia* is described and illustrated. This description is to be attributed to the junior author only. The remaining four species, three of which appear to represent new Texas records, are listed in the text. The arrangement given follows that of Douglas C. Ferguson in the most recent checklist of North American Lepidoptera (Hodges et al., 1983).

VESICA INFLATION

For a detailed description of this technique, the reader is advised to study the method in Hogue (1963). Briefly, the operation is performed under a dissecting microscope, upon which the watch glass containing the aedeagus is immobilized in a wooden platform. The tip of the caecum of the aedeagus is cut off with microscissors, and in most cases, it is necessary to pull the vesica part way out posteriorly, to clear the anterior end of the aedeagus. This requires great care, as the vesica is easily damaged. We use 30 or 32 gauge hypodermic needles rather than glass cannulas, and these are attached to a 2 cc glass syringe. The bevel of the needle must be reduced to a blunt tip with fine grade emery paper, before use. The syringe and needle are held in place with modeling clay, so that both hands are free for manipulation of the aedeagus. The aedeagus is then inserted over the needle tip, pushing ahead the vesica beyond the entrance of the ductus ejaculatorius. Once in place, the aedeagus is secured to the needle with a knotted loop of nylon thread. Gentle pressure on the plunger will then result in inflation of the vesica. Occasionally, a portion of the vesica may be trapped between the aedeagus and needle, and it is then necessary to untie and repeat the process, making sure that the vesica is entirely ahead of the needle tip. Inflation is performed in water, usually with alcohol in the syringe. After initial inflation, the water in the watch glass may be replaced with alcohol and pressure continued to assure maximum inflation. If photography is contemplated, the aedeagus can be stained in advance, using mercurochrome, or, following inflation, with an alcohol soluble stain, such as eosin Y. At times, the vesica will take very little stain and is then difficult to photograph. The senior author has found dark blue or green gelatin filters to be of great help in improving the contrast in these cases.

Our figures of adults and genitalia are at varying degrees of magnification. Forewing length (in mm) is given for each adult figured. The segments in other figures represent 1.0 mm. The figures of the eighth abdominal segment show the sternite (ventral plate) on the right, except Fig. 4, which shows only the sternite. Genitalia dissections are by junior author; photography is by senior author.

Eupithecia peckorum Heitzman & Enns (1977)

Figs. 1–4

This distinctively marked, reddish brown species has been well described by Heitzman & Enns (1977) and Rindge (1985). Photos of a Texas male and its genitalia were sent to Heitzman, who confirmed its identity. Specimens were collected by us in Texas at Conroe, Montgomery Co., Huntsville State Park, Walker Co., and Town Bluff, Tyler Co., all in March.

Eupithecia longidens kerrvillaria Cassino & Swett (1924)

Figs. 5–8

This taxon was reduced to subspecific rank by McDunnough (1949). Nominate *longidens* (Hulst) is not known to occur in Texas. Fresh specimens are greenish, quickly fading to gray. Recently collected Texas material includes the following: Kerr Co., Hunt, (March, October); Bexar Co., Ebony Hill Research Station (March); Bosque Co., Laguna Park (March); and Bell Co., Belton Reservoir (April).

Eupithecia ornata (Hulst) (1896)

Figs. 9–12

This species is light gray with well defined blackish markings. It is well described by McDunnough (1949), who included New Mexico and Utah in its range. Rindge (1963) reported this species from British Columbia, Wyoming, and Arizona. Texas specimens in our collections include the following: Brewster Co., Big Bend National Park, Chisos Basin (March, April); Green Gulch (May, August); Jeff Davis Co., Mt. Locke (April, July, August); Davis Mountains State Park (April, August).

Eupithecia maestosa (Hulst) (1896)

This name is tentatively applied to two females collected in Texas that match the description and figures of McDunnough (1949). Until males are collected in Texas, the identity will remain doubtful. Texas examples: Brewster Co., Big Bend National Park, Green Gulch, 29-IX-81, 2 ♀, genitalia on slides ECK 176 and ECK 180.

Eupithecia edna (Hulst) (1896)

Figs. 13–16

This species is dark brownish gray, with heavy blackish markings. McDunnough (1949) reported its occurrence in Arizona and New Mexico. Rindge (1963) reported it from California. We collected this species in Texas only in Culberson Co., Sierra Diablo Wildlife Management Area (May, June, September), where it is common.

Eupithecia placidata Taylor (1908)

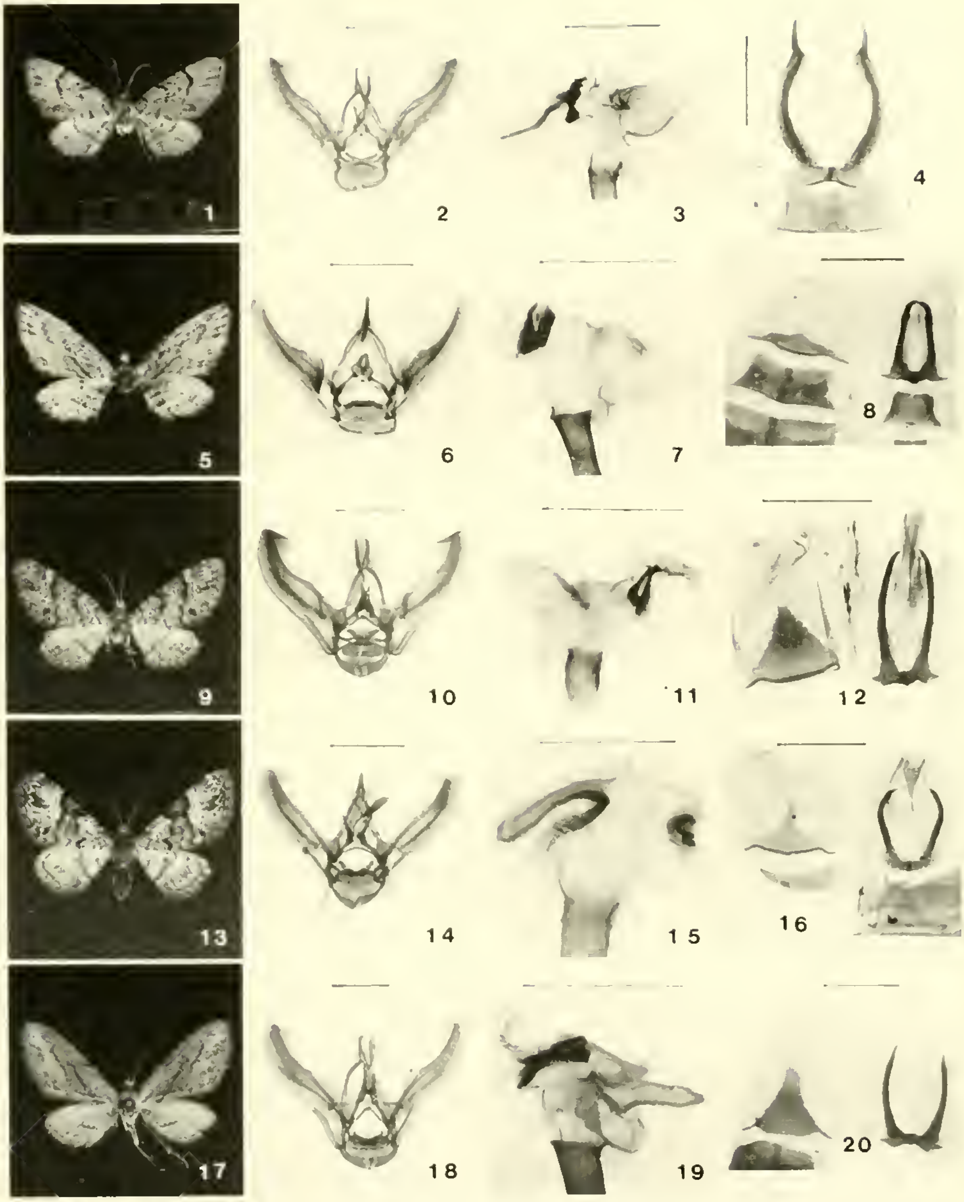
Figs. 17–20

This distinctively marked species may have yellowish green tints when fresh, but fades quickly to gray. McDunnough (1949) reported it from northern California and along the upper Pacific coast. Examples from Utah and Arizona were placed here tentatively. Photos of a Texas male and genitalia were sent to Klaus B. Bolte, who reported (in letter), "ECK 561 (Figs. 17–20) certainly appears to be *placidata*. The picture of the everted vesica matches my examples quite well." All Texas specimens were collected by us in Brewster Co., Big Bend National Park, Chisos Basin (March, September, October), and Green Gulch (August, September).

Eupithecia miserulata Grote (1863)

Figs. 21–24

This taxon is by far the most widely distributed species in Texas and the most common in the eastern half of the state. Adults vary from dark gray to yellowish



Figs. 1–20. Left column, ♂; second column, ♂ genitalia; third, inflated vesica; fourth, 8th abdominal segment. All specimens from Texas. 1–4, *E. peckorum*, all from Conroe, Montgomery County: 1 and 3, 17-III-66, A. & M. E. Blanchard, slide AB 5259, forewing 9.2 mm; 2 and 4, 13-III-83, E. Knudson, slide ECK 609. 5–8, *E. longidens kerrvillaria*, Ebony Hill Research Sta., Bexar Co., 11-III-84, E. Knudson, slide ECK 1013, forewing 8.8 mm. 9–12, *E. ornata*, Mt. Locke, Jeff Davis Co., 5-VIII-69, A. & M. E. Blanchard, slide AB 5232, forewing 10 mm. 13–16, *E. edna*, all from Sierra Diablo, Culberson Co.: 13, 27-VI-81, E. Knudson, forewing 9.7 mm. 14–16, 1-IX-69, A. & M. E. Blanchard, slide AB 5233. 17–20, *E. placidata*, Big Bend Nat'l. Park, Chisos Basin, Brewster Co., 29-III-82, slide ECK 561, forewing 9.6 mm.

brown in color and also vary considerably in size. Males can be identified by examination of the antennae, in which the segments of the flagellum are swollen distally, and with long ciliate setae. The male genitalia are most distinctive, with very large hair pencils attached broadly to the dorsal surfaces of the valvae and possessing two kinds of modified scales, one hairlike and the other spatulate (Fig. 22). Texas examples were collected mainly from October to May, but have also been taken in the summer months. Examples in our collections are from the following Texas counties: Anderson, Bastrop, Bell, Bexar, Blanco, Bosque, Brown, Cameron, Cass, Culberson, Dallas, El Paso, Hardin, Harris, Harrison, Hemphill, Hidalgo, Hill, Montgomery, Orange, Presidio, San Jacinto, San Patricio, Tarrant, Travis, Tyler, Walker, and Washington. This species is known to feed on many different kinds of woody and non-woody plants. An example from San Jacinto county was reared by the junior author on flower petals of blackberry (*Rubus* sp.).

Eupithecia coloradensis (Hulst) (1896)

We have seen only one Texas specimen of this species, a female, collected in Culberson Co., Nickel Creek, 26-V-81, by the junior author. The maculation and female genitalia are sufficiently distinctive to leave no doubt as to the correct identity (as determined by McDunnough, 1949).

Eupithecia jejunata McDunnough (1949)

Figs. 25–28

This small, obscure, gray species is fairly common in eastern and central Texas and flies from late February to early April. In Texas, it is most likely to be confused with *E. swettii* Grossbeck, which flies at the same time of year and in many of the same localities. However, *swettii* is larger and differences in the antennae of the two species have been well discussed by Rindge (1985). *E. jejunata* flies from February to April in Texas and has been collected by us in the following counties: Anderson, Bell, Bexar, Bosque, Harris, Jackson, Kerr, Marion, Montgomery, San Patricio, and Washington.

Eupithecia sierrae (Hulst) (1896)

Figs. 29–32

This long winged, gray species was reported by McDunnough (1949) from New Mexico, Arizona, and California. Rindge (1963) reported it from Utah. This species was collected by the senior author in Culberson Co., Sierra Diablo Wildlife Management Area, 29,30-V-73.

Eupithecia bolteri (Hulst) (1900)

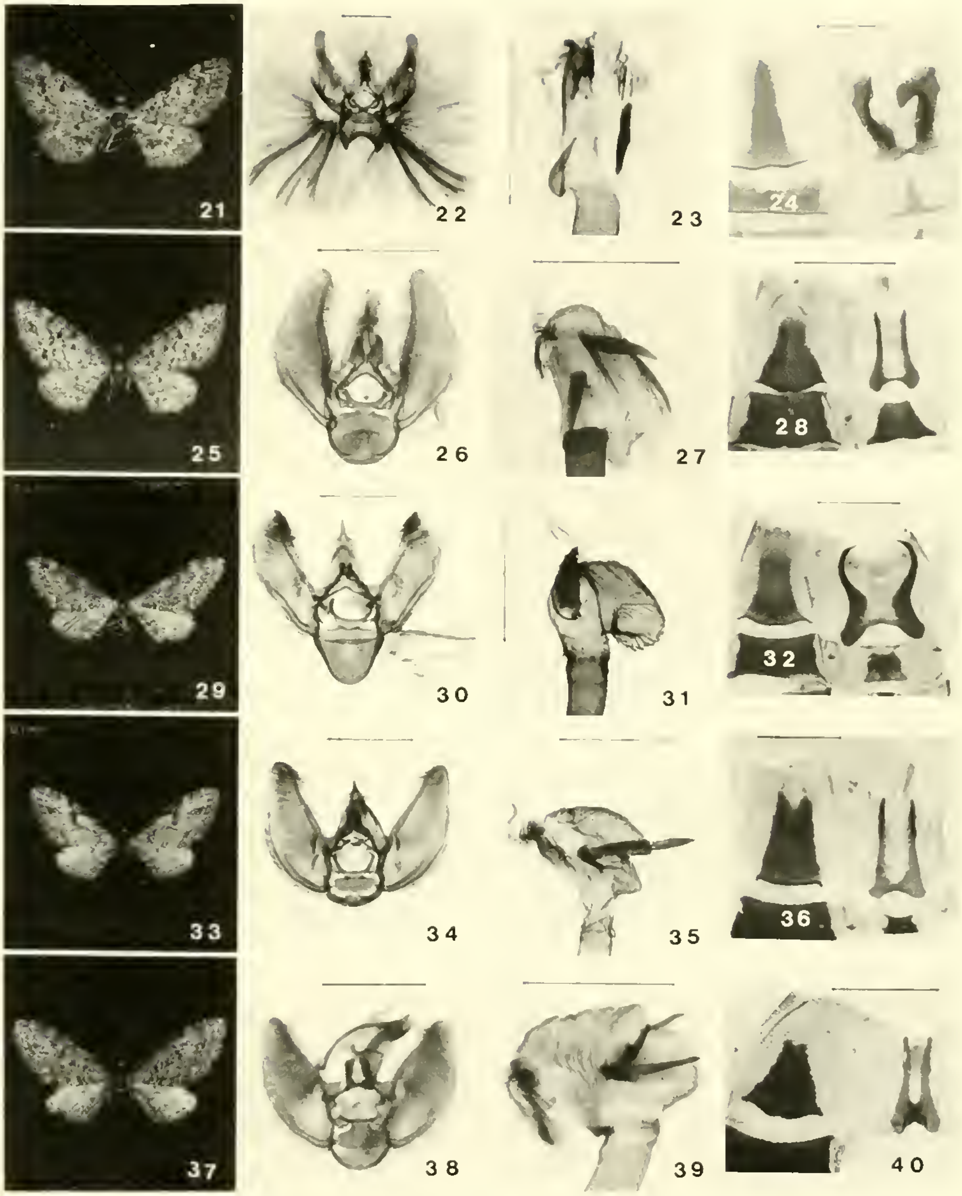
Figs. 33–36

This fairly large species, when fresh, is silvery gray, with brownish markings. It is the most abundant spring *Eupithecia* in the upper elevations of Big Bend National Park. We collected this species in March and April in the following Texas counties: Bexar, Brewster, Culberson, Jeff Davis, and Kerr.

Eupithecia alpinata Cassino (1927)

Figs. 37–40

This species and the next, *prostrata* McDunnough, are obscurely marked gray moths, indistinguishable from each other in pattern. McDunnough (1949) noted



Figs. 21–40. Left column, ♂; second column, ♂ genitalia; third, inflated vesica; fourth, 8th abdominal segment. All from Texas. 21–24, *E. miserulata,* Laguna Atascosa, Cameron Co., 11-XI-79, slide ECK 1014, forewing 9.5 mm. 25–28, *E. jejunata,* 25, Houston, Harris Co., 2-III-70, A. & M. E. Blanchard, forewing 8.1 mm. 26–28, Tennessee Colony, Anderson Co., 22-III-81, E. Knudson, slide ECK 578. 29–32, *E. sierrae,* all from Sierra Diablo, A. & M. E. Blanchard: 29–31, 30-V-73, slide AB 5244, forewing 11.1 mm. 32, 29-V-73, slide AB 5218. 33–36, *E. bolteri,* all from Jeff Davis Co., A. & M. E. Blanchard: 33, Ft. Davis, 25-III-68, forewing 11.2 mm. 34–36, Mt. Locke, 3-IV-70, slide AB 5216. 37–40, *E. alpinata,* Ft. Davis, 25-III-68, A. & M. E. Blanchard, slide AB 5243, forewing 10.2 mm.

that the type series of *alpinata* included males of both species and he based the sex association in this revision on a supposed genitalic dissection of the holotype of *alpinata*. This was contrary to the sex association made at the time of the description of *prostrata* in 1938. To attempt to clarify the matter, the authors sent photos (as represented here) of the two species to K. Bolte, who made the following comments. "I have recently gone over the problems associated with *alpinata* and *prostrata* and discovered that in McDunnough, 1949, the descriptions and illustrations of the male and female genitalia have been mismatched. The male *prostrata* as illustrated is in fact *alpinata* and the male *alpinata* as illustrated is in fact *prostrata*. Therefore AB 5243 (Figs. 37–40) is *alpinata* and ECK 586 (Figs. 41–44) is *prostrata*." These findings are well borne out in the sex associations found in our material. McDunnough's comments about the male antennae of the two species are also reversed in the 1949 revision, as *alpinata* is the species with shorter, more numerous setae. The female of *alpinata* is easily distinguished by the long, pointed papillae anales. Both species occur together in the Davis and Chisos Mountains of Texas, but *alpinata* also occurs in central Texas, on the Edwards Plateau. We have collected *alpinata* in March and April in the following Texas counties: Brewster, Jeff Davis, Kerr, and Kimble.

***Eupithecia prostrata* McDunnough (1938)**

Figs. 41–44

See remarks under preceding species. *Prostrata* can be distinguished from *alpinata* by the male antennae, which have fewer but longer setae and by the female papillae anales, which are broad, rounded and hairy. We collected this species in March and April in Brewster and Jeff Davis counties of Texas. Curiously, the distribution of the two species in each author's collection was quite different, though most were collected in the same localities at the same time of year. Those collected by the senior author, in the late 1960's, showed a 10 to 1 ratio of *prostrata* over *alpinata*, whereas the junior author's specimens, collected in the early 1980's, showed a 5 to 1 ratio of *alpinata* over *prostrata*, not including the *alpinata* from the Edwards Plateau.

***Eupithecia persimulata* McDunnough (1938)**

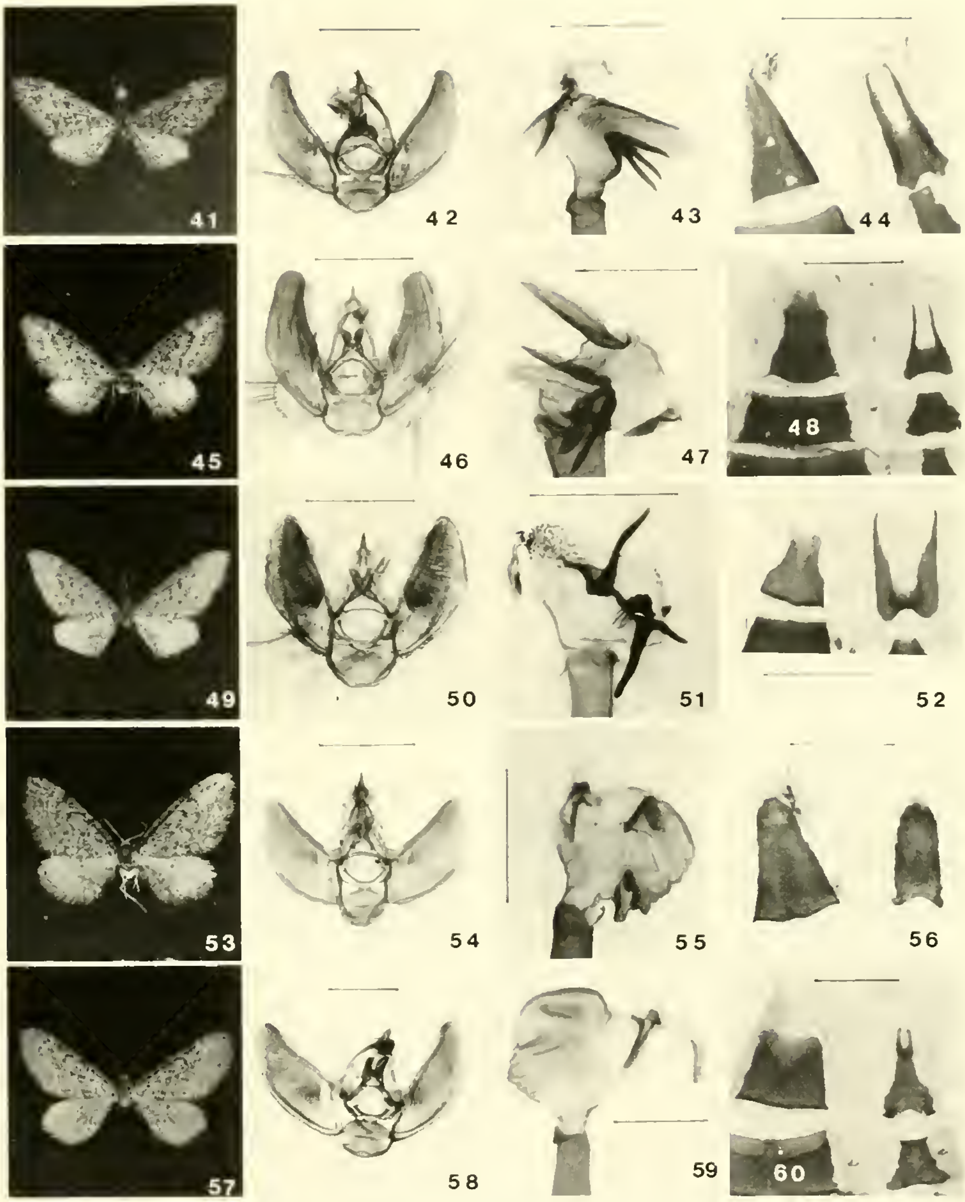
Figs. 45–48

This fall-flying species is dark gray, with a purplish sheen in fresh material. We found it common in Brewster Co., Big Bend National Park from late August to early October. It has also been collected in Jeff Davis and Culberson counties.

***Eupithecia matheri* Rindge (1985)**

Figs. 49–52

This species was described and illustrated by McDunnough (1949) as *herefordaria* Cassino & Swett. The differences between this species and the true *herefordaria*, which is known only from Arizona, are pointed out by Rindge (1985). Rindge has examined a dissected male and female from our material and identified them as *matheri*, including a female from Jeff Davis County. McDunnough (1949) also reported this species from Jeff Davis County (as *herefordaria*). This species is rather pale brownish gray and superficially similar to worn examples of *alpinata*



Figs. 41–60. Left column, ♂; second column, ♂ genitalia; third, inflated vesica; fourth, 8th abdominal segment. All from Texas. 41–44, *E. prostrata*, Big Bend Nat'l. Park, Green Gulch, 28-III-83, E. Knudson, slide ECK 586, forewing 9.0 mm. 45–48, *E. persimulata*, Big Bend Nat'l. Park, Chisos Basin, 14-IX-82, E. Knudson, slide ECK 1021, forewing 8.5 mm. 49–52, *E. matheri*, Ft. Davis, 29-III-83, E. Knudson, slide ECK 587, forewing 9.0 mm. 53–56, *E. swettii*, New Caney, Montgomery Co., 20-II-82, E. Knudson, slide ECK 576, forewing 10.1 mm. 57–60, *E. zygadeniata*, all from Laguna Park, Bosque Co.: 57 and 60, 28-III-81, E. Knudson, slide ECK 1010, forewing 12.5 mm. 58, 26-III-73, A. & M. E. Blanchard, slide AB 5196. 59, 27-III-73, A. & M. E. Blanchard, slide AB 5253.

or *prostrata*. The males can be distinguished by the antennal setae, which are longer than those of *prostrata*. We collected this species in Marion County (February), Kerr County (March), and Jeff Davis County (March, April).

Eupithecia swettii Grossbeck (1907)

Figs. 53–56

This species may be greenish when very fresh, but the color quickly fades to brownish-gray. It is rather common in early spring in east Texas woodlands. Rindge (1985) reported this species from Texas based on information provided by the junior author. We collected this species in February and March in the following east Texas counties: Anderson, Harris, Marion, and Montgomery.

Eupithecia zygadeniata Packard (1876)

Figs. 57–60

This is the largest *Eupithecia* species occurring in Texas. The color of the wings is powdery gray, with dark gray cross lines. This species is known only from Texas and is rare in collections. We found it to be very common at the type locality, in areas where the food plant *Zygadenus nuttalli* Gray (Liliaceae), is abundant. We collected this species in Bosque Co. (March), Comal Co. (May), and Kerr Co. (May).

Eupithecia pusillata interruptofasciata Packard (1873)

This subspecies is considered a North American representative of the palearctic species, *pusillata* Denis & Schiffermüller. This name has been recently found to have priority over *sobrinata* (Hübner) (Ferguson *in* Hodges et al., 1983). Although this subspecies was described from Texas, no subsequent specimens have been collected in or near this state. According to McDunnough (1949), *interruptofasciata* was described from a series including three different species, the types being later restricted to two female specimens from Texas by Swett. Presumably the locality of the holotype is accurate, as it was evidently collected by Belfrage. This species is not known to occur in Missouri (Heitzman & Enns, 1978) or Mississippi (Rindge, 1985). The food plant is known to be juniper, which is abundant in areas collected by the authors in central Texas. However, as this species flies late in the year, it is possible that in the southern part of its range it flies very late, perhaps during the winter months, and thus could be missed by collectors.

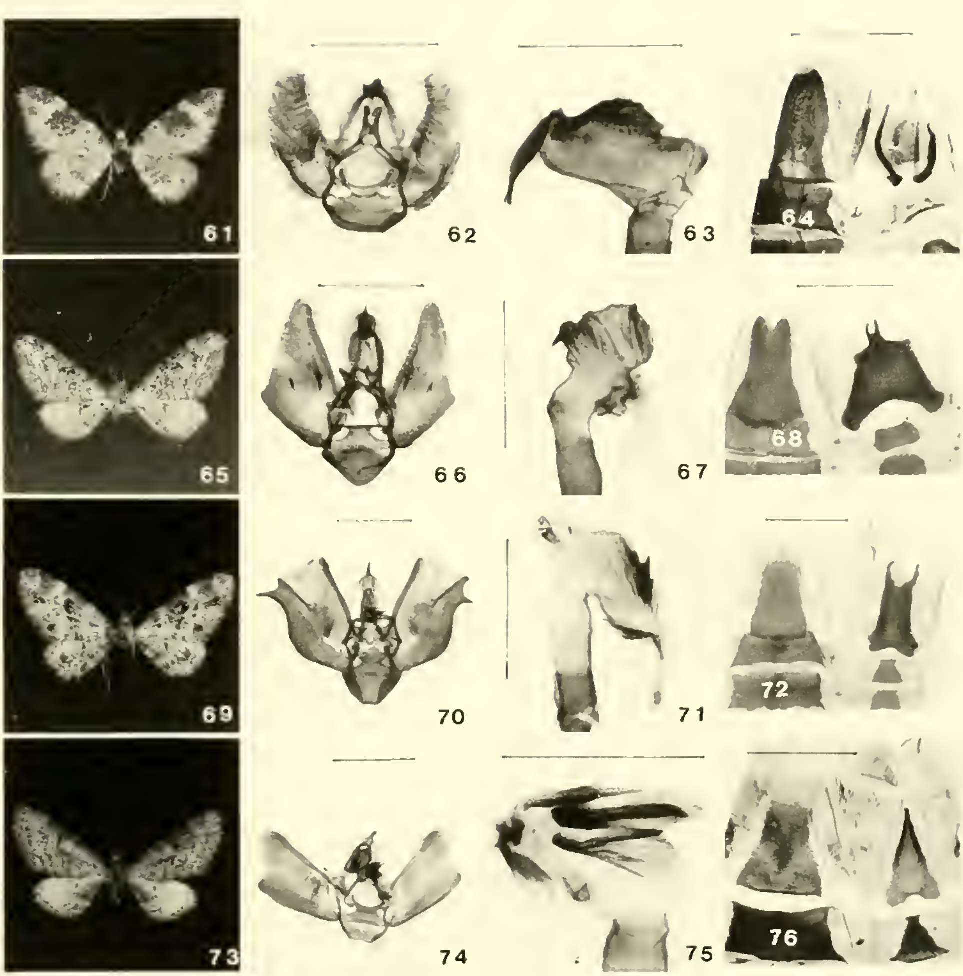
Eupithecia fredericki E. Knudson, New Species

Figs. 61–64

Male.—Head. Front pale ochreous, slightly bulging; vertex pale ochreous; labial palpi pale ochreous, porrect, barely exceeding front. Antennae with scape pale ochreous; flagellum with segments slightly longer than wide, clothed dorsally with two scale rows per segment, alternating whitish and brown; ventrally densely covered with very short setae.

Thorax pale ochreous above and beneath; legs pale ochreous with brownish scales along anterior surface of tibiae, tarsi faintly banded with brown at the joints.

Abdomen pale ochreous. 8th sternite (ventral plate) shown in Fig. 64, consisting of unequal sized, outwardly curved, tapering sclerotized rods, the longer being dextral.



Figs. 61–76. Left column, ♂; second column, ♂ genitalia; third, inflated vesica; fourth, 8th abdominal segment. All from Texas. 61–64, *E. fredericki,* new species, Sierra Diablo, 27-VI-81, E. Knudson, slide ECK 579, forewing 7.5 mm. 65–68, *E. huachuca,* Sierra Diablo, 16-IX-82, E. Knudson, slide ECK 565, forewing 7.9 mm. 69–72, *E. woodgatata,* Sierra Diablo, 16-IX-82, E. Knudson, slide ECK 529, forewing 8.3 mm. 73–76, *E. pertusata,* Big Bend Nat'l. Park, Chisos Basin, 2-X-67, A. & M. E. Blanchard, slide AB 5258, forewing 8.9 mm.

Upper surface of wings. Ground color pale ochreous, with numerous orange brown scales, especially over inner half, giving a pale orange shade to the naked eye. Maculation consists of violet-brown patches and spots, which are composed of blackish-brown scales, each narrowly tipped with white. Forewing with small violet-brown basal patch, extending from costal margin at basal 1/6 to median vein, the dark scaling extending narrowly along costal margin to about ¼ the distance from base. Beginning at the mid-costal margin and extending to ¼ the distance from apex is a large rectangular violet-brown patch, which extends to just beyond median vein. Apical 1/6 of wing violet brown, with the dark scaling extending narrowly along termen to tornus, as a terminal line. Within the apical patch, a whitish subterminal line is visible, forming a sharp inward angle before it is lost in the pale ground color. Hindwing mainly pale ochreous, obscurely banded with violet-brown, the extradiscal line being the most conspicuous marking. Fringes of both wings faintly checkered with pale ochreous and light brown.

Undersurface of wings pale brownish. Forewing with costa darker brown and with pale ochreous postmedian band. Fringes pale ochreous.

Length of forewing 7.5 mm in both holotype and paratype.

Male genitalia (Figs. 62, 63). Uncus bifid, dorsal process narrow and sharply pointed, exceeding the broad, truncate, ventral process. Valvae short and broad, tapering slightly at apex, costa well sclerotized. Aedeagus broad, and about equal in length to combined lengths of uncus, tegumen, and saccus. Inflated vesica (Fig. 63) membranous at base, with a few weak striations and scobinations; apex with a long flattened sclerotized process and a small, curved process; superior surface with a broad outpouching, armed with numerous short spines. Hair pencils of 9th segment arising from a single small globular base, with long hairlike scales.

Female unknown.

Holotype (Fig. 61). ♂, Culberson Co., Texas, Sierra Diablo Wildlife Management Area, 27-VI-81, genitalia on slide ECK 579, collected by E. Knudson and deposited in the American Museum of Natural History.

Paratype. Some data as holotype, 1 ♂, genitalia on slide ECK 152, collected by E. Knudson and deposited in the National Museum of Natural History.

Remarks. This delicate species is most similar to *E. phyllisae* Rindge (1963), from which it can be distinguished by the well defined apical and basal dark patches, and by the asymmetrical ventral plate. This species is named for Frederick H. Rindge in recognition of the many contributions he has made to the knowledge of North American *Eupithecia.*

***Eupithecia huachuca* Grossbeck (1908)**

Figs. 65–68

This small grayish species is similar in appearance to *jejunata,* but the ranges of the two species do not appear to overlap in Texas. McDunnough (1949) reported this species from western Texas. We collected this species in Jeff Davis County (March, August, and September) and Culberson County (August).

***Eupithecia woodgatata* (Cassino & Swett) (1924)**

Figs. 69–72

This species was originally described as a *Prorella* and later transferred to *Eupithecia* by McDunnough (1949). As McDunnough points out, *woodgatata* is superficially very close to *Prorella albida* Cassino & Swett, which also occurs at the same places and times in western Texas. As the authors have fresh material for study, mention might be made of some apparent points of difference, which may aid in separation of the two species. Both species are pale yellowish brown with reddish brown maculation. In *albida,* the lines tend to be complete and well defined and the extreme base of the forewing is dark brown. Both species have a prominent dark brown mid-costal patch, adjacent to the discal spot. In *woodgatata* the lines tend to be less well defined and incomplete, the wing being more suffused with reddish brown. The extreme base is not noticeably darker. *E. woodgatata* also has a prominent dark brown patch along the outer margin of the forewing, below apex, and another at the tornus. In addition, there is a small dark spot at the anal angle of the hindwing. These markings are not apparent in *albida.* There do not seem to be recognizable differences in the front or antennae of the two species, however the genitalia are very different. Specimens were collected by the junior author in Culberson Co., Sierra Diablo Wildlife Management Area, in September.

Eupithecia cocoata Pearsall (1908)

This species is evenly dark brown with obsolescent maculation, exept for prominent black discal dots. It was reported to occur in Missouri and Arkansas by Heitzman & Enns (1977). Texas examples were collected by the senior author in Brown Co., Lake Brownwood State Park, 9-IV-69, 1 ♂, 1 ♀, and 20-IV-66, 1 ♂. All were dissected soon after capture, before the senior author had begun to attempt inflation of the vesicae of *Eupithecia.*

Eupithecia pertusata McDunnough (1938)

Figs. 73–76

This species is yellowish, heavily irrorate with dark brown and copper-colored scales. The costal margin is dark brown. *Pertusata* is known only from Texas and New Mexico (Rindge, 1963). We collected this species in Brewster Co., Big Bend National Park (May, September, and October), and Jeff Davis Co., Mt. Locke (April).

Acknowledgments

The authors are extremely grateful to Klaus B. Bolte, Agriculture Canada, for examining the photos of several species, and making determinations, and to Frederick H. Rindge of the American Museum of Natural History, for review of the manuscript and providing much helpful information. The authors also acknowledge the assistance and cooperation of the National Park Service and Texas Parks and Wildlife Department, for providing the collecting permits, under which most of the above material was obtained.

Literature Cited

Cassino, S. E. 1927. Some new Geometridae. The Leipidopterist. IV, 65, 66.

Cassino, S. E. and L. W. Swett. 1924. Some new Eupithecias. Ibid. IV, 27, 28.

Grossbeck, J. A. 1907. Notes on *Eupithecia* with descriptions of new species. Entomol. News 18: 346.

———. 1908. New moths of the family Geometridae. J. N.Y. Entomol. Soc. 16: 22.

Grote, A. R. 1863. Additions to the catalogue of U.S. Lepidoptera, No. 3. Proc. Entomol. Soc. Phila. 2: 32.

Heitzman, R. L. and W. R. Enns. 1977. Descriptions of a new species of *Eupithecia* and the male of *E. cocoata* Pears. (Geometridae). J. Res. Lepid. 16: 75–82.

———. 1978 [1979]. Annotated list and keys to the geometrid subfamily Larentiinae (Lepidoptera, Geometridae) of Missouri. Trans. Mo. Acad. Sci. 12: 47–73.

Hodges, R. W. et al. 1983. Check list of the Lepidoptera of America north of Mexico. London. E. W. Classey, Ltd. xxiv + 284 pp.

Hogue, C. L. 1963. A standard method for mounting whole adult Lepidoptera on slides utilizing polystyrene plastic. J. Res. Lepid. 1: 232–235.

Hulst, G. D. 1896. A classification of the Geometrina of North America, with descriptions of new genera and species. Trans. Am. Entomol. Soc. 23: 266–268.

———. 1900. Some new species of Geometridae. Can. Entomol. 32: 102.

McDunnough, J. H. 1938. Some apparently new Texan Eupithecias. Can. Entomol. 70: 236–240.

———. 1949. Revision of the North American species of the genus *Eupithecia* (Lepidoptera, Geometridae). Bull. Am. Mus. Nat. Hist. 93: 533–728.

Montgomery, S. L. 1983. The case of the killer caterpillars. Nat. Geogr. Mag. 164: 218–225.

Packard, A. S., Jr. 1873. Descriptions of new American Phalaenidae. Fifth Rep. Trust. Peabody Acad. Sci. pp. 52–81.

———. 1876. A monograph of the geometrid moths or Phalaenidae of the United States. *In* Hayden, F. V., Report of the U.S. Geological Survey of the Territories. iv + 607 pp.

Pearsall, R. F. 1908. Eastern and central Eupithecias. J. N.Y. Entomol. Soc. 16: 103.

Rindge, F. H. 1952. Taxonomic and life history notes on North American *Eupithecia* (Lepidoptera, Geometridae). Am. Mus. Novit. 1569: 1–27.

———. 1956. Descriptions of, and notes on North American Geometridae (Lepidoptera). Ibid. 1784: 1–19.

———. 1963. Notes on and descriptions of North American *Eupithecia* (Lepidoptera, Geometridae). Ibid. 2147: 1–23.

———. 1985. The *Eupithecia* (Lepidoptera, Geometridae) of Mississippi and Louisiana. Ibid. 2809: 1–18.

Taylor, G. W. 1908. Notes of the Lepidoptera of Kaslo, B.C., with descriptions of seven new species. Can. Entomol. 40: 56.

NOTE

Cerchysiella scutellata from California (Hymenoptera: Chalcidoidea: Encyrtidae)

Members of the genus *Cerchysiella* have been previously treated under the generic name *Zeteticontus,* but this name was recently synonymized with *Cerchysiella* by Noyes and Hayat (1984, Bulletin of the British Museum of Natural History (Entomology), 48(3): 131–395). *Cerchysiella* has been represented in the United States by a single naturally occurring species, *C. insularis* (Howard) from Florida (Gordh, *in* Krombein et al., 1979, Catalog of Hymenoptera in America North of Mexico, Vol. 1 (Symphyta and Apocrita), Smithsonian Institution Press: 890–967). New World species of this genus were recently treated by Noyes (1979, Systematic Entomology, 4: 143–169), and distribution for *C. scutellata* (Howard) was given as West Indies and Brazil. We recently collected a series of 23 female *C. scutellata* from California (Riverside Co., Riverside, UCR Campus, October–November 1984). This is a significant range expansion for this species, as well as the first record for this genus from western United States. It is not known whether the collection of this species in southern California represents a part of a distribution which extends throughout much of the warm areas of the New World or an introduction by man.

Specimens were collected in yellow pan traps beneath cultivated guava trees (*Psidium guayava* L.), and reared from rotting guava fruits. One fully formed adult female was dissected from a mummified larva of one of the nitidulid beetles which infested the rotting fruit, *Stelidota geminata* (Say) (det. Iris Savage, California Department of Food and Agriculture). Specimens of this series of *C. scutellata* are in the collection of the University of California Riverside, with exemplars placed in the National Museum of Natural History and the British Museum of Natural History.

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NOTE

Observation with the Scanning Electron Microscope of a Fly Captured in Amber

Amber is a fossil plant resin which originated as a secretion from trees and appears in the fossil record as early as the carboniferous but is more common in Cretaceous and Tertiary strata (Langenheim, 1969. Science 163: 1157–1169). Succinite is the most common amber found in northern Europe in Oligocene deposits and also is cast up on the shores of the Baltic Sea. It possibly was secreted from a species which had affinities to the Pinaceae and the Araucariaceae but which is no longer extant (Langenheim, 1969). The plant and animal inclusions in Baltic amber have been described in numerous publications. Larsson (1978. Baltic Amber—a Paleobiological Study. Scandinavian Science Press Ltd., Klampenborg, Denmark) in his extensive bibliography cites more than forty publications by Meunier on insect inclusions published between 1892 and 1923. Most descriptions are based on light microscope studies of polished pieces of clear amber. The present note suggests that amber fragments may on occasion be profitably studied with the scanning electron microscope.

Often pieces of amber show a laminated structure which may have resulted from successive resin flows, and often insects were trapped on the surface of one flow and covered by a subsequent flow (Larsson, 1978). This lamination allows the amber to be fractured along an interface and thus expose the remains of an organism or the imprint it left in the solidifying resin. Small segments were split away from a 2 cm^3 piece of Baltic amber with the aid of a razor blade. A fragment that contained the impression of a fly was glued to a stub and coated with a 200 A thick layer of gold palladium (four thirty second bursts from a Balzers Union sputter coater) and photographed with a scanning electron microscope (AMR model 1000A). Figs. 1–4 show the impression that the fly made in the solidifying amber. Details of the compound eye and wing are shown at higher magnifications (Figs. 2–4). The small "holes" in the wing are probably the impression of hairs and at higher magnification a broken hair ("cross section") is seen in each hole (Fig. 4). From the micrographs, E. R. Hoebeke, J. K. Liebherr and Q. D. Wheeler (Department of Entomology, Cornell University) suggested that the fly is a member of the Dolichopodidae. Larsson (1978) notes that living members of this family are often encountered in large numbers in low vegetation where high humidity prevails and are also extensively represented as inclusions in Baltic amber.

It may be rewarding to study fragments of amber for other small inclusions especially small insects, mites, spores and pollen grains with the scanning electron microscope.

We thank Elizabeth Lawson for her technical help with the SEM.

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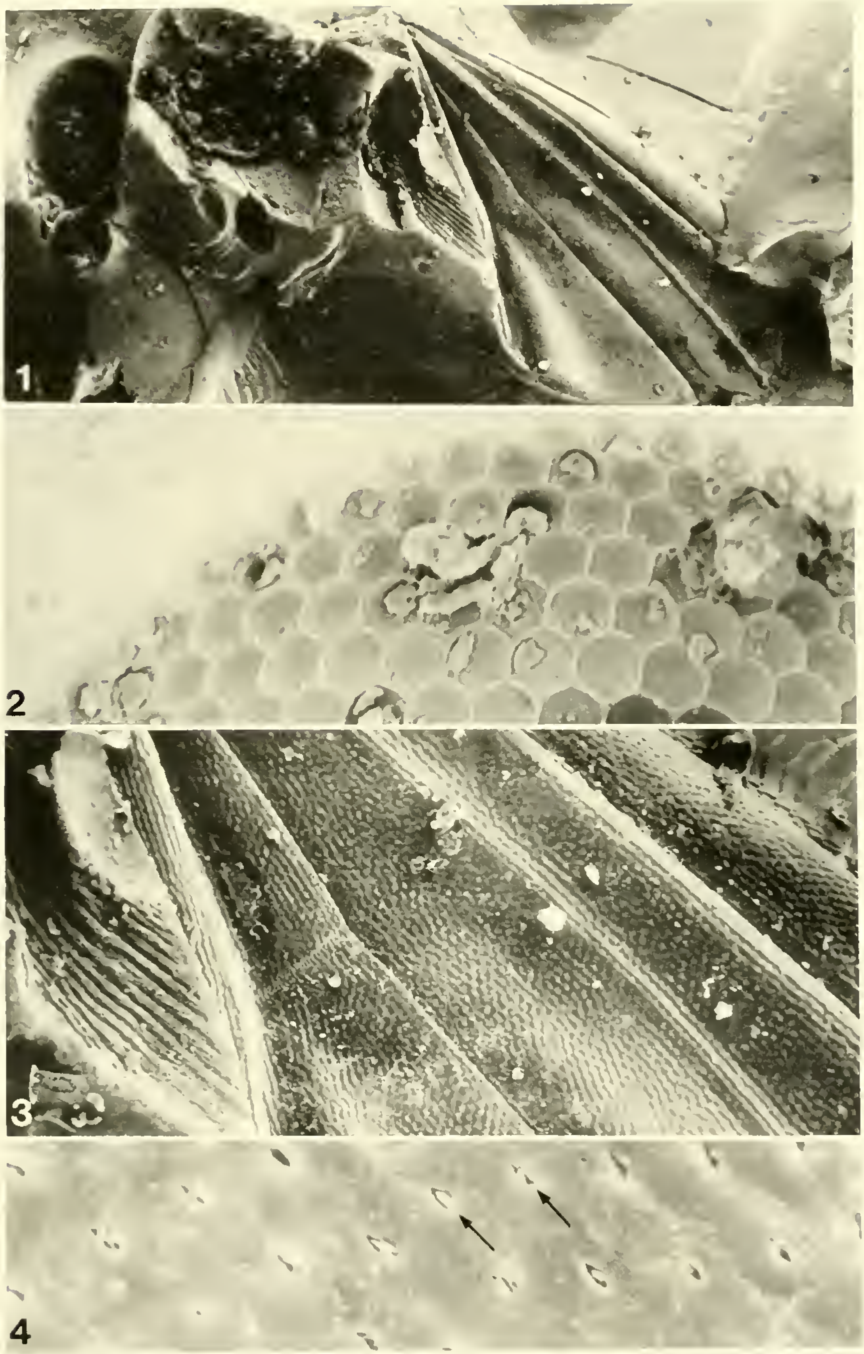

Figs. 1–4. Scanning electron micrographs of impression of fly in amber. 1, Impression with some organic (?) material ×32. 2, Part of compound eye ×530. 3, Part of wing ×105. 4, Cross sections of wing hairs (arrows) embedded in amber ×1050.

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NOTE

New Synonymy and New Combinations in African Predaceous Midges of the Genus *Phaenobezzia* (Diptera: Ceratopogonidae)

Grogan (1980. Proc. Entomol. Soc. Wash. 82: 510) recently established that *Parabezzia insolita* Vattier and Adam is a junior synonym of *Parabezzia falcipennis* Clastrier (1960, Arch. Inst. Pasteur Algérie 38: 258–298). However, this synonymy was based on the description and illustrations of *P. insolita* published by Vattier and Adam (1966, Ann. Spéléol. 21: 711–773) as the type of that species could not then be located at ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer) by Adam. One of us (MC) subsequently located the type of *P. insolita* at ORSTOM in Bondy, France in a box of ceratopogonids among Vattier's material. We can now reaffirm Grogan's (1980) new synonymy and wish at this time to clarify the taxonomic status of several forms described by Vattier and Adam (1966).

Wirth and Ratanaworabhan (1981. Pac. Insects 23: 396–431) recently remarked that "Most of the *Bezzia* species described by earlier authors in the genus or subgenus *Probezzia* Kieffer belong in *Phaenobezzia*." Since the genus *Phaenobezzia* was described by Haeselbarth (1965. Z. Angew. Zool. 52: 297–324) just before the publication of Vattier and Adam (1966), we wish to establish the following new synonymies and new combinations based upon examination of the type specimens from the Congo (Brazzaville).

***Phaenobezzia nzuari* (Vattier and Adam), NEW COMBINATION**

Probezzia nzuari Vattier and Adam, 1966: 750 (male).
Nilobezzia (*Parrotia*) *troglophila* Vattier and Adam, 1966: 754 (female). **NEW SYNONYMY.**

An examination of the holotypes of these two forms reveals that they are conspecific; the holotype female of *N. troglophila* is the opposite sex of the holotype male of *P. nzuari*. Also, they belong to the genus *Phaenobezzia* in the tribe Palpomyiini and not *Probezzia* or *Nilobezzia* both of which are in the tribe Sphaeromiini.

***Phaenobezzia pajoti* (Vattier and Adam), NEW COMBINATION**

Probezzia pajoti Vattier and Adam, 1966: 752 (male).
Nilobezzia (*Parrotia*) *congolensis* Vattier and Adam, 1966: 758 (female). **NEW SYNONYMY.**

An examination of the holotypes reveals that the female of *N. congolensis* is actually the opposite sex of the male of *P. pajoti*. As in the preceding two species, both are actually members of the genus *Phaenobezzia*, not *Probezzia* or *Nilobezzia*.

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NOTE

What is *Capsus frontifer* Walker, 1873 (Heteroptera: Miridae)?

Walker (1873. Cat. Hem. Het. Colln. Brit. Mus., 6: 94) described *Capsus frontifer* from "North America." No subsequent worker has published an association of this name with a species in our fauna. Uhler (1886. Check-list Hem. Het. N. Am., p. 21) listed *C. frontifer* under "Genera unascertained" and Van Duzee (1917. Cat. Hem. Am. N. Mex., p. 420) placed it with "Uncertain forms." Distant (1904. Ann. Mag. Nat. Hist., (7)8: 206), in studying the Walker types, stated that *C. frontifer* was not present in the British Museum and should be treated as nonexistent.

While cataloging the Miridae of the United States and Canada, it came to my attention that *C. frontifer* is one of the few unrecognized mirid species in our fauna. By piecing together Walker's description, I am able to say with certainty that *C. frontifer* is the senior synonym of *Coccobaphes sanguinarius* Uhler, 1878. The original description reads as follows: "Female. Red, fusiform, shining, very finely punctured. Head triangular; middle lobe [tylus] black. Antennae black; first joint a little longer than the head, red at the base. Prothorax with a slight transverse furrow, in front of which there is a callus on each side. Legs slender. Membrane and hind wings brownish. Length of the body 3½ lines [approx. 6.33 mm]." Only a few North American Miridae are red. Species of *Rhinocapsus, Tropidosteptes cardinalis* Uhler, and others are too small and do not fit the description. Only *Coccobaphes sanguinarius* is within the size range and fits the description exactly. Also, I discovered a single female in the National Museum of Natural History from Marquette, Michigan, collected 28 Aug. 1888, with a determination label, in Uhler's hand, reading: "*Coccobaphes frontifer* Walk!" It is apparent that nearly 100 years ago Uhler discovered what I have concluded but never published his opinion. Therefore, I propose the new combination *Coccobaphes frontifer* (Walker) and with it the new synonymy of *Coccobaphes sanguinarius* Uhler, the type-species of the monotypic genus *Coccobaphes* Uhler, 1878.

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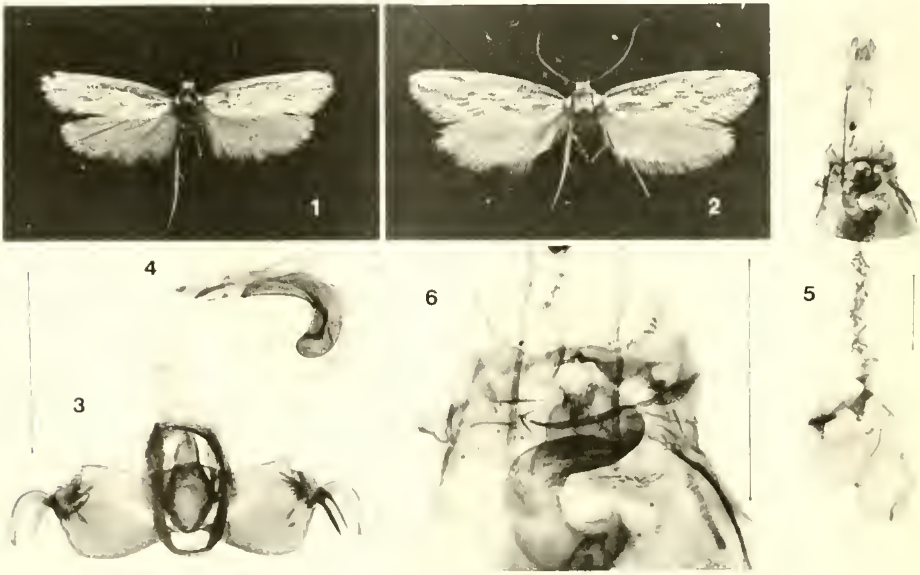
PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 680–681

NOTE

Ethmia angustalatella Powell (Lepidoptera, Oecophoridae): Description of the Female and First U.S. Records

Ethmia angustalatella Powell (1973. Smithson. Contrib. to Zoology, No. 120, p. 214) was described from a single male collected 3 miles east of Galeana, Nueva Leon, Mexico. The holotype is in the National Museum of Natural History, Washington, D.C. After reexamining some long overlooked material, we found that a series of *Ethmia* from five counties in southwestern Texas represented this species. The male agrees exactly with Powell's original description. The female has never been described. Texas specimens collected by the authors include the following: Brewster Co., Big Bend National Park, near Nugent Mt., 6-IV-67, 1 ♀ (Figs. 2, 5, 6) and Oak Spring, 8-V-72, 1 ♂ (Fig. 1), both collected by A. & M. E. Blanchard; Terrel Co., Sanderson, 25-IV-81, 7 ♂ (Figs. 3, 4), 1 ♀, Pecos Co., 40 miles south of Ft. Stockton, 25-IV-81, 1 ♀, Val Verde Co., Seminole Canyon State Park, 27-IX-81, 4 ♂, 2 ♀, and Starr Co., Roma, 24-III-78, 1 ♂, all collected by E. C. Knudson. The forewing lengths in 12 males ranged from 8.0—10.5 mm, averaging 9.4 mm; in 5 females, from 9.7–11.5 mm, averaging 10.5 mm.

Female description (Figs. 2, 5–6).—Head, thorax, and wings as in original description of holotype. Forewings are pale brownish gray with white streaks and bars, forming an indistinct striated pattern, hindwings are shiny brownish ochreous,



Figs. 1–6. *Ethmia angustalatella*. 1, Male, genitalia on slide AB 5395. 2, Female. 3, Male genitalia, slide ECK 1099. 4, Aedeagus, same specimen and slide as 3. 5, Female genitalia, slide AB 5396, same specimen as 2. 6, Enlargement of 8th segment and ostium of 5. Segments in Figs. 3–6 represent 1 mm.

with white fringes. The abdomen of both sexes is shiny brownish ochreous, terminal segment whitish. Female genitalia: Papillae anales membranous, except for interrupted, thin sclerotized bar at its base. Posterior apophyses twice as long as anterior apophyses. Eighth segment a sclerotized ring, sternite narrowed and emarginate over ostium. Lamina antevaginalis poorly sclerotized, except for a well sclerotized arcuate rim below ostium. Antrum well developed, sigmoid, with a posterolateral sclerotized plate. Ductus bursae membranous, helicoid, with about 10 tight coils (distorted in Fig. 5). Corpus bursae membranous, signum a deeply set notched keel, somewhat variable in shape of keel in three examples studied.

The female genitalia are most similar to species in the *trifurcella* group. This supports the conclusions in Powell (ibid.) that were based on male characters of *angustalatella* and on the closely related species *Ethmia punctessa* Powell.

We gratefully acknowledge the cooperation and assistance of the U.S. National Park Service and the Texas Parks and Wildlife Department.

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PROC. ENTOMOL. SOC. WASH.
87(3), 1985, p. 682

NOTE

Occurrence of *Hesperocimex coloradensis* List (Hemiptera: Cimicidae) in a Woodrat Nest in Arizona

Hesperocimex coloradensis List is primarily an ectoparasite of woodpeckers and Purple Martins, *Progne subis* (Linnaeus), in forested areas of western North America (Ryckman and Ueshima, 1964. Ann. Entomol. Soc. Am. 57: 624–638). There are only eight previously confirmed records from California (3), Colorado (2), Nevada (1), Oregon (1), and British Columbia, Canada (1) (see Usinger, 1966. Monograph of Cimicidae).[1] The species occurs in nest cavities made by woodpeckers that are frequently occupied by Purple Martins and occasionally by other vertebrates that may or not be suitable hosts.

On 18 October 1982, Haas collected one male, two females, and one nymph (all unengorged), 8.6 km WNW of Williams, Coconino Co. (2000 m elev.). They were found in the fine inner nest material of a *Neotoma ?mexicana* Baird den, at the base of a dead ponderosa pine (*Pinus ponderosa* Laws.) stub. Presumably there had been a woodpecker nest cavity in the broken-off part of the stub and the bugs had migrated from it to the woodrat nest. This collecting situation is similar to one in California reported from a fallen tree containing a chipmunk, *Eutamias* sp. (= *Tamias merriami* J. A. Allen) nest built over a Purple Martin nest in an abandoned woodpecker nest cavity (Ryckman, 1958. Ann. Entomol. Soc. Am. 51: 33–47). The nest cavity had been inhabited by Purple Martins a few months earlier, when the tree was still standing, and probably was already bug-infested when found and occupied by chipmunks.

Hesperocimex coloradensis, *H. sonorensis* Ryckman, and *H. cochimiensis* Ryckman and Ueshima have been described in the genus, and *H. coloradensis* is the second species to be recorded from Arizona. The collection locality falls on the southwestern edge of the probable distribution in Arizona as outlined by Ryckman and Ueshima (1964. loc. cit.) and is about 155 km NNE of Morristown, Maricopa Co., a locality where *H. sonorensis* has been collected. Although the two species have similar hosts they are separated ecologically. *Hesperocimex coloradensis* occurs in forested areas in woodpecker nest cavities made in trees whereas *H. sonorensis* occurs in desert areas in similarly constructed cavities in saguaro (*Cereus giganteus* Engelm.) and saguaro-like cacti (*Pachycereus pecten-aboriginum* (Engelm.), *Pachycereus pringlei* (S. Watson)).

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[1] Lattin and Schuh (1959. Pan-Pac. Entomol. 35: 175–176) listed it as occurring in Nebraska without giving additional data or citation. We know of no supporting evidence for this statement.

PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 683–684

BOOK REVIEW

Atlas of European Trichoptera. By Hans Malicky. Dr. W. Junk BV, The Hague, Series Entomologica 24. x + 298 pp. 1983. Dfl.175 (approximately $76). Distributed in U.S.A. by Kluwer Boston, Hingham, Massachusetts 02043.

The Trichoptera, or caddisflies, play an important role in the aquatic ecosystem. The habit of their larvae in making either portable cases or fixed nets has brought them to the attention of biologists from the earliest days. The European fauna is, as expected, perhaps the best known of the world's regions, but even here it is difficult to make certain identifications because of the scattered literature. The only previous attempt to cover the entire fauna was completed over 100 years ago (McLachlan's *Revision and Synopsis* of 1874–1880). We now have a new book to cover the fauna of Europe, including the Mediterranean countries north of the Sahara, the Canaries, Madeira, the Azores, the Arabian Peninsula, and Iran.

The previous listing of European species, published in 1967, enumerated about 750 species from a smaller area (it did not go south or east of the Mediterranean). The Malicky *Atlas* treats almost 1200 species. Part of the increase is due to the increased area covered, but most is due to recent intensive study with the discovery of many new species in the Iberian Peninsula, the Balkans, the Aegean Islands, the Near East and Turkey.

His manner of treatment is quite different from what one would, perhaps, expect. As the title implies it is an atlas, i.e. a picture book. There is a short introduction, a page of labeled drawings of parts, and another page of explanation of terminology, all in English, French and German. Then there is a page of tabulation for all combinations of three characters: the tibial spur counts, presence or absence of ocelli, and number of maxillary palpal segments in the males. For each unique combination is listed 1–12 genera or families that possess this combination of characters. One must then check out each taxon to make the identification. The final identifications are made by comparison of the male (or in many genera, the female) genitalia with the drawings. He makes use of arrows to point to diagnostic areas, much as do the popular Peterson bird guides. For one who has worked with Trichoptera, this is an excellent guide, as most of us recognize to family or genus the male genitalia of most species, but I am not sure how well it will work for the uninitiated. Perhaps one who uses the initial differential table with care will arrive at a correct identification quicker with the picture book approach than by attempting a long dichotomous key.

The illustrations come from many sources, but all are reproduced to the same size. Although there are many new figures in the book, there was no alternative but to use some old, inadequate figures, which are marked to indicate this. I am quite surprised to see how many species have been figured in the female sex, which are also included after the male figures. Yet in most of the larger genera 50% or less of the females are figured and the inadequate notation is frequent.

Although my first feeling is that the lack of some type of key, to families at least, will make it slower for the non-specialist to arrive at the correct identification of an unknown, I recognize that most of our current family keys are riddled with exceptions, errors, and unstated expectations of divine guidance that in many cases make them even more likely to lead to error in the hands of the novice. Overall, this is a book that all trichopterists as well as biologists who are going to work on the European aquatic fauna must have on their shelves. Beyond this, anyone who is contemplating an identification manual for a large group of organisms should consult the atlas for ideas on how to handle the problem. We trichopterists are indebted to the author for bringing together such a valuable identification manual.

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PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 685–687

Book Review

The Dragon Hunters. By Frank Graham, Jr. Truman Talley Book—E. P. Dutton, Inc., 2 Park Avenue, New York, New York 10016. 334 pp. 13 line drawings. $22.95.

Frank Graham has written an excellent review of biological pest control, a field of research that is unknown to most laymen and little understood by many entomologists and scientists in other fields of research. His book, derived from numerous interviews with scientists and excerpts from pertinent literature, presents biological control in a very personal way. The author vividly describes the research as a living and complicated endeavor involving real people. He has removed the various projects from impersonal pages of scientific publications and transformed them into a "storybook" report readily understood by the general reader. This transition was accomplished without losing the value of the book to the professional entomologist.

The introduction, an essay in itself, places the field of biological control in its proper perspective, i.e. what is it, why do we need it, what does it require, and how will we benefit from it? In my opinion, the last paragraph of the introduction (pp. 16–17) should be required reading for administrators of agricultural programs and their decision-making staffs as well as for peers who review the work of scientists involved in the biological control research of those programs. In a few lines on those pages the author has succinctly listed the knowledge and skills routinely expected of a scientist involved in biological control.

The book has 21 chapters, with one, or at times, two chapters, devoted to a particular pest and its natural enemies. Other chapters treat general areas of biocontrol-related research or, at least, what is included by some under the umbrella of "Biological Control."

There are 6 main topics in the book: review of biological control of insects; biological control of weeds; insect pathology; integrated pest management; and a brief discussion of new research approaches such as genetic engineering and the use of pheromones that require a more "laboratory-oriented" technology.

Control with parasites and predators is exemplified by projects concerning the following pests: the cottony cushion scale—*Icerya purchasi* Maskell; the citrus whitefly—*Dialeurodes citri* (Ashmead); other species of whiteflies; the gypsy moth—*Lymantria dispar* (L); the cereal leaf beetle—*Oulema melanopus* (L); the ice plant scales—*Pulvinariella mesembryanthemi* (Vallot) and *Pulvinaria delottoi* (Gill); the screwworm—*Cochliomyia hominivorax* (Coquerel); the California red scale—*Aonidiella aurantii* (Maskell); the alfalfa blotch leafminer—*Agromyza frontella* (Rondani); the boll weevil—*Anthonomus grandis* (Boheman); and the bollworm and tobacco budworm—*Heliothis* spp.

The control of weeds is discussed in chapter 15, "Plant Pests: The Water Hyacinth and the South." Although it's a minor point, the use of "Weeds" in place of "Plant Pests" would have been less ambiguous. To most of us plant pests are insects and mites that attack plants, but weeds are weeds. The weeds discussed are the water hyacinth *Eichornia crassipes* (Mart.) Solms; the Klamath weed or

St. Johnswort, *Hypericum perforatum* L.; and the alligator weed, *Alternanthera phylloxeroides* (Mart) Griseb.

The discipline of insect pathology is represented by reviews of the use of *Bacillus thuringiensis* (Berliner) against the spruce budworm, *Choristoneura fumiferana* (Clemens); *B. thuringiensis* subsp. *israelensis* for mosquito control; and the application of the microsporidian, *Nosema locustae* Canning against grasshoppers.

Whether or not the sterile male technique is really biological control is a debatable topic. Nevertheless, Dr. Graham includes the technique in *The Dragon Hunters* using the classic work with the screwworm as the example.

The all encompassing concept of Integrated Pest Management is described through the eyes of farmers and scientists involved in cotton production in the Southwest.

The last two chapters of the book include brief surveys of research approaches that have gone beyond the largely empirical methods of classical biological control. These are the more sophisticated fields that probe the importance and application of pheromones and kairomones, and the concept and possible use of genetic engineering in relation to biological control.

The author contacted most, if not all, of the contributors before the final copy of the manuscript went to press and this precaution was effective. I found very few factual errors or typographical mistakes. For example, there are more quarantine laboratories receiving exotic material than just the Newark, Delaware, and the Gainesville, Florida, facilities mentioned on p. 169. At latest count there are about 20 quarantine stations throughout the U.S. The insertion of the phrase "in the European Parasite Laboratory" between *cages* . . . and *outside Paris* in line 16, p. 97 would help clarify an uncertain situation. The few misspelled scientific names I found were: pp. 286 and 326 Chrom*a*phis; p. 324 Anaph*e*s and C*a*losoma; and p. 330 Mesembr*y*anthemum. On p. 122 and 325 the screwworm is now in the genus *Cochliomyia*, not *Callitroga*.

My main criticism is that the author presents several projects as if one researcher alone was responsible for the study. For example, Harry Smith certainly approved the Klamath Weed Project (chapter 15) but it was J. K. Holloway, USDA, and C. B. Huffaker, University of California, who led and performed the research. The same could be said for the alfalfa weevil, cereal leaf beetle, gypsy moth, etc., projects that otherwise were so well reported. Obviously, everyone cannot be interviewed, but the author should have made it clear that the final results were based on long term commitments and team work on the part of many.

Although not included as a discipline in biological control, the role of the taxonomist is a vital part of any project. Consequently, I believe the importance of taxonomy could have been emphasized more than it was. The confusion and problems associated with the use of *Aphytis* spp. against the California red scale (chapter 11) were an indication of the need for taxonomic support of any project. The biocontrol specialist must work hand in hand with the taxonomist from the inception of a project through to its final evaluation.

The Dragon Hunters is an excellent introduction to and a review of recent events in biological control. The author has captured the complexities of this research and has recounted each project as a story with action, suspense, at times a happy ending, but always with a challenge. The book should be required reading for all biological control adherents, and most entomology majors. It should be ready by high school and college students looking for a commitment to agriculture and to the preservation of environmental quality. Biological control is, as Dr. Graham quotes, "the thinking person's pest control."

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PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 688–689

Book Notice

Endocrinology of Insects. By Roger G. H. Downer and Hans Laufer, editors. New York, Alan R. Liss, 707 pp. 1983. $146, hardcover; $49.50, softcover. (Vol. 1 of "Invertebrate Endocrinology.")

Insect endocrinology was invented by arthropods and their ancestors in eons long past; it was discovered in large measure by V. B. Wigglesworth scant decades ago, and has since become as much a growth industry as Bloomsbury: papers, symposia, texts, even (it has been rumored) an abortive attempt at a journal, booklength reviews—these have increased in number from the trickle of the 1930's through the torrent of the 60's and 70's, to the flood of today.

A flood (to belabor the metaphor) carries everything with it; a flood does not discriminate. The volume I introduce here, the first in a series on invertebrate endocrinology, attempts, successfully, to filter the useful from the nugatory. Better, this volume reviews, analyzes, and synthesizes what we know about the major aspects of insect endocrinology and, in doing so, points useful directions for further work.

The subjects covered range from those long and thoroughly studied (such as metamorphosis, diapause, development, and the physiology and chemistry of the hormones effecting them) to subjects rather more recently studied in depth (myotropisms, pigmentation). Emphasized are the biochemical aspects and interactions, these being of the broadest current interest (if one may generalize about a field now become so large).

One may cavil at the presence here of a section on intracellular communication. Yet chemicals that communicate are hormones, and that they do it within a cell does not seem to me to place them beyond the study of endocrinologists. This section is a good one, and if its inclusion stretches the definition of endocrinology, we shall all survive. Better to sin by commission than by omission.

The major divisions of the book are these:

I. Organization of the Neuroendocrine System (46 pp., 2 papers).
II. Chemistry of Insect Hormones and Neurohormones (97 pp., 7 papers).
III. Regulation of Metamorphosis (109 pp., 7 papers).
IV. Regulation of Reproduction (83 pp., 5 papers).
V. Regulation of Growth and Development (77 pp., 7 papers).
VI. Metabolic Homeostasis (59 pp., 5 papers).
VII. Myotropic Factors and Regulation of Pigmentation (37 pp., 3 papers).
VIII. Novel Systems for Studying Insect Endocrines (25 pp., 3 papers).
IX. Pheromones (33 pp., 2 papers).
X. Intracellular Communication (69 pp., 3 papers).
XI. Distribution and Role of Insect Hormones in Plants (30 pp., 1 paper).
XII. Hormones and Insect Control (31 pp., 2 papers).

In summary, this book is excellent. The leading authorities in each field cover the material thoroughly and imaginatively, the facts are clearly presented, and speculation is both exciting and restrained. Achieving so consistent a level of excellence is not easy, and the editors are to be congratulated.

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PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 690–692

OBITUARY

OSCAR LING CARTWRIGHT
1900–1983

Oscar L. Cartwright was the eldest of three children, born to William R. and Lydia McDowell Cartwright. Cartwright, as he preferred to be called, was born on April 12, 1900 at Sharpesville, Pennsylvania.

At an early age, Cartwright was interested in natural history and in stamp and coin collecting. He also was active in the Boy Scouts of America. As a young man, his interest in natural history led him first to Allegheny College where he received his BS degree in 1923 and then to Ohio State University where he received his MS degree in Entomology in 1925.

Cartwright enjoyed telling how, when he started his graduate studies at Ohio State University, his advisors steered him away from research on his beloved scarab beetles because "scarabs were so well studied that no more work remained to be done on that family." Present day specialists studying scarabs should, like Cartwright, get lots of chuckles from that statement. However, Cartwright heeded the advice of his advisors and worked on leafhoppers instead of scarabs. His research, under the direction of Dr. Dwight W. DeLong, was entitled "The Genus *Chlorotettix*—a study of the internal male genitalia. Including the description of a new species." Cartwright's thesis and his first scientific article were published in 1926.

After graduation from Ohio State University in 1925, Cartwright was employed at the South Carolina Agriculture Experiment Station at Florence, South Carolina, where he worked for 1½ years before he moved to Clemson Agricultural College. At Clemson he conducted applied research studies on numerous pests of corn and was able to resume his strong interest in scarab beetles. He frequently went on collecting trips to the mountains of South Carolina with his new friends, Professor Franklin Sherman and David Dunavan. Those were interesting times and he enjoyed relating tales of moonshiners, stills, and revenue agents encountered on those trips as well as the good scarabs and tiger beetles that he collected.

Cartwright worked for the South Carolina Agriculture Experiment Station from 1925 to 1945. From 1945 through 1946 he worked on mosquito and rat borne diseases in South Carolina and Tennessee for the U.S. Public Health Service. Following that tour of duty he returned to the South Carolina Agriculture Station during 1947. By this time he had published numerous articles on scarab beetles and, consequently, he was offered and accepted a position as an Associate Curator in the Division of Insects at the Smithsonian Institution in 1948. Cartwright served several times as Acting Curator of the Division of Insects. In 1963, when the Division of Insects was raised to a Department of Entomology and divided into five Divisions, he was appointed Curator and Supervisor of the Division of Coleoptera. He remained as Supervisor until 1967 when he asked to be relieved of those heavy duties so he could use his remaining years before retirement to concentrate on systematic research studies.

Cartwright loved to collect and those of us who accompanied him on field trips found him to be a very pleasant companion with a keen sense of humor. Before he was employed at the Smithsonian Institution, he collected widely in the southeastern United States. After he joined the Smithsonian staff he collected in Costa Rica, El Salvador, Guatemala, Texas, Arizona, and Florida. He also was invited and participated in a yacht trip to the Bahama Islands to collect insects as part of a zoological collecting expedition. In addition, he visited several museums in Europe to examine type-specimens of scarab beetles in support of his research projects.

During his years at the Smithsonian Institution, Cartwright added thousands of beetles to the collections as a result of his collecting efforts. Also, his friendship, correspondence, and assistance to other colleagues throughout the world resulted in donations of their collections to the Smithsonian Institution. Notable among these are the Murayama collection of Asiatic scarabs and scolytids (25,000 specimens), the Rosenberg collection of North American scarabs and miscellaneous beetles (43,520 specimens), and the Lenczy worldwide collection of beetles (243,726 specimens).

In 1941, in recognition of his work on scarabs, Cartwright was honored by being made a Fellow of the Entomological Society of America. He also was awarded a Smithsonian Institution Service Award and plaque in 1954 after serving as Acting Curator of the Division of Insects for 7 months. During that time Cartwright processed a very large backlog of insect material which had accumulated since World War II and established a new series of modern, attractive, and enlightening public exhibits. Cartwright belonged to the Entomological Society of America (Fellow), the Entomological Society of Washington, the Association of Tropical Biology, the Coleopterists' Society, Sigma Xi, the Society of Systematic Zoologists, and the Cosmos Club. During his student days at Ohio State University, Cartwright was a member of Alpha Chi Rho fraternity. Other memberships were held in Chi Rho, Phi Beta Phi, and Gamma Alpha. He also was included in listings in American Men of Science, Who's Who in America, and Who's Who in the South and Southwest.

Although Cartwright was pleased by the honors listed above, he was even more pleased by the 17 beetles named for him by colleagues. One patronym that especially delighted him was the scarab genus *Cartwrightia,* dedicated to him by a Mexican colleague, Federico Islas, in 1958. Nine years later, with tongue in cheek and the usual twinkle in his eye, Cartwright named a new species in "his" genus for his brother who had occasionally collected aphodiine scarabs for him. Thus he coined the name *Cartwrightia cartwrighti* Cartwright (1967), for which he was subjected to considerable kidding. As part of his description of that species, he included a beautiful illustration of it drawn by a friend and Scientific Illustrator, Elsie Herbold Froeschner. This illustration appeared as a logo on the invitation to his retirement party and on a gift of stationery he received at the party. He also was delighted when he received a beautiful set of custom made bookends with a metal cast of the huge neotropical scarab *Megasoma elephas* on one end of the set and the equally huge African scarab *Goliathus goliathus* on the other.

During Cartwright's entomological career spanning 55 years from the appearance of his first paper in 1926 until his last article was published in 1981, he authored or coauthored 86 publications in which 132 new taxa were described. Although Cartwright was interested in all scarab beetles, his research was centered on the members of the subfamily Aphodiinae and from the 1930's until his death, Cartwright was "the" authority on Western Hemisphere Aphodiinae. Burdened with curatorial and administrative duties during most of his career at the Smithsonian Institution, Cartwright welcomed the opportunity to relinquish his supervisory duties in 1967 and concentrate on his research. Even after he reached the former mandatory retirement age of 70, Cartwright continued working for 11 more years as an Emeritus Entomologist. He enjoyed the much greater freedom this allowed him and he completed several of his larger publications during those unencumbered years.

Cartwright died at his home on March 21, 1983 from heart failure. He is survived by his wife Sara Marie, nee Richbourg, formerly of Summerton, South Carolina.

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PROC. ENTOMOL. SOC. WASH.
87(3), 1985, pp. 693–698

NEW TAXA DESCRIBED BY O. L. CARTWRIGHT

COLEOPTERA: CICINDELIDAE

Cicindela abdominalis floridana—1939b: 364.
Tetracha virginica melaena—1935a: 70.

SCARABAEIDAE

Aphodius acuminatus—1944c: 133.
Aphodius atwateri—1944c: 149.
Aphodius bottimeri—1957b: 56.
Aphodius brimleyi—1939b: 357.
Aphodius captivus—1944c: 147.
Aphodius geomysi—1939b: 356.
Aphodius goffi—1939b: 354.
Aphodius kirni—1944c: 131.
Aphodius lodingi—1957b: 59.
Aphodius pseudabusus—1957b: 60.
Aphodius robinsoni—1939b: 359.
Aphodius rossi—1944c: 130.
Aphodius sepultus—1944c: 146.
Aphodius silvanicus—1972: 59.
Aphodius texensis—1972: 60.
Aphodius windsori—1939b: 357.
Aphonus brevicruris—1944b: 36.
Aphotaenius—1952b: 181.
Aphotaenius colombiensis—1952b: 183.
Aphotaenius howdeni—1963b: 51.
Aphotaenius plaumanni—1963b: 49.
Ataenius barberi—1974a: 51.
Ataenius duncani—1974a: 24.
Ataenius edistoi—1978: 17.
Ataenius fattigi—1948b: 151.
Ataenius glaseri—1974a: 57.
Ataenius griffini—1974a: 77.
Ataenius hesperius—1974a: 61.
Ataenius hoguei—Cartwright and Spangler, 1981: 785.
Ataenius linelli—1944b: 28.
Ataenius miamii—1934b: 200.
Ataenius nunenmacheri—1974a: 53.
Ataenius parkeri—1974a: 21.
Ataenius pseudohirsutus—1974a: 37.
Ataenius punctifrons—1974a: 59.
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Ataenius sabinoi—1974a: 38.
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PUBLICATIONS BY O. L. CARTWRIGHT

1926. The genus *Chlorotettix*—a study of the internal male genitalia. Including the description of a new species. Annals of the Entomological Society of America 19(4): 499–511 (with D. M. DeLong).
1926. Thirty-ninth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 35–36, Corn Billbugs.
1927. Fortieth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; p. 44, Corn Billbug, Corn Weevil.

1928. Forty-first Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 45–47, Corn Billbugs.

1929a. The maize billbug in South Carolina. South Carolina Agriculture Experiment Station, Clemson Agricultural College, Bulletin 257: 1–35.

1929b. Forty-second Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 64–66, Corn Weevil, Corn Earworm Studies; pp. 66–68, Larger Corn Stalk Borer; p. 68, Corn Billbugs; p. 68, Fall Army Worm; p. 69, Lesser Corn Stalk Borer.

1930a. The rice weevil and associated insects in relation to shuck lengths and corn varieties. South Carolina Agriculture Experiment Station of Clemson Agricultural College, Bulletin 266: 1–28.

1930b. Forty-third Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 67–70, The Corn Weevil and Associated Insects; pp. 70–71, Corn Billbug; pp. 71–73, The Southern Corn Stalk Borer.

1931. Digger wasps and Buprestidae (Hym.: Cerceridae, Coleop.: Buprestidae). Entomological News 42(10): 269–270.

1931. Forty-fourth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 64–66, The Southern Corn Stalk Borer; p. 66, The Corn Billbug; p. 71, *Trichogramma minutum* Riley (with W. C. Nettles).

1932. Forty-fifth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 66–67, Southern Corn Stalk Borer; pp. 67–68, Corn Billbug; p. 68, Control of Corn Earworm in Sweet Corn; pp. 68–70, Boll Weevil Hibernation at Clemson College.

1933. Forty-sixth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; p. 72, The Southern Corn Stalk Borer; pp. 72–74, Corn Billbugs; pp. 74–76, The Corn Weevil; p. 76, Boll Weevil Hibernation; pp. 82–84, Biology and Control of Thrips Attacking Cotton (with J. G. Watts).

1934a. The southern corn stalk borer in South Carolina. South Carolina Agriculture Experiment Station of Clemson Agricultural College, Bulletin 294: 1–32.

1934b. New *Ataenius* from Florida (Coleoptera, Scarabaeidae). The Canadian Entomologist 46: 200–201.

1934c. A list of Scarabaeidae collected at Clemson College, South Carolina (Coleoptera). Entomological News 45: 237–240, 268–269.

1934d. Forty-seventh Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 56–57, The Southern Corn Stalk Borer; pp. 57–58, The Rice Weevil in Corn; p. 58, Boll Weevil Hibernation; p. 58, Oriental Fruit Moth.

1935a. The tiger beetles of South Carolina with the descriptions of a new variety of *Tetracha virginica* (L.) (Coleoptera: Cicindelidae). Bulletin of The Brooklyn Entomological Society 30(2): 69–77.

1935b. A new species of *Phyllophaga* from Florida (Coleop.: Scarabaeidae). Entomological News 46: 102–104.

1935c. Forty-eighth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 43–45, The Oriental Fruit Moth; pp. 45–46, Corn Insect Studies; p. 46, Miscellaneous Notes on Injurious Insects.

1936. Forth-ninth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 42–43, Oriental Fruit Moth Studies; pp. 43–45, Corn Insect Studies.

1937. Fiftieth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 52–54, The Rice Weevil in Corn; p. 58, Southern Corn Stalk Borer; p. 58, Oriental Fruit Moth.

1938. A South African *Onthophagus* found in United States (Coleoptera: Scarabaeidae). Entomological News 49: 114–115.

1938. Fifty-first Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 65–69, The Rice Weevil in Corn; pp. 69–70, The Oriental Fruit Moth; p. 70, Corn Earworm Studies (with J. M. Todd).

1939a. Corrections and additions to the Clemson list of Scarabaeidae and other records from South Carolina (Coleoptera: Scarabaeidae). Entomological News 50: 284–286.

1939b. Eleven new American Coleoptera. Annals of the Entomological Society of America 32(2): 353–364.

1939. Fifty-second Annual Report of the South Carolina Agriculture Experiment Station, Clemson

Agricultural College; pp. 77–78, Cowpea Curculio (with F. Sherman); pp. 78–79, Oriental Fruit Moth.

1940a. A survey of field infestations of insects attacking corn in the ear in South Carolina. Journal of Economic Entomology 32(6): 780–782.

1940. Fifty-third Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 61–62, Oriental Fruit Moth; pp. 62–66, Tomato Fruit Worm (with F. Sherman, J. C. Watts, W. M. Upholt); p. 68, Corn Ear Worm Studies.

1941a. Concerning the distribution of *Ataenius miamii* Cartw. Bulletin of the Brooklyn Entomological Society 36(1): 33.

1941. Fifty-fourth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; p. 68, Oriental Fruit Moth; pp. 68–70, Tomato Fruit Worm (with F. Sherman, W. M. Upholt, J. C. Watts).

1943. Fifty-fifth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 62–64, Tomato Fruit Worm (with F. Sherman, W. M. Upholt); p. 62, Cowpea Curculio (with F. Sherman).

1943. Synonyms of *Ataenius spretulus* (Hald.). Bulletin of the Brooklyn Entomological Society 38(3): 108.

1944a. Fifty-sixth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 61–62, Rice Weevil in Farm and Stored Corn.

1944b. New Scarabaeidae from United States (Coleoptera). Annals of the Entomological Society of America 37(1): 28–36.

1944c. New *Aphodius* from Texas gopher burrows. Entomological News 55(5): 129–135, 146–150.

1945a. Fifty-seventh Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; p. 57, Rice Weevil and Associated Insects; p. 57, The Oriental Fruit Moth; pp. 58–59; Tomato Fruit Worm; pp. 60–61, Observations and Preliminary Tests of "DDT" During 1944.

1945b. *Ataenius darlingtoni* Hinton a synonym of *A. salutator* Fall. Bulletin of the Brooklyn Entomological Society 40(2): 47.

1946a. A new *Phyllophaga* from Alabama and Georgia (Scarabaeidae: Coleoptera). Entomological News 57(1): 10–12.

1946b. Two new *Psammodius* from southeastern United States (Coleoptera, Scarabaeidae). Bulletin of the Entomological Society 41(3): 89–91.

1947a. Flood collecting for Coleoptera. The Coleopterists' Bulletin 1: 30.

1947b. The use of cellophane in papering duplicates. The Coleopterists' Bulletin 1: 86.

1948a. The American species of *Pleurophorus* (Coleoptera: Scarabaeidae). Transactions of the American Entomological Society 74: 131–145.

1948b. *Ataenius strigatus* (Say) and allied species in the United States. Transactions of the American Entomological Society 74: 147–153.

1948c. Sixtieth Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 79–80, Oriental Fruit Moth; pp. 80–82, The Corn Earworm; pp. 82–83, Sweet Potato Weevil; pp. 83–84, Red Spider on Peaches.

1949a. *Aphodius vestiarius* Horn, a synonym of *Aphodius cuniculus* Chevrolat. The Coleopterists' Bulletin 3(3): 37–38.

1949b. The egg-ball of *Deltochilum gibbosum* (Fab.). The Coleopterists' Bulletin 3(3): 38.

1950. Further corrections and additions to the Clemson, South Carolina, list of Scarabaeidae. 61 (3): 72.

1950. Sixty-seventh Annual Report of the South Carolina Agriculture Experiment Station, Clemson Agricultural College; pp. 43–44, Control of the Rice Weevil and Associated Pests in Stored Grain (with J. H. Cochran, Frances McAllister).

1951. New synonymy in the Aphodiini of the United States. The Coleopterists' Bulletin 5(2): 29–30.

1952a. A new *Megasoma* from Arizona (Coleoptera, Scarabaeidae). Proceedings of the Entomological Society of Washington 54(1): 36–38.

1952b. *Aphotaenius*, a new genus of dung beetle (Coleoptera: Scarabaeidae). Proceedings of the United States National Museum 102(3295): 181–184.

1953. Scarabaeid beetles of the genus *Bradycinetulus* and closely related genera in the United States. Proceedings of the United States National Museum 103(3318): 95–120.

1955. Scarab beetles of the genus *Psammodius* in the Western Hemisphere. Proceedings of the United States National Museum 104(3344): 413–462.

1956. Descripcion de una nueve especie Mexicana de *Onthophagus* con anotaciones ecologicas sobre especies asociadas a nidos de animales y a cuevas. Acta Zoologica Mexicana 1(9): 1–16 (with H. F. Howden, G. Halffter).

1957a. Records of *Strigoderma teapensis* Bates from the United States (Scarabaeidae). The Coleopterists' Bulletin 11: 32.

1957b. Three new American *Aphodius* with notes and a key to related species. The Coleopterists' Bulletin 11: 56–61.

1958. Another old record of *Aphotaenius carolinus* (Van Dyke) (Coleoptera, Scarabaeidae). Proceedings of the Entomological Society of Washington 60(3): 134.

1959. Scarab beetles of the genus *Bothynus* in the United States (Coleoptera: Scarabaeidae). Proceedings of the United States National Museum 108(3409): 515–541.

1963. Scarab beetles of the genus *Onthophagus* Latreille north of Mexico. Proceedings of the United States National Museum 114(3467): 1–133, 11 figs., 9 plates (with H. F. Howden).

1963a. Two new species of *Megasoma* from the United States and Mexico (Coleoptera: Scarabaeidae). The Coleopterists' Bulletin 17(1): 25–29, 1 plate.

1963b. Two new beetles of the genus *Aphotaenius* (Coleoptera: Scarabaeidae). The Coleopterists' Bulletin 17(2): 49–51, 5 figs.

1964. Lectotype designations and new synonymy in the genus *Ataenius* (Coleoptera: Scarabaeidae). The Coleopterists' Bulletin 18(4): 101–104.

1966. A new species of *Ceratophyus* found in California (Coleoptera: Scarabaeidae). Occasional Papers, Bureau of Entomology, California Department of Agriculture 9: 1–7.

1967a. A new *Thyce* from Georgia (Coleoptera: Scarabaeidae). Proceedings of the Entomological Society of Washington 69(3): 238–240, 1 plate.

1967b. Two new species of *Cartwrightia* from Central and South America (Coleoptera: Scarabaeidae: Aphodiinae). Proceedings of the United States National Museum 124(3632): 1–8, 3 plates.

1967. A review of the genus *Euparixia* with description of a new species from nests of leaf-cutting ants in Louisiana (Coleoptera: Scarabaeidae). Proceedings of the United States National Museum 123(3616): 1–21, 2 plates, 13 figs. (with R. E. Woodruff).

1968a. *Ataenius frankenbergeri* Balthasar. The Coleopterists' Bulletin 22(1): 27.

1968b. [Obituary]. Mark Robinson (1906–1965). Entomological News 79(10): 285–286.

1969. Ten *Rhyparus* from the Western Hemisphere (Coleoptera: Scarabaeidae: Aphodiinae). Smithsonian Contributions to Zoology 21: 1–20, 15 figs. (with R. E. Woodruff).

1970a. A review of the aphodiine beetles of the Galapagos Islands (Coleoptera: Scarabaeidae). Proceedings of the Biological Society of Washington 83(4): 51–58, 2 figs.

1970b. Two new synonyms of *Ataenius picinus* Harold (Coleoptera: Scarabaeidae: Aphodiinae). Proceedings of the Entomological Society of Washington 72(2): 225.

1970c. A new name for *Onthophagus monticolus* Howden and Cartwright (Coleoptera: Scarabaeidae). Proceedings of the Entomological Society of Washington 72(1): 54.

1970d. The male of *Megasoma vogti* Cartwright (Coleoptera: Scarabaeidae: Dynastinae). Proceedings of the Entomological Society of Washington 72(2): 224–226.

1971. Coleoptera: Scarabaeidae. *In* Insects of Micronesia 17(4): 257–296, 25 figs. (with R. D. Gordon).

1972. A key to the crassulus group of *Aphodius* with descriptions of new species from Texas and Maryland (Coleoptera: Scarabaeidae: Aphodiinae). Proceedings of the Biological Society of Washington 85(4): 57–62, 5 figs.

1973. Additional lectotype designations in the Aphodiinae (Coleoptera: Scarabaeidae). The Coleopterists' Bulletin 27(1): 41–43.

1974. *Ataenius*, *Aphotaenius*, and *Pseudataenius* of the United States and Canada (Coleoptera: Scarabaeidae: Aphodiinae). Smithsonian Contribution to Zoology 154: i–iv, 1–106.

1974. Survey of food preferences of some No. American Cathonini (Coleoptera: Scarabaeidae). Entomological News 85(5&6): 181–185 (with R. D. Gordon).

1976a. Adult feeding by *Dynastes tityus* (Linn.) (Coleoptera: Scarabaeidae). The Coleopterists' Bulletin 30(4): 336.

1976b. A new *Megasoma* from Baja California, Mexico (Coleoptera: Scarabaeidae: Dynastinae). The Coleopterists' Bulletin 30(1): 85–89.

1977. A new species of *Psammodius* from sand dunes of California (Scarabaeidae: Aphodiinae: Euparinna). The Coleopterists' Bulletin 31(3): 281–282.

1978. Bredin-Archbold-Smithsonian Biological Survey of Dominica. The Superfamily Scarabaeoidea (Coleoptera). Smithsonian Contributions to Zoology 279: i–iv, 1–32, 16 figs. (with F. E. Chalumeau).

1978. Concerning *Aphodius aegrotus* Horn and *Aphodius geomysi* Cartwright. The Coleopterists' Bulletin 32(3): 258.

1980. The Western Hemisphere species of *Rhyssemus* and *Trichiorhyssemus* (Coleoptera: Scarabaeidae). Smithsonian Contributions to Zoology 317: i–iii, 1–29.

1981. [Obituary]. Doris Holmes Blake. Proceedings of the Entomological Society of Washington 83(3): 544–564 (with R. C. Froeschner and E. M. L. Froeschner).

1981. A new *Ataenius* from the Socorro Islands, Mexico (Coleoptera: Scarabaeidae: Aphodiinae). Proceedings of the Entomological Society of Washington 83(4): 785–789, 5 figs. (with P. J. Spangler).

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TRIGONOTYLUS COELESTIALIUM (HETEROPTERA: MIRIDAE), A PEST OF SMALL GRAINS: SEASONAL HISTORY, HOST PLANTS, DAMAGE, AND DESCRIPTIONS OF ADULT AND NYMPHAL STAGES

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Abstract.—*Trigonotylus coelestialium* (Kirkaldy), a holarctic plant bug (Mirinae: Stenodemini), is known as a pest of small grains in the Palearctic Region but has remained little studied in the Western Hemisphere. Presented are a summary of its seasonal history and host plants in Pennsylvania, its relative density in oat fields, the effects of different densities of adults on growth of oat seedlings under greenhouse conditions, and its potential for injuring cultivated grains. Even small numbers of adults (1–2 per 2 seedlings) significantly inhibited growth, and it is concluded that this multivoltine bug is potentially injurious to spring grains. The nymphal stages are described and illustrated; the adult is illustrated and diagnosed with emphasis on its separation from the related *T. ruficornis* (Geoffroy).

Entomologists are becoming more aware of plant bugs as pests of grasses and small grains. Species of the mirid genera *Irbisia* Reuter (McKendrick and Bleicher, 1980; Schwartz, 1984) and *Labops* Burmeister (Todd and Kamm, 1974; Hewitt, 1980) decrease productivity of range grasses in western United States. Feeding occurs mainly on grass blades, causing chlorotic spots in areas of stylet penetration. Other grass-associated plant bugs feed more on culms (stems) or on maturing flower and seed heads. Their injury appears as silvery-white heads that, although mature, produce sterile flowers. Usually referred to as silvertop (or sometimes white ear), this condition results from the piercing of culms before pollination occurs. In North America the agents responsible for silvertop may differ among regions, but mirids often are important causal agents (Arnot and Bergis, 1967; Peterson and Vea, 1971; Kamm, 1979; Gagné et al., 1984). Species implicated in producing silvertop belong mainly to the subfamily Mirinae, except for the phyline *Amblytylus nasutus* (Kirschbaum). Most of the mirines are members of the tribe Stenodemini, e.g., the genera *Leptopterna* Fieber, *Litomiris* Slater, *Megaloceroea* Fieber, and *Stenodema* Laporte. In Europe, the holarctic *Leptopterna dolabrata* (L.) is known to cause silvertop of grasses (Wagner and Ehrhardt, 1961).

Species of the stenodemine genus *Trigonotylus,* often abundant in grasses and small grains, have received little attention in North America, though they have been studied in the Palearctic Region. In the USSR, Agafonova and Belizin (1964) recorded large populations of *T. ruficornis* (Geoffroy) (3–5/plant) on all corn plants in a 115-hectare plot. Mikhailova (1979) determined the various abiotic and biotic factors influencing population dynamics of *T. coelestialium* (Kirkaldy) in winter wheat, (1980) developed a method of forecasting the occurrence of this cereal pest based on 10-day counts on spring grains and on date of appearance of second generation adults, and (1983) discussed resistant wheat cultivars. Bilewicz-Pawinska (1982) reported on populations of *T. coelestialium* developing in barley, oat, rye, and wheat fields in Poland and on parasitism by three species of the braconid genus *Peristenus* Foerster.

In the North American literature, Watson's (1928) "Miridae of Ohio" included *T. ruficornis* in a list of economically important mirids, stating it is occasionally abundant in wheat and oats. Knowlton (1947) noted the presence of *T. ruficornis* in rye fields in Utah but reported that *Leptopterna ferrugata* (Fallén) was the mirid most often associated with fields showing chlorotic blades. Arnot and Bergis (1967), in studying the silvertop problem in British Columbia, collected only 3 adults of *T. ruficornis* in fields examined but noted that it induced typical silvertop symptoms in the greenhouse. In Pennsylvania this species was the most abundant heteropteran associated with grass sod and various legumes seeded in old-field sward environments (Mangan et al., 1982).

T. coelestialium, described from China by Kirkaldy (1902), was later recognized from Germany (Wagner, 1956) and from Poland where it is the most common member of the genus (Korcz, 1979). The first North American records were those of Carvalho and Wagner (1957) from Alaska, Illinois, New York, and Ohio. It is known in Canada from Nova Scotia and Prince Edward Island west to Alberta (Kelton, 1971, 1980) and in the U.S. from New England south to Georgia and Louisiana and west to Wyoming (Kelton, 1971; Stephens, 1982; Snodgrass et al., 1984). *T. coelestialium* has been recorded as common on grasses in Michigan (Niemczyk and Guyer, 1963), and we have found it is this holarctic species rather than the holarctic *T. ruficornis* that is abundant on various grasses in Pennsylvania. Blinn and Yonke (1982), in reporting tall fescue, *Festuca arundinacea* Schreb., as a host plant in Missouri, noted the probable occurrence of two annual generations. Stephens (1982) considered *T. coelestialium* as univoltine in southeast Wyoming; recorded this species feeding on tufted hairgrass, *Deschampsia cespitosa* (L.) Beauv., and timothy, *Phleum pratense* L.; and also collected it on wheatgrass, *Agropyron intermedium* (Host) Beauv., and on *Poa rupicola* Nash ex Rydb. Snodgrass et al. (1984) listed it from bermudagrass, *Cynodon dactylon* (L.) Pers., in Mississippi.

Owing to confusion with *T. ruficornis* in the Old World (see Wagner 1956; Bozdechova, 1973; Korcz, 1979; Josifov, 1980), it is likely that *T. coelestialium* has been present in Europe longer than published records would indicate. In North America it is unlikely that *T. coelestialium* is a recent invader. Some of the references to *ruficornis* in the economic literature probably refer to *coelestialium*, as does the record of *T. americanus* Carvalho from various grasses and small grains in New York (Hardee et al., 1963).

We summarize here our data on seasonal history, host plants, and habits of *T. coelestialium* in Pennsylvania during 1977–83, including results of a preliminary laboratory study designed to assess its potential for inhibiting the growth of small grains. A diagnosis and illustration of the adult are provided; the nymphal stages are described and illustrated. Voucher specimens are deposited in the collections of the Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg (BPI, PDA) and the Department of Entomology, U.S. National Museum of Natural History, Washington (USNM).

MATERIALS AND METHODS

Field studies.—Estimates of the relative density of *T. coelestialium* were obtained in 1977 by taking 100-sweep samples with a standard sweep net from 70 oat fields in 10 central Pennsylvania counties. Most fields were sampled in May and in June. Contents of the net bag were transported to the laboratory in 1-pint ice cream cartons and the numbers of adults and nymphs counted and recorded.

Seasonal history of *T. coelestialium* was followed mainly in the Harrisburg (Dauphin Co.) area. Observations were made at irregular intervals during 1978, 1980, and 1982, and the proportion of adults and various nymphal stages present were estimated in the field. In 1979 a population was sampled weekly or biweekly from early May to mid-August, and in the field 10 or more individuals were "rough sorted" to stage. To determine interplant movements, 50-sweep samples were taken from grasses adjacent to a wheat field and at 8 m and 15 m into the field. In 1983 several populations were sampled similarly from late April to late September and the nymphs preserved in 70% alcohol for sorting to stage in the laboratory. Supplemental early- and late-season collections and host plant observations were made in other areas of the state during 1978–83.

Laboratory studies.—In a greenhouse (18.3–26.7°C, 50–90% R.H.) we established oat seedlings in styrofoam pots (2 seedlings/pot) and introduced adult bugs at different densities to determine whether their feeding could stunt plant growth. Clear plastic (Mylar) cylinders covered at the top with fine nylon mesh were placed over the mirid-infested seedlings. In experiment 1 seeds were sown on 22 June 1979 and bugs introduced one week later. In the second experiment seeds were sown on 12 July 1979 and bugs introduced on 18 July.

In experiment 1 we examined the treatment effects of 0 (control), 6 (3 males, 3 females), and 12 (6 males, 6 females) bugs on plant growth using a randomized complete block design. In experiment 2 the number of bugs introduced was 0 (control), 1 (either sex), and 2 (1 male, 1 female). Each treatment included 4 repetitions, each represented by a pot of 2 seedlings. Two samples/repetition were included, with each sample consisting of the measurement of one seedling (in cm). We measured seedling height daily (except on weekends) from soil surface to tip of highest leaf and replaced any dead individuals with bugs of the same sex. For analysis we compared seedling height after 15 days with that when bugs were introduced (labeled "Mean difference in seedling growth" in Tables 2, 3). Treatment effects were analyzed by the Waller-Duncan K-ratio *t* test (Duncan, 1975).

BIOLOGY

Seasonal history and host plants.—The following account is based on several years' observation and sampling of *Trigonotylus coelestialium* in Pennsylvania, but we caution that phenology in *Trigonotylus* spp. is difficult to characterize. In the USSR, Roshko (1976) reported a univoltine population of *T. ruficornis* at high altitudes and the production of 2 or 3 generations in low-lying areas. Mikhailova (1979) stressed the indirect effects of weather and direct effects of Soviet agricultural practices on population dynamics of *T. coelestialium*. In the USSR the

Fig. 1. Grassy strip (tall plants) growing between two oat fields (foreground and background), which often harbors overwintering eggs and first generation of *T. coelestialium.*

hatching of overwintered eggs and appearance of adults varied as much as 30 days during a 4-year period. In an early season when second generation adults appeared in July, a third generation was produced, but because winter and early summer crops had been harvested, suitable oviposition sites were scarce. The forced deposition of eggs on decaying grains or on roadside grasses that would be mowed or tilled resulted in a small, patchily distributed brood and little accumulation of overwintering eggs in winter grains. In years of bivoltine populations when second generation adults did not appear until August, more eggs were deposited in winter grains, resulting in larger numbers of bugs in crop fields the following spring. In Mikhailova's words, man's agricultural activity allows uninhibited reproduction of this pest while depriving it of a suitable place for further reproduction.

In central Pennsylvania overwintered eggs began to hatch from mid-April to early May. By the first week of May instars II–IV usually were present, and the first adults appeared from mid- to late May. On the same grass species, overwintered eggs of *Amblytylus nasutus, Leptopterna dolabrata,* and *Megaloceroea recticornis* (Geoffroy) hatched at nearly the same time, but adults of *T. coelestialium* were the first grass-feeding mirids to appear. The first generation developed mainly on various native or naturalized grasses bordering crop fields (Fig. 1), only rarely in winter grains that typically are planted in late September through October, or after most previous-season females have oviposited. The small number of first generation bugs that we found developing in small grains may be attributed to migration of nymphs from adjacent grasses, as Bilewicz-Pawinska (1982) observed

Table 1. Relative densities of *Trigonotylus coelestialium* in central Pennsylvania oat fields in 1979.

	No. of Fields		Mean No. Trigonotylus/100 Sweeps ± SE (Range)	
County	Sample 1[a]	Sample 2[b]	Early Sample	Late Sample
Adams	0	4	—[c]	67.8 ± 27.8 (9–139)
Cumberland	2	4	3.5 ± 0.5 (3–4)	96.8 ± 89.2 (1–364)
Dauphin	3	3	47.0 ± 19.7 (14–82)	91.9 ± 16.7 (60–117)
Franklin	4	7	11.8 ± 5.1 (1–25)	83.1 ± 40.0 (4–301)
Lancaster	13	13	29.0 ± 5.3 (0–60)	49.8 ± 11.0 (12–142)
Lycoming	0	10	—	214.2 ± 146.5 (17–1523)
Northumberland	1	4	87.0 ± 0	438.2 ± 322.7 (89–1405)
Snyder	0	4	—	95.0 ± 51.0 (17–243)
Union	5	5	93.2 ± 19.8 (53–167)	216.6 ± 88.4 (39–497)
York	16	16	35.9 ± 6.7 (8–90)	204.5 ± 50.0 (18–619)

[a] Taken 11–27 May.
[b] Taken 15–29 June.
[c] No sample taken.

in Poland. Some females of the first generation deposit eggs on wild grasses, but the majority appear to invade small grains such as winter wheat, winter barley, oats, or rye. Occasionally, adults dispersed to feed on nectar or pollen of nearby plants, e.g., on inflorescences of staghorn sumac, *Rhus typhina* L. Flight capacity in *Trigonotylus* apparently is well developed. *T. ruficornis,* although the least abundant of Stenodemini at England's Rothamsted Experimental Station, exhibited the highest level of flight activity among stenodemine mirids caught in suction and light traps (Southwood, 1960).

We found eggs of a probable second generation within leaf sheaths of oats during late May. First instars of this generation appeared as early as 7 June and were common in mid- to late June. The abundance of second generation *T. coelestialium* in small grains was consistently greater than in the first generation, which is consistent with Mikhailova's (1979, 1980) observations on this mirid in the USSR. The numbers we found in oats—often 1/sweep and sometimes 14–15/sweep (Table 1)—are similar to those of the second generation recorded by Mikhailova (1980). During late June we also observed large numbers in mature wheat, with the bugs concentrated on heads and on the partially green stems just beneath. Based on the observations of Sannikova and Garbar (1981) in the USSR, *T. coelestialium* may inflict considerable injury to the heads of cereal crops. With the cutting of barley, wheat, and rye from mid-June to mid- or late July, second generation adults dispersed widely to wild grasses and corn. The harvesting of grain probably is responsible for considerable *Trigonotylus* mortality. On grasses a third generation began to develop as early as mid-July in 1979. During late July of other years, the small numbers of adults taken in samples and discovery of eggs help confirm the mid- to late July beginning of another generation. In most years populations remained in oat fields, which often were not harvested until early or mid-August.

With the overlapping of successive broods, delineating generations became more difficult as the season progressed, but the appearance of first and second instars in late August 1983 marked the beginning of a fourth generation. The nymphs (instars II–V) observed through late September probably all belonged to this

Fig. 2. Rows of *T. coelestialium* eggs in leaf sheath of oats.

generation, which always seemed fewer in number than preceding ones. The abundance of *T. coelestialium* may well have been less than earlier in the season, although the scattering of populations on numerous hosts accentuated the perception of diminished numbers. Nymphs seldom were taken after late September or early October. Adults were rarely seen during October; our latest records are 29 October and 14 November.

In addition to the crop plants mentioned above—barley, corn, oats, rye, and wheat—*T. coelestialium* develops occasionally on timothy. As breeding hosts it also uses various grasses growing in moist and dry habitats. Along roadsides and at the periphery of fields we found nymphs on *Anthoxanthum odoratum* L., *Agrostis stolonifera* L., *Dactylis glomerata* L., *Digitaria sanguinalis* (L.) Scop., *Eleusine indica* (L.) Gaertn., *Panicum dichotomiflorum* Michx., and *Setaria viridis* (L.) Beauv. In dry ballast along railroad tracks host plants observed were *Agrostis stolonifera* var. *palustris* (Huds.) Farw., *Cynodon dactylon, Eragrostis minor* Host, *E. pectinacea* (Michx.) Nees, *Panicum capillare* L., and *Setaria viridis.* In a wet area along a railroad we found adults and nymphs on *Echinocloa muricata* (Beauv.) Fern. *T. coelestialium* occurred most often on these native and naturalized grasses during the first generation and in August and September when small grains had been harvested. Although the host range is rather broad in the Poaceae, *T. coelestialium* seems to prefer certain species, e.g., *Eragrostis minor,* and was rarely collected on annual bluegrass, *Poa annua* L., or on Kentucky bluegrass, *P. pratensis* L.

Laboratory observations and host injury.—The bugs mated on oat seedlings, the pairs orienting side by side with the male displaced to the female's right and his abdomen bent under the female's. Kullenberg (1944: Taf. 11, Fig. 5) illustrates

Fig. 3. Experimental oat seedlings used to determine effects of feeding by *T. coelestialium*: Controls (four pots at left) were free of bugs; seedlings at right contained one adult per pot.

this position in *T. ruficornis* observed in Sweden. Eggs were deposited in rows within leaf sheaths (Fig. 2), often at the base of a plant near soil level. Rows of 4–10 and occasionally more than 20 were observed. In one timed oviposition, 4 eggs were laid in 61 seconds (range 13–18/egg, $\bar{x} = 15.2$ sec). Mirids that insert their eggs into plant stems, rather than in leaf sheaths, require considerably more time for oviposition, e.g., *Macrolophus separatus* Blatchley on hayscented fern, *Dennstaedtia punctilobula* (Michx.) Moore (Wheeler et al., 1979), and several species on apple, *Malus sylvestris* P. Mill. (Knight, 1915).

T. coelestialium fed on seedling stems and blades, and with 6 and 12 bugs/pot (experiment 1) foliar chlorosis appeared after 4 days. Browning of seedling tips and dark fecal spotting on blades were apparent within 6 days. With 1 or 2 bugs/pot (experiment 2) mottling appeared within 5 days. In addition to causing extensive chlorosis and browning, the bugs inhibited seedling growth (Fig. 3). For experiments 1 and 2 there were no significant statistical interactions between repetitions and main treatment effects ($P = 0.05$), and repetition effects also were insignificant. But, at the 5% level in experiment 1 there was a significant difference between the controls and treatments 1 and 2, with plant height of controls greater than either 1 or 2. No significant difference was found between the two treatments (Table 2). At the 5% level in experiment 2 there was a significant difference among all treatment effects (Table 3); seedling height of controls was significantly greater than that of either treatment. Treatment 1 seedling height was less than in controls but greater than for treatment 2, with average height of treatment 2 seedlings less than for the controls or treatment 1.

Table 2. Effects of *Trigonotylus coelestialium* on growth of oats after 15 days using 0, 6, and 12 adults/pot of 2 seedlings.

Treatment	Mean Difference in Seedling Growth (cm)[1] (Range)
Control: 0 bugs	35.4 a (27.6–39.7)
No. 1: 6 bugs	7.5 b (3.8–11.1)
No. 2: 12 bugs	5.7 b (1.3–11.4)

[1] Values followed by different letters are significant ($P = 0.05$).

Discussion.—Under laboratory conditions, it is apparent that 1 or 2 *T. coelestialium* adults/pot of 2 seedlings can significantly retard plant growth. In the field this mirid usually was one of the most abundant insects we collected in sweep net samples from small grains. Although populations of 1–2 and even 14 and 15/sweep were encountered, these levels were attained only in the second generation when winter grains were well established. In central Pennsylvania most small grains, except oats, are planted in the fall; there is little spring wheat or barley. As already discussed, the number of first generation *T. coelestialium* developing in winter grains is small. But because the bugs may invade oats when plants are relatively young, deleterious effects on plant growth are possible. In areas where spring grains are common this plant bug may pose more of a threat to crop development.

As Osborn (1916) pointed out, "insect depredations on grass are of such a character as to escape recognition" because the species involved are mostly small, the obscure nature of their attack consists of a steady drain on hosts and rarely results in plant destruction, and any damage that might be noticed is likely to be attributed to adverse weather, soil deficiency, or some physiological problem. Additional field and laboratory studies similar to those of Quisenberry and Yonke (1981a, b) for assessing the morphological and physiological response of tall fescue to feeding by the leafhopper *Forcipata loca* DeLong & Caldwell are needed to quantify the effects of feeding by *T. coelestialium* on vegetative and reproductive structures of small grains.

DESCRIPTIONS

Adult (Fig. 4).—Male [female measurements in parentheses]: Length 5.25–5.75 mm (6.00–6.50 mm). Head: Width 0.66–0.72 mm (0.76–0.80 mm), vertex 0.34–0.36 mm (0.40–0.44 mm). Rostrum: Length 1.72–1.76 mm (1.92–1.96 mm),

Table 3. Effects of *Trigonotylus coelestialium* on growth of oats after 15 days using 0, 1, and 2 adults/pot of 2 seedlings.

Treatment	Mean Difference in Seedling Growth (cm)[1] (Range)
Control: 0 bugs	33.7 a (29.3–38.7)
No. 1: 1 bug	13.8 b (2.3–29.2)
No. 2: 2 bugs	8.9 c (5.5–14.2)

[1] Values followed by different letters are significant ($P = 0.05$).

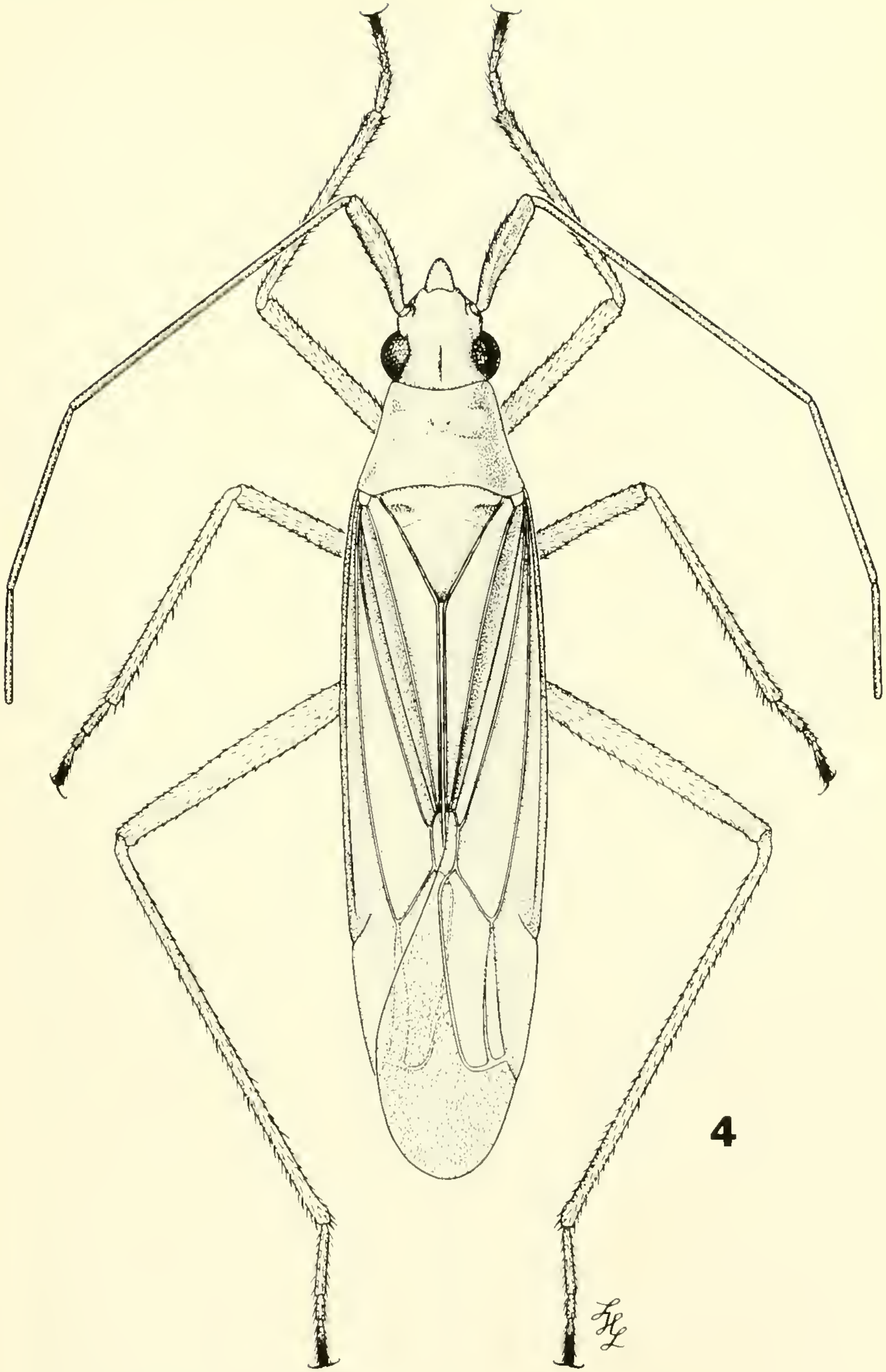


Fig. 4. Adult male of *T. coelestialium.*

extending to metacoxae. Pronotum: Basal width 0.52–0.60 mm (0.56–0.60 mm), mesal length 0.46–0.52 mm (0.64–0.68 mm). Antenna: Length, segment I 0.68–0.70 mm (0.68–0.76 mm); II, 2.00–2.12 mm (2.00–2.36 mm); III, 1.84–1.88 (1.71–2.12 mm); IV, 0.36–0.52 mm (0.64–0.72 mm).

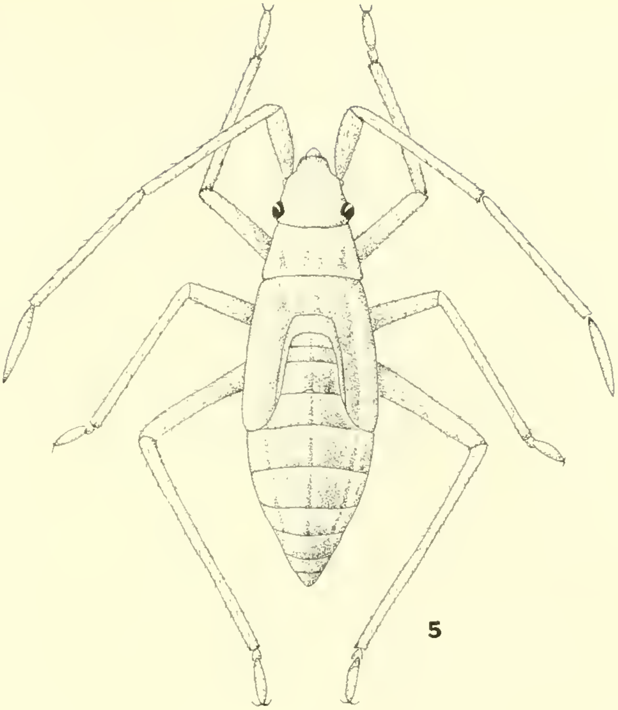
Nearly uniformly green, mesal groove of head, narrow line behind each callus, and border of mesal line on pronotum and scutellum diffused brown, legs green with apical ¼ of metatibiae and most of metatarsi red, antennae red with 3 pale stripes on segment I; dorsum glabrous, alutaceous except finely punctate pronotum; antennal segment I sparsely set with short, recumbent, black setae, segments II–IV thickly set with short, fine brown to golden setae, legs with sparse, recumbent, pale to brownish setae, tarsal spines fine, blending in with setae.

Remarks.—*T. coelestialium* is the most common species of the genus in northeastern United States. Most of the American literature referring to *T. ruficornis* before Kelton's (1971) revision should be applied to *T. coelestialium.* Carvalho and Wagner (1957) suggested that *T. ruficornis* did not occur in North America, but Kelton (1971) clarified that it occurs across northern North America from Quebec to Alaska, and considered *T. viridis* (Provancher) and *T. montanus* Carvalho junior synonyms.

Trigonotylus coelestialium can be separated from all other species of *Trigonotylus* in eastern United States by the red antennae with three distinct, broad, pale stripes on segment I, the apically red hindtarsi, the relatively large size (5.25–6.50 mm) with the rostrum measuring more than 1.70 mm, and the aedeagus lacking a spiculum. *Trigonotylus ruficornis* lacks the distinct pale stripes on antennal segment I, is on the average slightly larger (length 5.60–6.65 mm as given by Kelton, 1971), and has a distinct, thickened spiculum on the aedeagus.

Fifth instar (Fig. 5).—Length 3.83–5.00 mm. Head: Width 0.68–0.76 mm; vertex 0.40–0.44 mm. Rostrum: Length 1.48–1.76 mm, extending just past bases of metacoxae. Antenna: Segment I, length 0.48–0.60 mm; II, 1.44–1.64 mm; III, 1.60–1.76 mm; IV, 0.60–0.68 mm. Body coloration green to pale green; mesal impression between eyes, narrow line on either side of meson of thoracic segments, and broad stripe on each side of pronotum continuing onto inner half of forewing pads brownish; legs greenish, tinged pale brown, especially tibiae, metatibiae reddish, tarsi brown to dark brown, claws fuscous, antennae uniformly reddish except pale 1st segment having 3–4 broad red stripes; pronotum well developed, wing pads extending to middle of 4th or base of 5th abdominal segment; dorsal abdominal scent gland opening weakly brownish (as in all instars); legs and antennae sparsely set with short, recumbent, black bristles; body nearly glabrous, with very short, scattered setae, slightly longer setae evident on distal two abdominal segments.

Fourth instar (Fig. 6).—Length 2.84–3.80 mm. Head: Width 0.56–0.60 mm; vertex 0.30–0.36 mm. Rostrum: Length 1.24–1.36 mm, extending to bases of metacoxae. Antenna: Segment I, length 0.38–0.44 mm; II, 1.00–1.12 mm; III, 1.10–1.32 mm; IV, 0.54–0.62 mm. Body coloration green, similar to instar V but lacking much of the darker brown and green markings, legs green, tibiae brown, with metatibiae faintly tinged with red, tarsi brown, apex of 3rd tarsal segment and claws fuscous, antennae green to pale brown tinged with red, segment I with 3–4 red stripes; body nearly glabrous, legs and antennae with very short, sparse, fuscous setae.



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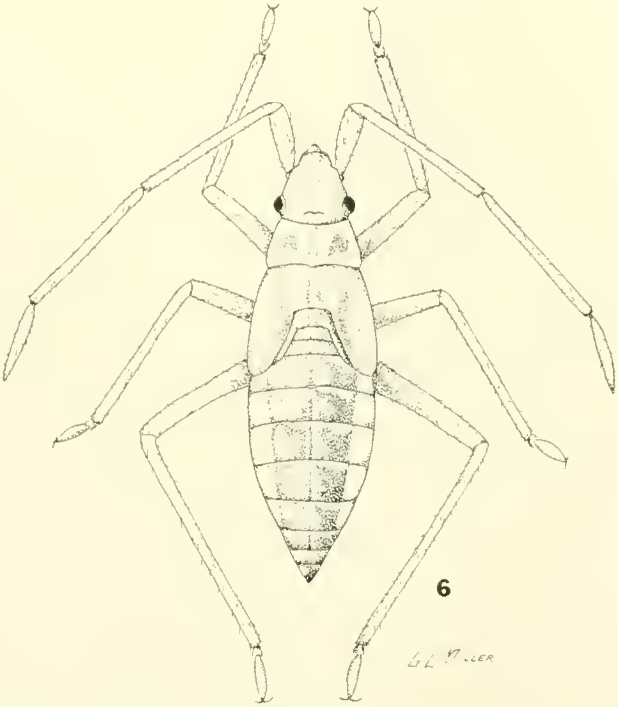

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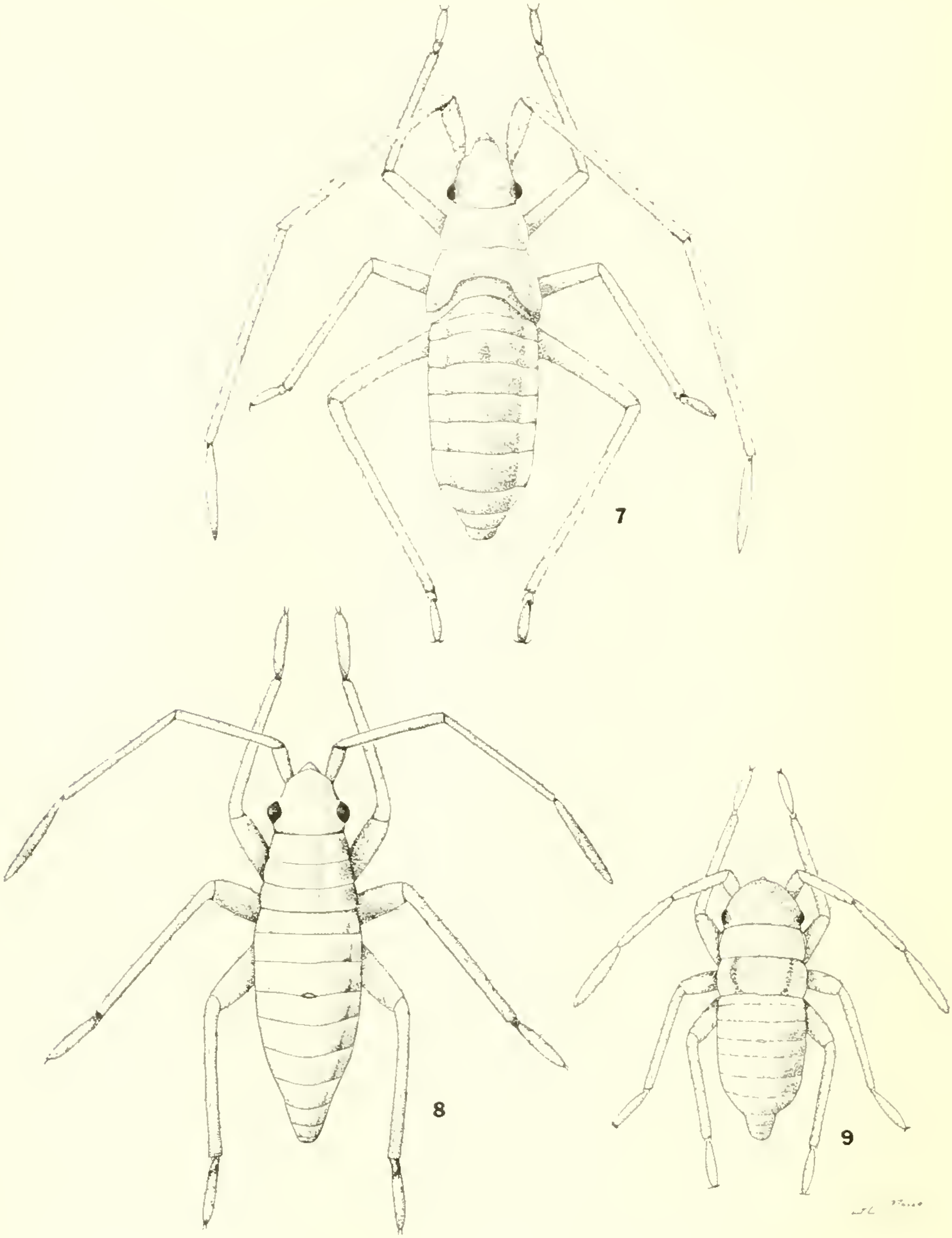
Figs. 5, 6. Nymphs of *T. coelestialium*. 5, Fifth instar. 6, Fourth instar.



Figs. 7–9. Nymphs of *T. coelestialium.* 7, Third instar. 8, Second instar. 9, First instar.

Third instar (Fig. 7).—Length 2.12–2.48 mm. Head: Width 0.48–0.50 mm; vertex 0.28–0.30 mm. Rostrum: Length 1.02–1.08 mm, extending to base of 2nd abdominal segment. Antenna: Segment I, length 0.28–0.30 mm; II, 0.60–0.64 mm; III, 0.80–0.84 mm; 0.52–0.58 mm. Body and legs green, thoracic nota darker green with mesal line pale, claws and apices of tarsi dark brown or fuscous, head and antennae green to pale brown, segment IV red; pronotum quadrate, longest of thoracic segments, meso- and metanota subequal, emarginate, with distinct wing pads; setae short, dark, indistinct.

Second instar (Fig. 8).—Length 1.60–1.88 mm. Head: Width 0.44–0.46 mm; vertex 0.26–0.30 mm. Rostrum: Length 0.76–0.80 mm, extending to 3rd or base of 4th abdominal segment. Antenna: Segment I, length 0.16–0.20 mm; II, 0.40–0.42 mm; III, 0.50–0.52 mm; IV, 0.46–0.48 mm. Body and legs greenish, with head and thoracic nota tinged with darker green, mesal line pale, antennae green, slightly tinged with pale brown or red, segment IV red, claws and apices of tarsi dark brown; pro- and mesonota about of equal length, metanotum slightly shorter (wing pads lacking); setae on head, thorax, and abdomen short, erect, fuscous, proportionately shorter and more slender than for instar I.

First instar (Fig. 9).—Length 1.17–1.36 mm. Head width 0.32 mm (for all specimens measured); vertex 0.22 mm (for all specimens measured). Rostrum: Length 0.64–0.68 mm, extending to 4th or 5th abdominal segment. Antenna: Segment I, length 0.12–0.14 mm; II, 0.22–0.24 mm; III, 0.32 mm (for all specimens measured); IV, 0.36–0.38 mm. Body and legs green, thoracic nota tinged with brown or darker green, antennae green to slightly pale brown, segments II–IV sometimes tinged with red, claws and apices of tarsi dark brown; pro-, meso-, and metanotum about equal in length (wing pads lacking); each notal segment with a transverse row of 4 or 5 long, erect, fuscous setae, head with several scattered, erect, fuscous setae, including a transverse row between eyes, abdomen and apices of femora with scattered pale to fuscous setae.

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LITERATURE CITED

Agafonova, Z. Ya. and V. I. Belizin. 1964. Maize pests in the Kursk Province. Entomol. Rev. 43: 123–130.

Arnott, D. A. and I. Bergis. 1967. Causal agents of silver top and other types of damage to grass seed crops. Can. Entomol. 99: 660–670.

Bilewicz-Pawinska, T. 1982. Plant bugs (Heteroptera, Miridae) and their parasitoids (Hymenoptera, Braconidae) on cereal crops. Pol. Ecol. Stud. 8: 113–192.

Blinn, R. L. and T. R. Yonke. 1982. New state records of plant bugs (Hemiptera: Miridae) from Missouri with notes on their host-plant associations. J. Kans. Entomol. Soc. 55: 597 (abstr.).

Bozdechova, J. 1973. Diagnostische Merkmale der Arten *Trigonotylus ruficornis* und *T. coelestialium* (Heteroptera, Miridae). Folia Mus. Rerum Nat. Bohemiae Occident., Plzen. Ser. Zool. 3, pp. 3–18.

Carvalho, J. C. M. and E. Wagner. 1957. A world revision of the genus *Trigonotylus* Fieber (Hemiptera-Heteroptera, Miridae). Arq. Mus. Nac., Rio de J. 43: 122–155.

Duncan, D. B. 1975. *t* tests and intervals for comparisons suggested by the data. Biometrics 31: 339–359.

Gagné, S., C. Richard, and C. Gagnon. 1984 La coulure des graminées: état des connaissances. Phytoprotection 65: 45–52.

Hardee, D. D., H. Y. Forsythe, Jr., and G. G. Gyrisco. 1963. A survey of the Hemiptera and Homoptera infesting grasses (Gramineae) in New York. J. Econ. Entomol. 56: 555–559.

Hewitt, G. B. 1980. Tolerance of ten species of *Agropyron* to feeding by *Labops hesperius*. J. Econ. Entomol. 73: 779–782.

Josifov, M. V. 1980. Über die Verbreitung mancher Heteropterenarten auf der Balkanhalbinsel. Acta Zool. Bulgarica 15: 20–23.

Kamm, J. A. 1979. Plant bugs: effects of feeding on grass seed development; and cultural control. Environ. Entomol. 8: 73–76.

Kelton, L. A. 1971. Revision of the species of *Trigonotylus* in North America (Heteroptera: Miridae). Can. Entomol. 103: 685–705.

———. 1980. The insects and arachnids of Canada. Part 8. The plant bugs of the Prairie Provinces of Canada. Heteroptera: Miridae. Agric. Can. Publ. 1703. 408 pp.

Kirkaldy, G. W. 1902. Memoir upon the Rhynchotal family Capsidae Auctt. Trans. Entomol. Soc. Lond. 1902: 243–272.

Knight, H. H. 1915. Observations on the oviposition of certain capsids. J. Econ. Entomol. 8: 293–298.

Knowlton, G. F. 1947. Mirid damage to rye. J. Econ. Entomol. 40: 427–428.

Korcz, A. 1979. *Trigonotylus coelestialium* (Kirk.) (Heteroptera, Miridae), new to the Polish fauna. Pol. Pismo Entomol. 49: 175–183.

Kullenberg, B. 1944. Studien über die Biologie der Capsiden. Zool. Bidr. Uppsala 23: 1–522.

McKendrick, J. D. and D. P. Bleicher. 1980. Observations of a grass bug on bluejoint ranges. Agroborealis 12: 15–18.

Mangan, R. L., R. A. Byers, A. Wutz, and W. C. Templeton, Jr. 1982. Host plant associations of insects collected in swards with and without legumes seeded by minimum tillage. Environ. Entomol. 11: 255–260.

Mikhailova, N. A. 1979. Factors of dynamics of the numbers of *Trigonotylus coelestialium* (Hemiptera, Miridae). Zool. Zh. 58: 839–848 [In Russ. with Eng. summary].

———. 1980. On forecasting the cereal mirid. Zast. Rast. 1980(9): 47.

———. 1983. Model of a wheat cultivar resistant to some sucking insects. S.-kh. Biol. 2: 32-35 [In Russ. with Eng. summary].

Niemczyk, H. D. and G. E. Guyer. 1963. The distribution, abundance and economic importance of insects affecting red and mammoth clover in Michigan. Mich. State Univ. Agric. Exp. Stn. Tech. Bull. 293. 38 pp.

Osborn, H. 1916. Studies of life histories of leafhoppers of Maine. Maine Agric. Exp. Stn. Bull. 248, pp. 53–80.

Peterson, A. G. and E. A Vea. 1971. Silvertop of bluegrass in Minnesota. J. Econ. Entomol. 64: 247–252.

Quisenberry, S. and T. R. Yonke. 1981a. Responses of 'Kentucky-31' tall fescue to varying *Forcipata loca* DeLong & Caldwell infestation levels: growth chamber study (Homoptera: Cicadellidae, Typhlocybinae). Environ. Entomol. 10: 550–553.

———. 1981b. Responses of Kentucky-31 tall fescue to varying *Forcipata loca* DeLong and Caldwell infestation levels: field study. Environ. Entomol. 10: 650–653.

Roskho, G. M. 1976. Miridae (Heteroptera) of the Ukrainian Carpathians, Transcarpathia and Ciscarpathia. Entomol. Rev. 55: 51–55.

Sannikova, M. F. and L. I. Garbar. 1981. Cereal bugs in the Tyumen region. Zast. Rast. 1981(4): 29.

Schwartz, M. D. 1984. A revision of the black grass bug genus *Irbisia* Reuter (Heteroptera: Miridae). J. New York Entomol. Soc. 92: 193–306.

Snodgrass, G. L., T. J. Henry, and W. P. Scott. 1984. An annotated list of the Miridae (Heteroptera) found in the Yazoo-Mississippi Delta and associated areas in Arkansas and Louisiana. Proc. Entomol. Soc. Wash. 86: 845–860.

Southwood, T. R. E. 1960. The flight activity of Heteroptera. Trans. R. Entomol. Soc. Lond. 112: 173–220.

Stephens, G. M. III. 1982. The plant bug fauna (Heteroptera: Miridae) of grasses (Poaceae) of the Medicine Bow Mountains and Pole Mountain Ranger District, Wyoming. Univ. Wyom. Agric. Exp. Stn. Sci. Monogr. 43. 175 pp.

Todd, J. G. and J. A. Kamm. 1974. Biology and impact of a grass bug *Labops hesperius* Uhler in Oregon rangeland. J. Range Manage. 27: 453–458.

Wagner, E. 1956. *Trigonotylus coelestialium* Kirk. in Nordwestdeutschland (Heter. Miridae). Schr. Naturwiss. Ver. Schleswig-Holstein 28: 69–71.

Wagner, F. and P. Ehrhart. 1961. Untersuchungen am Stichkanal der Graswanze *Miris dolabratus* L., der Urheberin der totalen Weissährigkeit des Rotschwingels (*Festuca rubra*). Z. Pflanzenkr. 68: 615–620.

Watson, S. A. 1928. The Miridae of Ohio. Ohio Biol. Surv. Bull. 16: 1–44.

Wheeler, A. G., Jr., G. L. Miller, and T. J. Henry. 1979. Biology and habits of *Macrolophus tenuicornis* (Hemiptera: Miridae) on hayscented fern (Pteridophyta: Polypodiaceae). Melsheimer Entomol. Ser. 27: 11–17.

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APHANOGMUS FLORIDANUS, A PRIMARY PARASITE OF *FELTIELLA ACARIVORA*, A PREDATOR OF SPIDER MITES ON STRAWBERRY (HYMENOPTERA: CERAPHRONIDAE; DIPTERA: CECIDOMYIIDAE)

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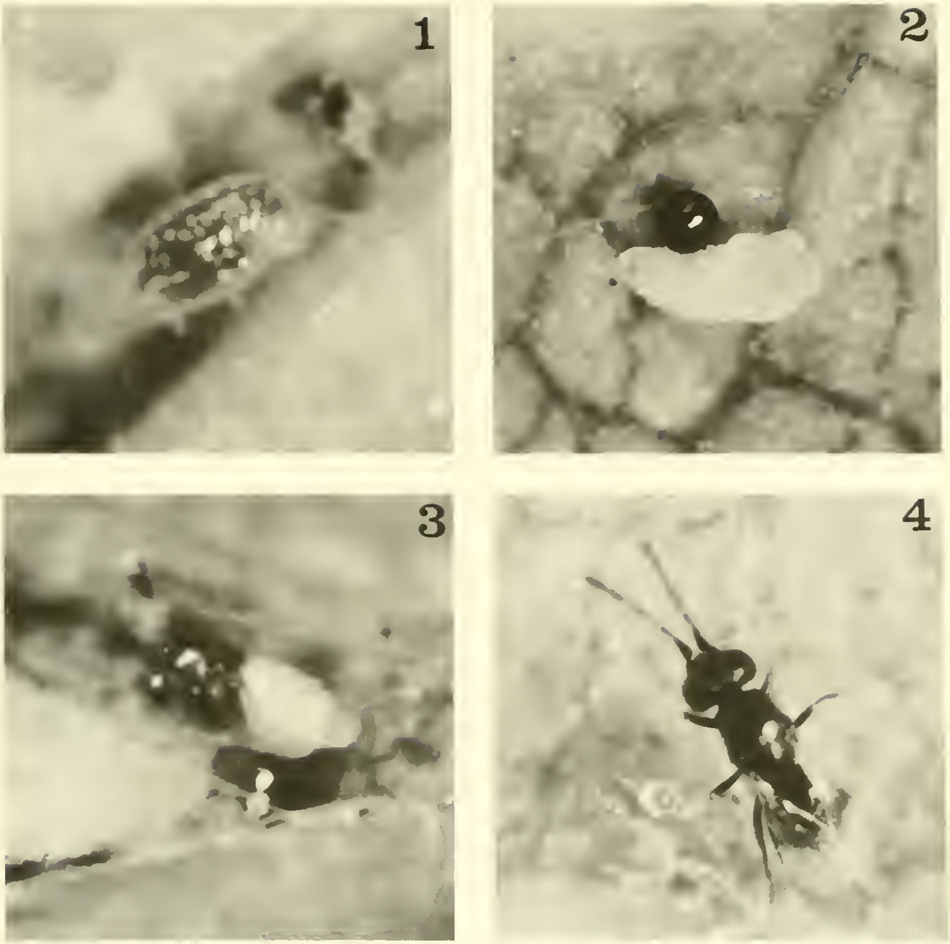
Abstract.—The parasitic activity of a ceraphronid, *Aphanogmus floridanus* Ashmead, is briefly given and its life stages are figured. The parasite was found to be a major mortality factor, affecting *Feltiella acarivora* Felt, a cecidomyiid predator of the two-spotted spider mite, *Tetranychus urticae* Koch, on strawberry.

While studying predation on the two-spotted spider mite, *Tetranychus urticae* Koch, on strawberry (Oatman et al., 1985), a minute, black hymenopterous parasite was observed to emerge from cocoons of *Feltiella acarivora* (Felt), a cecidomyiid predator of spider mites. To determine the identity of the parasite species involved and the extent of parasitization, cecidomyiid cocoons were collected at random from spider mite-infested strawberry plants in untreated check plots during May and June in 1979 through 1982, and in April, May, and June in 1983. The cocoons, attached naturally to pieces of leaflets, were isolated individually in gelatin capsules (size 000) and held for adult (host parasite) emergence.

The parasites obtained were identified as *Aphanogmus floridanus* Ashmead and *Aphanogmus* sp. (apparently new) (Ceraphronidae) by P. Dessart, Taxonomist, Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium. Of 382 specimens examined from the 1983 material, 372 (97.4%) were *A. floridanus* and 10 (2.6%) were *Aphanogmus* sp.

Ashmead (1893) described *A. floridanus* from a male and female collected by sweeping on the edge of a swamp near Jacksonville, Florida. Muesebeck (1979) noted that some species of *Aphanogmus* are primary parasites of certain Diptera, particularly Cecidomyiidae, and others are hyperparasites. He also reported that *A. floridanus* was recorded from Florida, Ohio, and South Carolina, and that the species had been reared from two cecidomyiids, *Arthrocnodax carolina* Felt and *Mycodiplosis acarivora* (Felt), both now in *Feltiella*.

Except for the above, there is no published information on *A. floridanus*. In the present study, *A. floridanus* was determined to be an endoparasite of *F. acarivora* larvae. The parasite larva emerges from the pupating host larva after the latter spins its cocoon. The mature parasite larva is pinkish-orange dorsally and milky-white ventrally (Fig. 1). The prepupa is milky-white. The head and thorax of the pupa are dark, the abdomen milky-white. The adult male and female



Figs. 1–4. Life stages of *Aphanogmus floridanus.* 1, Mature larva. 2, Prepupa. 3, Pupa. 4, Adult. The round, black object in Figs. 2 and 3 is the meconium.

are black in general appearance. Ashmead (1893) gave a detailed description of adult coloration.

Of 273 adults that emerged from 452 total cocoons collected in 1979, 1980 and 1981, 30.8% were parasites. In 1982, mean percent parasitizaton was 15.2% (Table 1). Parasitization was highest overall in 1983 when 69.2% of the cecidomyiid larvae were parasitized. Parasitization increased from 0 on April 14 and 20 to a high of 89.7% on May 18. Larval mortality, apparently due to desiccation inside the capsules, averaged 21.4 and 56.1% in 1982 and 1983, respectively. The data show that *A. floridanus* is a substantial mortality factor affecting *F. acarivora* populations. *Feltiella acarivora* was the predominant predator of the two-spotted spider mite on strawberry in southern California in 1978 and 1979 (Oatman et al., 1985). Therefore, parasitization of *F. acarivora* by *A. floridanus* is a major, negating factor in natural control of this serious pest.

Table 1. Parasitization of cecidomyiid larvae collected on strawberry in southern California.

Survey Date	Cocoons Collected	No. Adults Reared[1]		Mean % Parasitization
		Cecidomyiids	Parasites	
1982				
May 11	16	9	0	0
18	47	36	3	7.7
25	35	23	9	28.1
June 1	164	116	17	12.8
8	87	64	7	9.9
15	103	53	23	30.3
22	90	50	19	27.5
29	83	57	5	8.1
1983				
Apr. 14	24	17	0	0
20	26	16	0	0
27	81	13	22	62.9
May 4	226	33	61	64.9
11	217	31	82	72.6
18	205	4	35	89.7
25	190	14	74	84.1
June 1	186	15	53	77.9
8	172	17	60	77.9
15	144	22	70	76.1
22	141	36	33	47.8

[1] Adults did not emerge from many of the cocoons, apparently due to desiccation of larvae therein. Such cocoons were not used in calculating percent parasitization.

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LITERATURE CITED

Ashmead, W. H. 1893. A monograph of the North American Proctotrypidae. U.S. Natl. Mus. Bull. 45. 472 pp.

Muesebeck, C. F. W. 1979. Superfamily Ceraphronoidea, pp. 1187–1195. *In* Krombein, K. V., et al., Catalog of Hymenoptera in America north of Mexico. Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington D.C. 1198 pp.

Oatman, E. R., M. E. Badgley, and G. R. Platner. 1985. Predators of the two-spotted spider mite on strawberry. Calif. Agric. 39(1 and 2): 9–12.

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REPRODUCTIVE RESPONSE OF NATIVE SCREWWORM (*COCHLIOMYIA HOMINIVORAX* (COQ.)) POPULATIONS TO STERILE FLY RELEASE

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Abstract.—Data were analyzed from 14 field experiments designed to test interactions between released, sterile screwworm adults and the native population. These tests provide extensive information concerning behavior and ecology of a relatively rare, inconspicuous insect. In ten tests carried out in regions not previously treated with sterile flies, egg mass deposition by native screwworms declined by an average of 43% immediately following sterile fly release. Four tests in previously treated areas did not show a decline in egg mass deposition. Aggressive mating behavior by males is hypothesized to interfere with female host-seeking activity. Predictable changes in reproductive activity may be integrated into the eradication program for scheduling use of toxic baits and rates of sterile fly release.

With the enormous diversities of habitats and species to select from, studies of insect behavior and ecology have generally centered on species that are locally abundant due to swarming behavior or localized substrates, are conspicuous due to size, coloration, or mate attracting behavior, and are of interest due to studies carried out in other disciplines or due to their economic importance. Species of economic importance also tend to be those which are least locally abundant. Those species which tend to have highly dispersed populations at low densities and are not conspicuous in most aspects of their behavior are less likely to receive attention. They are difficult to find in nature, are not likely to arouse much interest among naturalists, and usually have minimal economic impact. Among the dipterans, however, these make up a significant portion of the total species.

Diptera that can cause significant economic damage at low densities as disease vectors and parasites, such as the tsetse fly (*Glossina* spp.) and screwworm (*Cochliomyia hominivorax* (Coquillett)) may be susceptible to autocidal measures for control or eradication. Collecting sufficient ecological data to achieve this control is difficult and expensive. Extrapolation from knowledge of better studied populations is always tenuous, particularly so when the model species has been studied because it is locally abundant or conspicuous.

As the screwworm eradication program, now being executed by the Comision Mexico-Americana, has progressed to the Isthmus of Tehuantepec in southern Mexico, considerable information concerning the response of native populations, which normally have extremely low density populations, to sudden influx of sterile adults has accumulated. I present here a summary of field experiments carried out between 1953 and 1983 with respect to this response. While the primary purpose of this summary is to elucidate screwworm population ecology and behavior as a model for rare species, I hope this summary will lead to some appreciation of the extent of the efforts by various agencies to investigate screwworm biology.

HISTORICAL CONSIDERATIONS

The screwworm eradication program has progressed from southern United States through Mexico to the presently treated regions of eastern Mexico from the Isthmus of Tehuantepec to the Guatemala border and Yucatan peninsula. Historically, a number of proposals have been made explaining or predicting program failure, usually from a population genetics or evolution point of view. Several mechanisms have been presented as hypotheses. Smith and von Borstel (1972), citing a "genetic improvement" model of Kojima (1971), predicted that selection favoring female genotypes which discriminated against sterile males would result in native populations "that will be found near the Mexico-Texas border that will have nothing to do with the screwworms that are reared, irradiated and released."

A second type of prediction (reviewed in Bush, 1978) emphasized fitness of factory reared flies in competition with native flies for mates. These studies were mainly concerned with electrophoretic differences between factory produced and native screwworm adults. A study of α-GDH, a muscle enzyme important for flight, indicated that frequencies of two forms of this enzyme did change under mass rearing conditions. Although no in vivo tests were ever made on screwworm activity levels for the alleles, Bush et al. (1976) and Bush and Neck (1976) argued that increase in frequency in a "factory type" enzyme resulted in non-competitiveness of sterile flies.

A third hypothesis has been proposed by Richardson and Makela (1978), Richardson et al. (1982a, b) and Richardson (1982). Although details of this hypothesis have changed from one report to another, the general hypothesis is that there are distinct mating groups of screwworms which can be identified by karyotype, male genitalic morphology, and ecology. These groups, called gamodemes, are often sympatric but may be regionally distributed. For example, Richardson et al. (1982a) identified four gamodemes from Sinaloa and three others from Northern Veracruz, Mexico. From the Pacific coast of Chiapas they reported the four Sinaloa gamodemes and two of the Veracruz types. Richardson and Makela (1978) predicted that "we might expect to find a greater number of cryptic species toward the center of the screwworm's range in southern Mexico and southward." Richardson et al. (1982a) announced a total of at least nine of these groups, seven of which were reported from Chiapas. At this writing, four years after the completion of the Chiapas sampling, descriptions of these types, their frequencies and ecologies have yet to be published. The eradication program has progressed eastward through Veracruz and into Tabasco on the north coast, and through Guerrero and Oaxaca into Chiapas on the Pacific coastal regions in about 18 months. No attempts to identify mating types among the now extinct target populations have been made by either Comision Mexico-Americana or USDA support agencies.

Several of the tests described in this report were designed and executed in response to one or more of the above hypotheses. In particular, field tests of new strains for factory production have been carried out on all strains in areas scheduled for future treatment. The evidence presented by Bush and his co-workers provided a basis for the nearly regular change of factory strains from 1974 to the present on an annual basis, thus necessitating these field tests annually.

Other tests cited here were designed to test different methods of program execution, particularly patterns of sterile fly dispersal. An alternate hypothesis to explain a number of program failures, notably the 1971–73 outbreaks in Texas, was that flight lanes were too widely separated and that too many flies were being dispersed in large boxes at too distant intervals to insure adequate coverage of areas between lanes and drop sites. These hypotheses in general were proposed by personnel working within the program. While results and recommendations were published (Davis et al., 1968; Hightower et al., 1968; Krafsur and Garcia, 1978; Krafsur et al., 1980), they were only briefly mentioned, if considered at all, in the above works favoring genetic explanation for eradication problems.

Clearly, if eradication by sterile fly release is to be successful, vigorous flies must be released in proximity to the target populations and must interact with them. Experiments which address the problems of assuring that sterile flies have actually had an opportunity to mate with the target population should have priority over tests of hypotheses that the flies are not copulating due to genetic barriers. At present, proper dispersal can be checked by collecting released flies in traps located in treated regions. Matings between released males and native females are demonstrated by measuring the final result, i.e., sterility of egg masses or decline in number of screwworm cases. This type of evidence cannot separate failure in dispersal or fly vigor and failure due to genetic factors.

Materials and Methods

Behavioral and ecological effects of massive releases of sterile factory reared flies interacting with wild populations of screwworm adults have been inferred from egg mass sterility rates, numbers of screwworm cases, and adult trapping data. Since the success of an eradication effort has been assumed to be dependent on the ratio of sterile to fertile matings, these methods of monitoring are logical and have thus far been accurate indicators of program success. The possibility that massive inundation and the following competition, courting and other interactions from sterile insects may negatively affect reproduction among native females is not necessarily reflected in percent sterility. The effects of this type of interaction, tested for *Dacus tryoni* Frogg (Tephritidae) by Monro (1966), have not been evaluated previously for insect control programs.

In order to examine the possibility of density dependent population structure in screwworm reproductive behavior, comparisons of reproductive activity before and following sterile fly release in a test area are made. In field tests of sterile fly release, total screwworm density (wild plus released) is drastically increased. Most reports of these tests evaluate effects of the sterile fly activity by measuring percent sterility of egg masses produced by wild flies. Total reproductive activity of wild flies can also be evaluated by comparing rates of egg mass deposition before and after sterile fly release or by comparing control (no release) and release areas in similar communities. Since factory reared, sterile females produce no eggs or only a few eggs, egg mass number estimates reproductive activity of wild females.

All data reviewed here are from field tests carried out by USDA agencies or the Comision Mexico-Americana para la Erradicacion del Gusana Barrenador del Ganado. In general, these studies were tests of new methods, new strains for factory production, or were for experimental examinations of screwworm biology. Areas of the tests were chosen by several criteria, high screwworm populations and accessibility for twice daily sampling being the most important. Designs and methods used in the experiments discussed here are not identical. Changes in technology between 1951 and 1983 as well as constraints imposed by habitats and research goals are reflected in the considerable variability in designs and methods used. In all tests, however, a relatively dense native screwworm population was challenged by a sudden increase in total population density due to release of sterile flies. Sterile fly release rate is standardized here as flies released per sq km. In all tests, males and females were released. In some tests corrections were made for mortality estimates before release, in others no estimates were made. Release rates are therefore only approximate. Native fly activity, estimated by egg mass deposition rate on wounded, screwworm infested sentinal animals, was monitored during the release and these data are discussed here.

Below, I summarize the various field tests used as a data base in this examination and their results. The first nine tests described below are similar in that a uninured population, that is, a population not previously treated with sterile flies, was suddenly inundated with sterile screwworm adults. The second group of tests involve populations that had been previously treated as part of the eradication program, had been treated with sterile flies previously for other tests, or had otherwise been manipulated in such a way that the adult populations were disturbed or reduced.

This sampling method may be compared to a baited trap, sampling with release, system: e.g., ovipositing females are not removed from the population, but returned to the community in slightly different condition (with fewer eggs) than when they entered the "trap." In these tests, sentinel animals occasionally died, were lost or were stolen. Local conditions also occasionally prevented certain pens from being checked as scheduled, required that pens be closed or moved, or that new pens be added. In treating these data, oviposition rate is defined as the number of masses sampled over a given period on a constant number of locations on sentinel animals. If numbers of animals changed during a test, oviposition rate was calculated as masses per pen per week. I assume that errors introduced due to daily problems in sampling or missing animals were equally distributed for treatment and control areas or for pre- and post-release sampling periods.

Populations of screwworms vary tremendously in density, even in permanently infested, coastal regions of Mexico (Spencer et al., 1983). The reproductive behavior of these insects must include not only activities for finding mates among the thousands of other sympatric blowflies, but also behavior for females to avoid courting males after they are mated in order to reduce probability of injury and loss of time when searching for oviposition sites (see Guillot et al., 1977a, b for review of this behavior). Basically I ask: does oviposition rate from a target population respond after a massive inundation of sterile flies? Second, does this change appear to be permanent or do the native flies recover from this treatment with oviposition returning to the previous level? Finally, I examine the possible mechanism of this response with respect to behavior and distribution of target (fertile) and sterile populations. This may allow application of the effects of reproductive fluctuations for implementation of the total integrated program including animal husbandry practices, adult suppression programs and the sterile fly release program.

TEST DESCRIPTIONS AND RESULTS

The first group of field experiments was executed in regions of moderate to heavy screwworm infestation in zones where sterile screwworms had not been recently, or had never been, introduced. All the tests described here were carried out with control areas outside the sterile fly treatment area or with at least some (7 days) pre-release record of egg deposition rate. There were nine tests of this sort carried out from 1953 to 1983.

Sanibel and Captiva islands.—This was the first field test of the sterile male technique for pest eradication. Oddly, the details of this test have appeared only in an "in house" USDA report (Baumhover et al., unpublished report). The test was performed during the period from January to April 1953. The area considered here consisted of Sanibel and Captiva islands, which make up part of a chain of small islands extending northward from Sanibel, Florida. The approximately 41.3 square kilometer area was treated with flies dispersed from a single engine airplane at about 77 flies/sq km weekly. Egg mass data were collected for one pre-release and 11 post-release weeks from wounded, screwworm infested goats which were used as sentinel animals. Hosts for screwworms on these islands were mainly domestic cats and dogs, feral cats, rabbits, and particularly raccoons.

While the total area treated in this experiment included a number of additional islands and mainland sites, data included here are only from three of the six sentinel animal pens which provided over 95 percent of the total 536 egg masses. These sites were the most isolated from the mainland and were always treated with the full quota of sterile flies each week.

Fig. 1 shows the number of screwworm egg masses per pen per week collected during the test. With only one week of pre-release data, interpretations are tenuous; however, the drop from 22 masses before release to 12 masses for the week following release suggests a trend in the direction of negative reproductive response of wild females to sterile fly release. There is, of course, significant probability that the decline during the second week was due solely to chance. Egg mass deposition declined as much as 50 percent twice during the sampling period, at weeks 2 and 11. Decline at week 11 probably reflected the population decline due to sterility, while decline at week 2 coincided with the introduction of sterile flies.

Curaçao Island 1954.—Eradication of screwworms from Curaçao, Netherlands Antilles, provided the first proof of the feasibility of the sterile male technique for screwworm eradication. This project involved a preliminary test from March to May 1954. Ten goat pens were stocked with four sentinel goats, two wounded and two healing, over the test period. The 440.3 sq km island was treated with sterile flies dropped in weighted paper bags, twice weekly, at a rate of 77 sterile males per sq km per week. Data were collected for 2 pre-release weeks, 1 transition week, and 6 post-release weeks. Neglected domestic goats and sheep, along with pigs, burros, deer and rabbits, were cited as most probable screwworm hosts. Complete details of this experiment and the following eradication of screwworms from Curaçao are given in Baumhover et al. (1955).

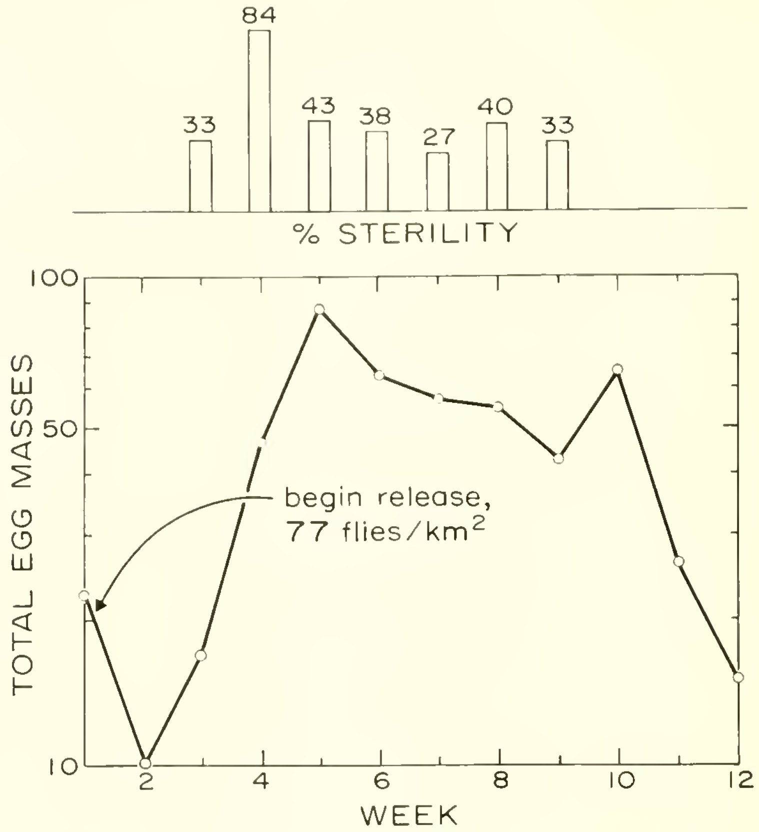

Fig. 1. Sanibel and Captiva islands, Florida. Decrease in egg mass number at 3 pens for approximately 1 week following release of sterile flies. Data are from unpublished USDA report, summarized in Baumhover et al. (1955).

Numbers of egg masses collected from sentinal goats, wounded and infested as in the Sanibel test, were recorded. Total egg masses collected per week are summarized in Fig. 2. Here, as in the Sanibel test, following sterile fly release there was a drop in oviposition rate for a brief period followed by an increase to levels above the pre-release reproductive rate. Again, sterility did not appear until the second week of release; thus the reduced oviposition was not caused by declining population size due to sterile egg masses.

This reduction, again, may be the result of chance fluctuations. The change is, however, suggestive of reproductive interference. As noted in Baumhover et al. (1955), oviposition rate on Curaçao was much greater than that during the Sanibel test. Despite this natural higher density in screwworms, an artificial increase in density of flies was associated with a temporary reduction in oviposition rate.

Central Florida 1957.—This test demonstrated the feasibility of screwworm eradication from southeastern United States, which had become infested in 1933. The experiment was carried out in 1957 to test the effects of sterile release for eradication of screwworm populations in a mainland zone where they are contiguous with a large, untreated, population. Details of this test were reported by

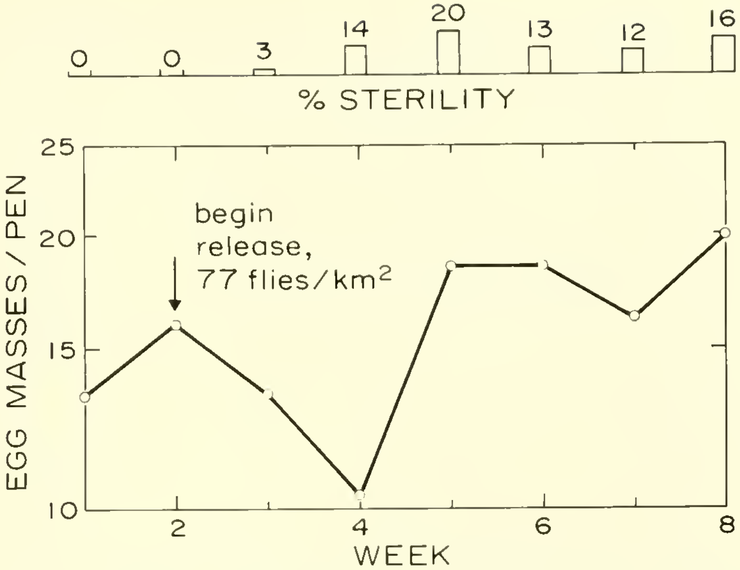

Fig. 2. Curaçao, Netherlands Antilles. Data from first release period at low rate. Two weeks of lower oviposition at 10 sentinal pens followed introduction of sterile flies after week 2. Data from Baumhover et al. (1955).

Baumhover et al. (1959). The 5180 sq km treated area on the eastern coast of Florida between Orlando and Vero Beach contained 8 to 10 goat pens in two groups, each with 2 wounded and 2 healing goats. One of these groups had 4 pens, the other group had 4 to 6 pens. Only the group with a constant 4 pens can be used in this analysis because the number of pens for the other group was changed during the weeks following initial fly release. Three control groups of 4 pens each were located just outside the release area to the north, south, and west. Sterile flies were released via single engine airplane at 386 flies per sq km per week. Initial plans were to treat this area from 2 May to 17 August 1957. Due to rearing problems, however, the area with the constant 4 pens considered here did not receive flies until the week of 12 May. For this reason week 3 is considered the first week of sterile treatment in this analysis.

Trends in oviposition rate for the treatment and control areas are shown in Fig. 3. This experiment had the advantage of a control area for comparison, but as shown in the figure, natural oviposition in that area was considerably below that shown in the test area at the beginning of this test. Another problem with this test was the inexact knowledge of when the first released flies reached the treatment group of pens. Since Baumhover et al. (1959) showed significant sterility in the control pens during the release period, migration of sterile males or sterile-mated native females into the treated area before week 3 may have occurred. If sterile males had entered the area during the first 3 weeks, they had no noticeable effect on oviposition rate. If native females entered this area, the elevated oviposition rate during weeks 2 and 3 may have been due to activity of females "flushed" from the adjacent area.

Clearly, however, reproductive activity of native females was much lower in

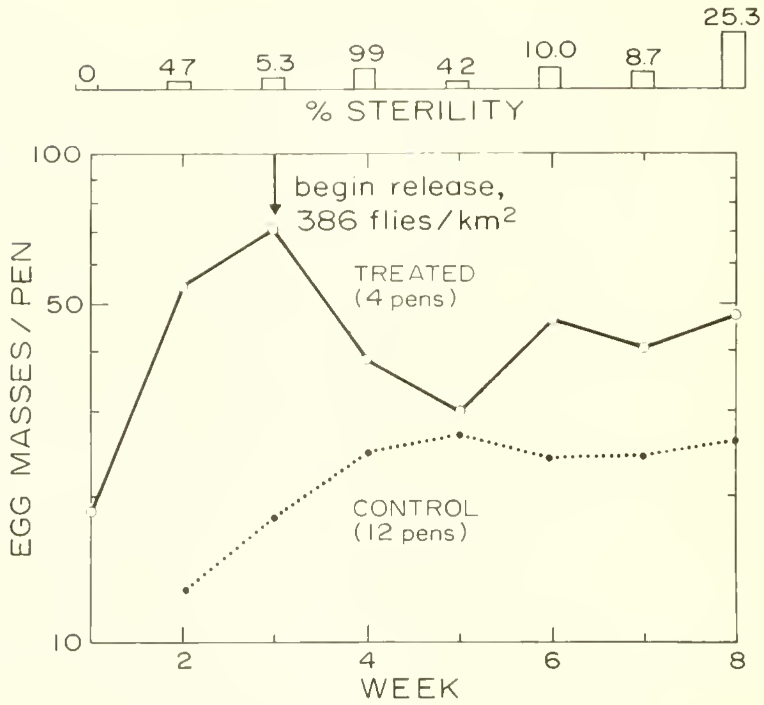

Fig. 3. East central Florida test. Oviposition rate from 4 pens in treated area dropped following release of sterile flies. Control area shows gradual increase in rate for this period. Data from Baumhover et al. (1959).

the release area for the two weeks following direct release of sterile flies. This reduction was not reflected in the activity of the control area females, which suggests that sterile fly treatment was responsible.

Veracruz 1964.—This test was part of a two year series of experiments to examine sterile fly dispersal techniques for eradication of permanent screwworm populations in moist, tropical communities. The region, which was used for field tests in a number of experiments, has been described in detail in publications describing tests following this one (Davis et al., 1968; Krafsur et al., 1979, 1980; Krafsur and Hightower, 1979). The area was centered roughly on Poza Rica, Veracruz and was a 80.5 by 64.4 km rectangle. The area at that time was a mixed agricultural community. Principal land use included banana and citrus groves interspersed with pastures and narrow strips of natural vegetation along waterways and hill tops. Most ranches were small and raised zebu or zebu-brown Swiss cattle. Other animals included horses, pigs and a few sheep and goats at higher elevations. Rainfall during the test period (August to October) was 50 to 75 percent below normal.

Six flight lanes, 12.9 km apart and 80.5 km long were used throughout the tests. Release rate, assuming uniform dispersal of flies, was about 154 flies/sq km/week. Eight sheep pens were used throughout the test and 3 were added during the test. One pen was a control, located 9.6 km outside the test area, and the other added pens were at least 8 km from the nearest pen and probably had little effect on

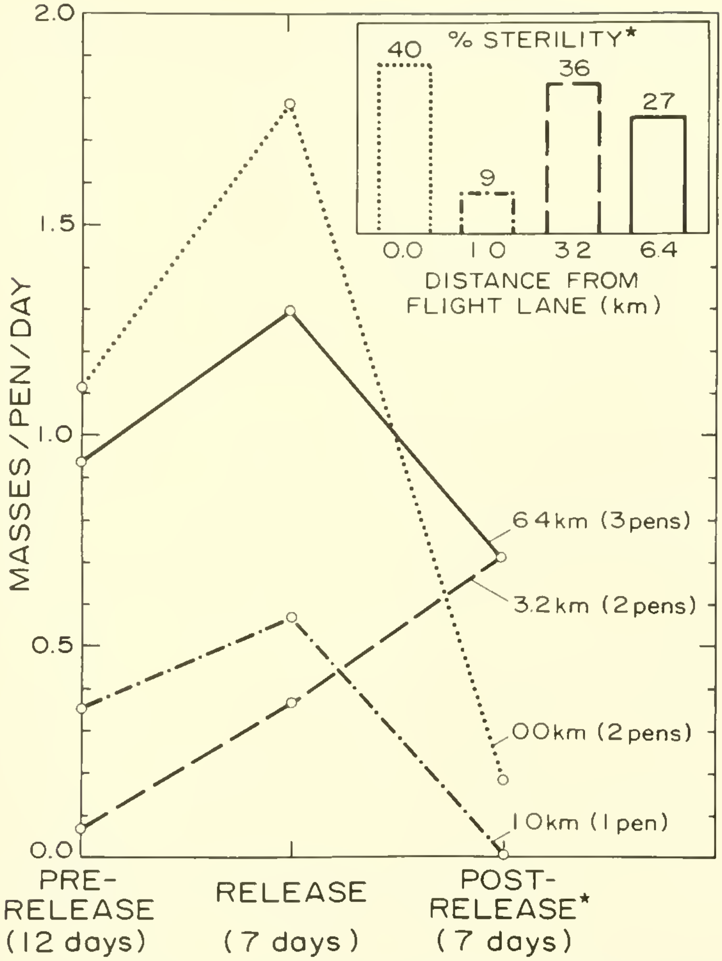

Fig. 4. Veracruz 1964. Oviposition rate increased previous to release, then decreased in 3 of 4 groups following release. The pens not showing an oviposition decrease were those with lowest initial infestation. Data from unpublished USDA report by Davis et al., summarized in Davis et al. (1968).

reproductive activity at the original pens. Only the original 8 pens are used for this analysis.

Results of this test, grouped according to distances from pens to flight lanes, are given in Fig. 4. For approximately 16 pre-release days (July 27 to August 11), there was an increasing trend in rate of oviposition at all pens. For 10 days following the release period there was a decline in egg mass number in 3 of the 4 groups. Only pens located 3.2 km from the flight lanes showed increase in oviposition rate. These pens had the lowest oviposition rate previous to release, suggesting that the sites represented least preferred screwworm habitats. Trapping data given in Davis et al. (1968) indicate that the 3.2 km sites were not attractive to dispersing sterile flies during most of the test, yet sterility at these pens was 36 percent for the total test period; only the 0 km pens with 40 percent had greater sterility. Dry weather undoubtedly had some effect on oviposition rate changes

Table 1. Analysis of egg mass distribution for pens various distances from flight lanes for collections from (I) 19 August to 9 November 1965, and (II) 16 November 1965 to 7 January 1966.

	No. of Pens	No. of Weeks	Total Mean Masses/Wk	Var	Crowdedness	Patchiness
I						
0 km	3	8	32.88	434.90	45.11	1.37
9.6 km	3	8	34.88	188.13	39.27	1.13
II						
0 km	3	13	15.69	126.56	22.75	1.45
4.8 km	3	13	20.23	93.35	23.84	1.18
9.6 km	3	13	26.38	146.08	30.98	1.17

over this time period. Sterility was not a factor in the initial change in oviposition rate as total sterility did not exceed 10% until after 28 August. The coincidence of oviposition decline and release of sterile flies, which resulted in the lowest oviposition rate at pens closest to flight lanes, suggests that sterile fly release inhibited native fly reproductive activity. The increase in numbers of masses at least preferred sites and high sterility at these sites despite a lack of sterile flies, suggests that native females dispersed to the less preferred sites after interacting with sterile flies.

Veracruz 1965 Release Pattern Study.—This study was continued as part of a survey of screwworm ecology for eradication in regions where screwworms are present throughout the year. Pens were set up in the 5180 km sq region centered on Poza Rica, the same site used for the 1964 test, and the tests reported later by Krafsur and Hightower (1979). Flies were distributed from 80.5 km flight lanes separated by 19.3 km with a release rate of about 154 flies per sq km. Pens were located at 0 and 9.6 km from the flight lanes from 21 August until 16 October. Three additional pens were added at locations 4.8 km from flight lanes for the remainder of the test lasting until 14 January 1966. The primary purposes of this test were to compare sterility at various distances from flight lanes and to compare mating success of flies reared on different diets.

Two factors in the design complicate analysis. There was no pre-release sampling and pens were added after the eighth week. However, since pens were set up a known distance from flight lanes and data were recorded separately for pens, the effects of fly introduction can be compared for pens receiving sudden influxes of flies and those more distant from the flight lanes and exposed only to migrant sterile flies. The expectation is that if the native flies respond negatively to sterile flies, fluctuations in reproduction should be greatest for pens located immediately below release lanes. Distribution indices derived by Lloyd (1967), and discussed by Southwood (1978) and Pielou (1977) and others, are used here to compare variability in reproduction rate for pens 0, 4.8, and 9.6 km from flight lanes.

Egg mass distribution is summarized in Table 1 for periods with pens 0 and 9.6 km from flight lanes (I), and with pens 0, 4.8 and 9.6 km from lanes (II). Krafsur et al. (1979) showed that screwworm egg masses are more clumped in distribution in space and time than would be expected by chance. The relationship between mean density (masses/week) and mean crowdedness which adjusts mean density for each mass due to this clumping, is patchiness (Lloyd, 1967). For randomly dispersed (Poisson distribution with variance = mean) egg masses patchiness equals 1.0.

For the first eight weeks after first drop, mean egg mass density is slightly higher for 9.6 km pens. Since there is no pre-release data, the effects of fly release on total mean density cannot be evaluated. Variance in mass number for pens under the flight lanes is 2.3 times greater than that for 9.6 km pens as would be expected if periodic sudden release of sterile flies interfered with oviposition by wild females.

For the last 13 weeks (II), patchiness is also greatest for the pens located under the flight lanes and nearly identical for those 4.8 and 9.6 km from the lanes. During this period 6 drops were made and none were made from October 28 to November 26. Total sterility during the first eight weeks (August 14 to November 9) was 7.9 percent for the 0 km pens and 2.2 percent for the 9.6 km pens. For the second period (II) sterility was 11.2 percent at 0 km pens, 15.2 percent at 4.8 km pens and 5.8 percent at 9.6 km pens. These percentages are not sufficient to explain the variation in numbers of egg masses. Since the patchiness index is independent of mean density (Pielou, 1977), this index reflects the differences in behavior over time rather than changes in native fly density. These trends in oviposition behavior over time are consistent with the hypothesis that sudden increase in fly density interferes with reproduction.

Veracruz 1974.—Following screwworm outbreaks from 1971 to 1973, hypotheses were proposed that screwworm populations were adapting to sterile male treatments in the barrier zone along the U.S.-Mexico border (Smith, 1974; Bushland, 1974). An experiment was performed (Krafsur and Hightower, 1979) to compare egg sterility rates between populations which had been exposed to sterile males for several years in Tamaulipas, Mexico and those in central Veracruz, Mexico which had not recently been treated.

The central Veracruz test is comparable to the other experiments in that the test was performed on a uninured population, treatment rates are known and pre- and post-release data were recorded. The Veracruz experiment, carried out from May to October 1974, involved a treated area of 4000 sq km. Flies of the Tex-Mex strain, then in production for the program, were released weekly by C47 aircraft at a rate of 386 flies per sq km. Egg masses were collected from sheep in 10 pens during most of the test. Oviposition rate was monitored at these pens for 5 weeks previous to release of sterile flies and 11 weeks after release. Egg masses were collected from these sites with some changing of pen location and number, for about a year following this test. As in the 1964 and 1965 tests beef cattle ranches and livestock on small farms were probably the major hosts for screwworms in this region. Details of this experiment as well as the Tamaulipas tests are given in Krafsur and Hightower (1979).

The results of the 1974 test are shown in Fig. 5. Oviposition is given as masses per pen per week. On week 6, the number of pens was reduced from 10 to 9. Ten pens were maintained for the next 11 weeks (Krafsur et al., 1979). The drop in oviposition rate corresponded to sterile fly introduction quite clearly. Weather data did not indicate any sudden changes in rainfall during this period; in fact rainfall averaged 70–75 mm per week from week 6 (18 June) to week 10 (9 July) when the population showed some recovery. As shown in Krafsur et al. (1979), total egg deposition appeared to cycle on a 3 to 4 week period well into the following October.

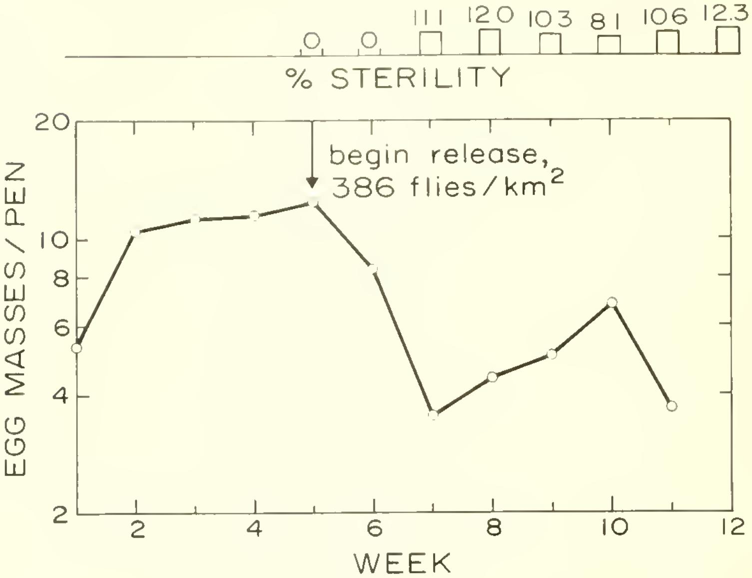

Fig. 5. Veracruz 1974. Oviposition rate per pen for 10 pens decreased following sterile fly release after 4 weeks of relatively stable rate. Data from Krafsur and Hightower (1979).

Sampling in this locality was continued through the fall, winter, and spring 1975. The region was treated again in mid-June. Pre-release means for 1975 were 3.31, 3.85, 5.46 and 7.46 masses per pen per week from 21 May to 17 June. Post-release means were 6.69, 5.85, 5.54, 3.85, 5.46 and 7.46 masses per pen per week from 18 June to 22 July. Comparison of oviposition rate 2 weeks pre-release and 2 weeks post-release indicates only a 3 percent decrease in oviposition. The 1974 and 1975 treatments differed in that, while both used the same mean release density, in 1975 the flies were distributed more evenly, using 3 times as many containers and narrower flight lanes.

Krafsur et al. (1979) present data which suggest a lack of movement of native females among pen locations. There is, therefore, a possibility that since the majority of these pens had been removing egg masses for over a year, the local populations may have been somewhat below the carrying capacity for adult activity including oviposition sites. Population reduction, plus a more even distribution of sterile adults, thus reduced the mean crowding of both sterile and native flies. This was likely to have reduced any negative interaction between sterile flies and ovipositing females.

Sinaloa.—As part of the annual strain-changing routine initiated during the mid-1970's, field evaluations of new strains were performed annually. A new strain derived from Veracruz (DE-9) was tested in Sinaloa, Mexico in 1979. Native flies in this area had not been previously tested with sterile males. The test was carried out in a 5014 sq km area near Sinaloa de Leyva from October to December 1979. Sterile flies were dispersed at a weekly rate of 508 flies per sq km per week with heavier treatments, up to 1000 flies per sq km per week, near rivers or other permanent water sources. Egg masses were collected from wounded sheep in 4 pens during the first weeks of the test. The number of pens was increased to 7

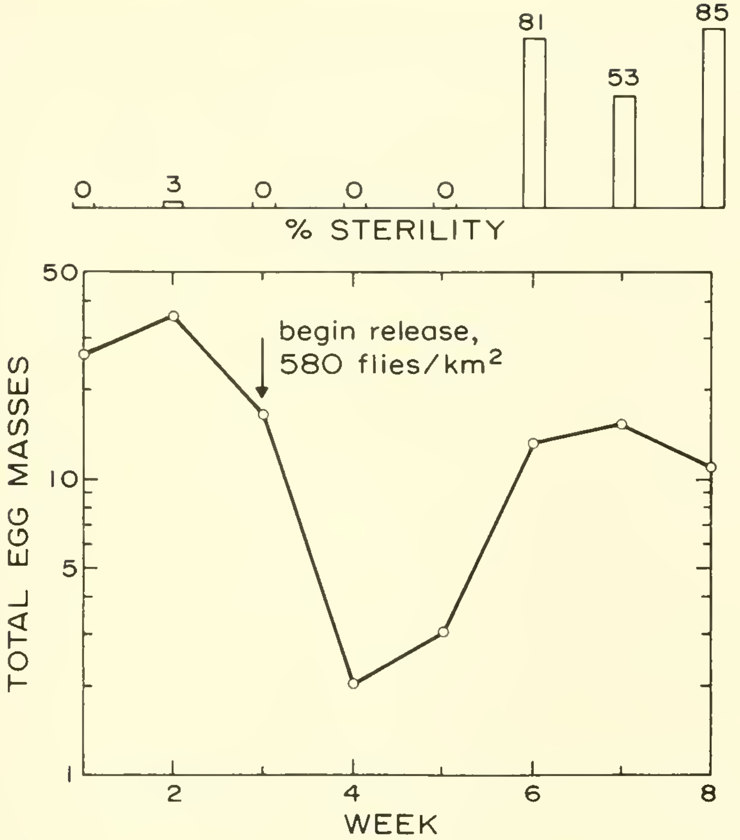

Fig. 6. Sinaloa. Reduction in oviposition per pen following fly release. Pen number ranged from 4 to 7 with pens being added during the fifth week. Data from unpublished report, J. P. Spencer and C. J. Whitten.

during the latter weeks after release. Data were collected for 3 weeks previous to release of sterile flies and 5 weeks after release. In addition to cattle, feral animals, domestic burros and other livestock were likely screwworm hosts in this area. Details of this test have not been published. The test was originally designed to test hypotheses that screwworm populations on the east and west coasts of Mexico were of different genetic makeup and that these differences were reflected in mating behavior. Thus, a strain made up of lines collected in Veracruz was field tested in Sinaloa.

Results of this test are given in Fig. 6. This test involved the heaviest treatment densities of sterile flies discussed this far. The two week decline in egg mass number following this release is also the most drastic. The three week sterility (Fig. 6) achieved and maintained after release is also one of the highest ever achieved. Again, while this evidence consists of only correlative data, the direction of reproductive response to sterile fly release was strong and negative.

Arriaga.—A test to compare mating success in lines of differing genetic derivation was performed in 1981. This experiment compared a broad based strain (V-81) made up by reciprocal, forced crossing of 16 separate egg mass lines from southern Veracruz with a narrow based strain (RGM-6) derived from a single egg mass collected in the Arriaga region of Chiapas.

A test area totaling 4800 sq km was divided into 3 zones along the narrow Pacific coastal plain of Chiapas. Zone A, at the western end near Arriaga, was 76 by 18 km and was treated by RGM-6. Zone B, in the center, was 55 by 18 km and was not treated. Zone C at the eastern end was 72 by 30 km and was treated with V-81. These dimensions were changed during later experiments. Each zone contained 5 sheep pens, wounds were monitored from late April to mid-August 1981. Egg masses were collected for 5 weeks before sterile fly release and 4 weeks after first release at 43 flies per sq km per week. Some pens were moved the first week in July and a higher release rate of 125 flies per sq km per week was used for 4 weeks. Potential host animals in this region were mainly cattle belonging to large ranching operations. Domestic dogs, swine and other animals were numerous near villages and ranch buildings. Feral dogs provided additional substrates particularly near six towns (pop. 15,000–40,000) located within the test region.

Results of this test are discussed in McInnis et al. (1983), mainly from a cytogenetic standpoint, and are reviewed in Richardson et al. (1982a). Rates of oviposition are summarized in Fig. 7. During this test extreme fluctuation in weather, particularly due to storms from the Pacific Ocean, resulted in large fluctuations in both daily and weekly oviposition rates. Reproduction is therefore summarized as egg mass number in the treated area minus that in the control. As indicated in Fig. 7, zones A and C had weekly fluctuations which were independent from each other until the week of release. For two weeks after release both zones were far below the control in screwworm activity; for the next six weeks the two zones were again independent from each other. In this test there is some indication that females may actually leave areas that are inundated with sterile flies. The rate of sterility in the untreated zone was higher for the period immediately following release than either of the treated zones. Since total number of egg masses also increased during this period in zone B (McInnis et al., 1983), native females mating to sterile males and migrating into this zone from the adjacent treated areas were the likely causes of this sterility and increase in oviposition.

Guerrero.—Iso-female lines collected during the Arriaga test were combined by "fly choice" (lines of the same adult age combined without separating the sexes) to produce the A-82 strain. This strain was field tested in Guerrero, Mexico, east of the town of San Marcos, centered on the 99th degree longitude line. The test area was roughly rectangular (30 by 50 km) with the long side parallel to the Pacific coast. The southern boundary of the area was about 3 to 10 km from the coast.

A variety of potential hosts inhabiting this region included goats, swine and cattle belonging to small agricultural operations. Feral and domestic dogs, cats and burros were also potential hosts. Ten corrals were set up containing infested animals. These included a total of 30 sheep, 3 goats, 3 cows, 3 pigs, and 1 horse. These pens were located in the southern part of the test area with at least 2 pens outside the zone of sterile fly release. Wounded animals were monitored for 2 weeks before initial sterile fly release. Flies were released from a single engine plane from 11 July to 19 September, 1982. For the two weeks in July, release rate

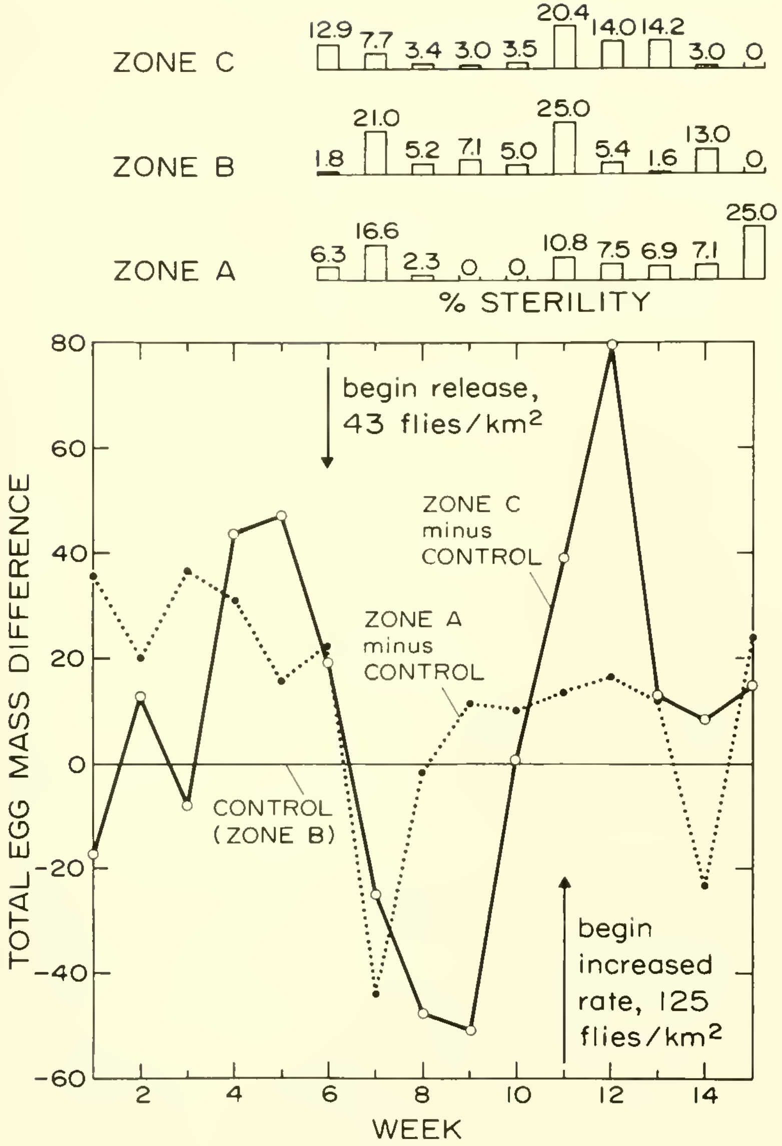

Fig. 7. Arriaga. Difference between oviposition rates in treated (A, C) and control (B) zones before release and following release at low and high rates. Each zone had five pens. Rates in both A and C decreased relative to B following release, flies from treated zones may have been flushed into control zone. Data from McInnis et al. (1983).

was 298 and 338 flies per sq km, for all remaining weeks release rate was greater than 412 flies per sq km.

Fig. 8 gives the rates of oviposition and sterility for this test. The two large drops in oviposition rate are both associated with introduction of sterile flies. Rate of oviposition before introduction of sterile insects was extremely high, probably reflecting the lack of care given the relatively high density of domestic animals in the region. The sudden apparent decrease in oviposition during the week of July 8 to 14 was not associated with any obvious weather changes. Captures in wind oriented traps using an adult attractant (Swormlure-4) also decreased drastically during this period. The drop from week 5 to week 6 coincides with the introduction of sterile flies at approximately 50 percent higher density. These data appear to be in mild agreement with the hypothesis of density dependent interference in reproduction. This test was carried out during a period of extremely high reproductive activity and population fluctuation, partly due to the onset of the rainy season (see Spencer et al., 1981; Krafsur et al., 1979). Baumhover (1963) showed, with laboratory tests, that pupae are highly susceptible to low humidity (<40%), oviposition increases following onset of rainy season are likely to have been due to increased survival of pupae in moist soil. These fluctuations, especially the drop at week 3, could be responses, at least in part, to other factors.

The next group of field tests include 3 tests executed in areas which were part of the eradication barrier or were performed in regions as a continuation of a previous experiment. These areas were generally at the southern margin of the eradication zone or in regions previously described here. Again, sites were chosen with respect to accessibility and high screwworm activity. These tests are of particular interest in that they provide insight into the probability that native populations change their distribution or behavior after sterile fly introduction in a manner which allows them to reproduce at their pre-release rate. Unfortunately, tests in which treatments were monitored in a comparable manner to the tests on uninured populations all have weaknesses which preclude simple comparisons. I include these tests here as illustrations of the possible types of responses that may be shown by treated populations with the admonition that these data have major deficiencies.

Tamaulipas A and B 1974.—These adjacent areas were located at the southern edge of the barrier zone being maintained along the United States-Mexico border. Details of the design and purpose of these tests are given with the Veracruz 1974, summary in Krafsur and Hightower (1979). Two sites, measuring 64 by 80 km were oriented such that flight lanes were directed north and south and separated by approximately 4 km. Zone A, centered on San Fernando, and zone B, centered on Soto la Marina, were treated with sterile flies of the currently used Tex-Mex (zone A) and newly constituted FF8 (zone B) strains respectively, at 386 total flies per sq km per week. Drop rates were planned to be from mid-June to late August, with 11 weekly releases. Actual releases were reduced by weather conditions such that the first 4 releases in zone A and the first 5 releases in zone B were poorly targeted or missed the zones.

Results of these tests and other tests in areas previously exposed to sterile flies are summarized in Table 3. Total masses per pen per week are averaged for pre- and post-release weeks. For post-release data, the 2 weeks following release are averaged since this represents the period when reproductive activity has been shown to drop in untreated populations.

Comparison of the pre-release and post-release means for these two areas indicates that no decline in oviposition rate resulted from sterile fly introduction. Whether this indicated that the population was below adult carrying capacity, that native flies were acclimated to inundation by sterile flies, or that the problems

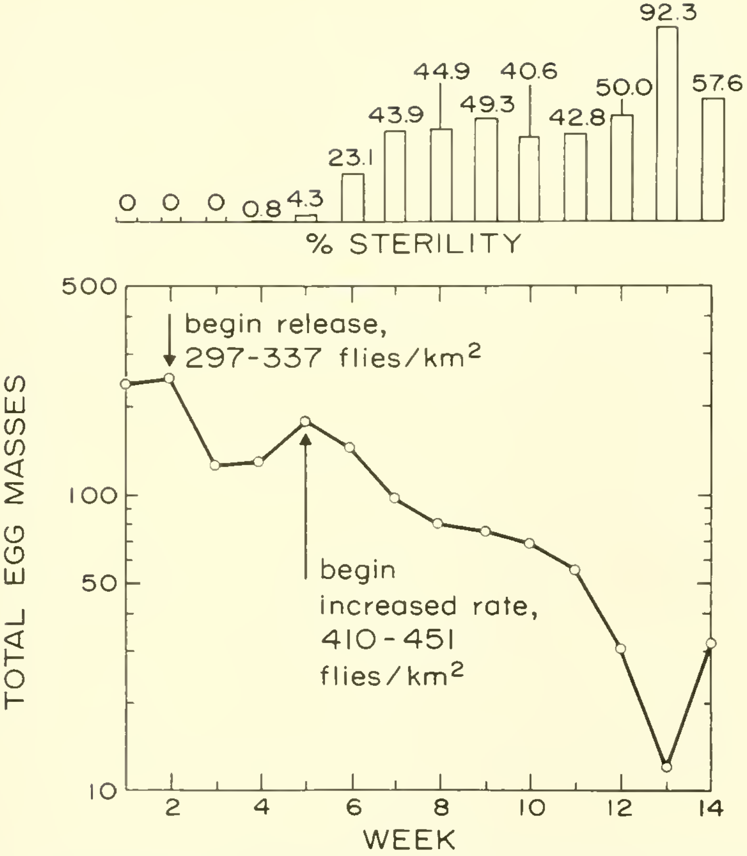

Fig. 8. Guerrero. Total masses collected per week from ten corrals containing various animals. Two release rates were used, a two week decline occurred following the low release rate then began a steady decline following the second, higher rate. Data from unpublished strain evaluation report, Comision Mexico-Americana (1982).

in release had resulted in a gradual increase in fly density to which the native flies adapted, cannot be determined.

Veracruz 1980.—This test involved release of a strain of sterile flies derived from the west coast (Sinaloa) of Mexico in an area on the east coast. This was a reciprocal of the Sinaloa (1979) test for genetic differentiation of geographically isolated populations. The test area, south of the city of Veracruz, had been the site of several field tests of sterile flies and attractants. Sterile flies had been released at this site as part of the eradication program, capture rates of 0.14 sterile flies and 0.09 fertile flies per trap per week were recorded before introduction of the Sinaloa strain. Flies were released at about 579 flies per sq km per week over a 2331 sq km area. The test was performed from July 4 until 14 August 1980. Initial release date was 15 July 1980. This test, while achieving its purpose of field testing a candidate strain for plant production and testing for geographically based mating barriers, did not provide conclusive results relative to the effects of sterile flies on oviposition rates. A major problem involved changes in experi-

Table 2. Summary of field tests in regions previously treated with screwworms or manipulated to reduce screwworm density.

Test Locality	Year	Pre-release Masses/Week	Post-release Masses/Week	Total Sterility %
San Fernando, Tamps.	1974	55	72	36.6
Soto la Marina, Tamps.	1974	55.3	60.5	30.5
Veracruz	1980	19	35.5	49.5
Arriaga V81	1981	59.5	91.0	11.5

mental design during the test. The pen receiving the second largest numbers of egg masses was initiated the day before first drop. This pen was located at the same ranch as the pen receiving the most egg masses; the likely interaction between pens perhaps biases any estimate of the effect of fly release even when this new pen is omitted from the data. In addition to the changes in pen number, this test was initiated during the beginning of the rainy season when screwworm populations are known to increase in the tropics (Spencer et al., 1983), and the test could not be performed to the planned conclusion due to hurricane Allen.

Despite these conditions, data in Table 2 show that considerable sterility was achieved; thus the sterile flies were successfully interacting with native flies. Without a control area, during this period of naturally changing population structure, the conclusions concerning the effects of sterile fly inundation are tenuous. It may be concluded, however, that this test did not show a decline in oviposition rate due to sterile fly release.

Arriaga V81.—Following the Arriaga test of genetic lines discussed above, a field test was performed in the same region, using nearly identical pen sites from 10 August to 7 November 1981. This test, designed to evaluate the performance of the V81 line as a strain for plant production, was carried out at release densities approximating those used in the eradication program.

The test was carried out in two stages, the first using zone B as an untreated control zone as in the comparison test; the second stage was executed without a control zone and with pens moved to new locations. Since the second stage of this test followed the first stage with only two nonsampling days, there were no pre-release data and no control pens. Data from the second stage are not included in this study.

Results of this test, shown in Table 2, indicate that there was no reduction in oviposition rate either in absolute numbers of masses or in the difference between treated and control areas. While the sterility in this region seldom exceeded 10 percent during the strain comparison test, that level of sterility and the removal of egg masses from 25 April until the initiation of this test may have reduced population density to a level below that which would result in reduction of native fly reproduction. It is at least equally probable that after more than 3 months of sterile fly treatment, the native population had acclimated to sterile flies in the region.

Discussion

Natural populations of screwworms were shown in these tests to have reduced reproductive activity in response to sterile fly inundation. The response is tem-

Table 3. Summary of effects of sterile fly release for field tests with oviposition data collected before and after release.

Test Site	# Masses Before Release	# Masses After Release	% Drop	Sample Period*
Sanibel	22	10	55	1 week
Curaçao	288	238	17	2 weeks
Florida	497	270	46	2 weeks
Veracruz 1964	106	55	48	10 days
Veracruz 1974	240	110	54	2 weeks
Veracruz 1975	168	163	3	2 weeks
Sinaloa 1979	46	13	72	2 weeks
Guererro 1982**	536	254	53	2 weeks
Guererro 1982***	286	165	42	2 weeks

* Period of time pre- and post-release.

** For weeks before and after actual release.

*** For weeks before and after first released flies were trapped.

porary, lasting about two weeks. Evidence from nine tests on populations in regions of heavy screwworm infestation indicates that this reduction in oviposition rate is consistent and normally occurs before there is significant sterility. This suggests that the interaction between mated native females and introduced sterile flies caused this reduction.

In two tests carried out in a barrier zone (Tamaulipas A and B) where sterile flies had been released on a regular basis, and two tests where populations had been disrupted by previous sterile fly introductions (Arriaga V81) or long term heavy sampling (Veracruz 1975), there was no reduction in oviposition rate as a response to sterile fly introduction. These results suggest that some sort of density dependant interactions or changes in behavior patterns occur when population density is increased.

Possible types of interactions responsible for this response are competitive interference at oviposition sites or adult feeding sites. Since flies reared from eggs collected in the field can feed at densities of 200–300 flies on a few square centimeters of food or moist cotton, and crowding the females in small (6 dram) vials stimulates oviposition, interference competition does not appear to be responsible for the drop in reproductive activity. This increase in adult density is not likely to cause resource depletion since both liver trap and swormlure trap data indicate that screwworms make up less than 1% of adult Calliphoridae in natural communities.

Observations of sterile flies (Guillot et al., 1978; Krafsur, 1978; Mackley and Long, 1983) indicate that both sexes are attracted to flowering trees and shrubs. Observations of fertile flies indicate that only females are attracted to wounds, though not all females collected on wounds contain mature eggs (Guillot et al., 1977a). Native females spend minimal time around wounds. Oviposition is initiated within a minute after a female lands on a wound, the female feeds on fluids before and during oviposition and leaves immediately after oviposition. I have observed up to 3 females simultaneously ovipositing on a single wound with an opening of less than 2 cm sq. Guillot et al. (1977a) report that females may orient toward other ovipositing females, then commence oviposition. Since females typically mate once, most activities by mated females are probably associated with host and nutrient location. Male efforts are apparently mainly expended on mating at sites where both sexes feed. I have found no evidence, either in the literature or in field observations, indicating that inter-female competition occurs at wound sites.

A logical and, I believe, likely cause of the reduced oviposition following release is a change in behavioral structure of the native population induced by changes in total population density. While screwworm females are capable of moving great distances under certain conditions (Barrett, 1937), data collected from high infestation regions in Veracruz (Krafsur et al., 1979) and Chiapas (Brenner, 1984) suggest that little dispersion occurs during periods of optimal local environmental conditions. Evidence from Florida 1957, Veracruz 1964 and Arriaga suggests that the influx of sterile flies is correlated with dispersion of native females resulting in a net emigration of native females away from the release zone.

Mating behavior in screwworms is apparently initiated by males striking from perches on flowering shrubs and trees. Females are grasped (this is called striking in screwworm jargon) in midair, the pair falls to the ground where the female is either released or copulation lasting about 2 minutes occurs (Krafsur, 1978; Guillot et al., 1977a). Other flies are frequently struck by males but are immediately released. In laboratory cages, mortality rate for females caged with males greatly exceeds that of females caged alone. In a study by Guillot et al. (1977b), reproductively young females differed significantly from older females in their response to baits and host animals. Virgin females were significantly less attracted to host animals than to liver or chemical attractant baits.

In the natural populations studied here, egg masses were collected at a rate ranging from about 10 to 50 masses per pen per week. Assuming that half of these masses are from the first gonadotrophic cycle, 5 to 25 females per week visit pens for deposition of their first egg mass. If male courting sites attract females at a similar rate, this number represents a maximum estimate of the number of encounters per week for a courting male. That is, a male would have 1 to 4 opportunities per day to compete for females approaching a courting site. Parker (1974) has shown that courting effort (persistence) is optimized if it is proportional to time between courting opportunities. If male screwworms are optimizing their courtship efforts, they would be expected to expend maximal effort for each encounter since encounters are relatively rare.

Baumhover (1965), Crystal and Ramirez (1975), Crystal and Whitten (1976) and others have shown that as screwworm strains undergo adaptation to laboratory or production rearing conditions, their courtship becomes more aggressive, that is, females caged with males from older laboratory lines die at a faster rate than females caged with newly colonized strains. The result of high density sterile fly release is then to create a community in which females are being struck by males at a higher rate and perhaps more aggressively than normal. Since the majority of these males are released on grid patterns, any localization of native males existing before sterile fly release is swamped out. Native females have no way of avoiding this courtship except to migrate or seek refuge.

Evidence from most of these field tests and experiments indicates that for moderate to high release rates, i.e., exceeding 300 flies per km sq, a drop in oviposition rate of 50 percent may be expected. This effect appears to last for about 2 weeks, then recovery may occur (Curaçao, Florida 1957, Veracruz 1974, Sinaloa 1979) but not always (Guerrero, 1982). Program managers might take advantage of this effect by first flooding new areas with a much higher initial rate of flies than normal., 500 to 1000 flies per sq km for example, to achieve maximal interference. Then by calculating when unmated females from the recovery generation are expected to appear (approximately 3 to 4 weeks later), a second massive drop could be made to insure that these females are courted by sterile males so further interference may occur.

Another possible advantage of this interaction is in stopping migration of fertile flies into or across a barrier zone such as is in place at the Isthmus of Tehuantepec in Mexico. While theoretical studies of sterile release dynamics have claimed to demonstrate maximum release rates, above which additional releases are not effective (Costello and Taylor, 1973), several tests have shown that sterility in a test zone can be maintained at a higher rate when density of released flies is excessive, such as during the Sinaloa 1979 test. Brenner (1984) showed that a significant difference in sterility rate could be maintained between pens inside and outside a release zone, separated by less than 40 km, if ground released sterile fly density exceeded 2000 flies/sq km/week but no difference was observed when release rate was less than 1000 flies/sq km/week. Maintenance of a barrier zone might be greatly enhanced if massive releases within the barrier are adjacent to outbreak zones outside the barrier.

In this discussion I have inferred, mainly from laboratory evidence and indirect interpretation of field data, that the interactions between wild and released flies are either directly behavioral or of the interference type. Monro (1966) suggested in experiments with the fruit fly *Dacus tryoni* Frogg that native flies were flushed by introduced flies due to competition for space or some other consumable resource. This is not likely for screwworms since no evidence suggests they ever reach stable equilibrium or saturation densities relative to adult resources. The temporary (2 week) nature of this interference in most tests further indicates that the mechanism of eradication is due to sterility and not interference alone. During the period of screwworm eradication, extensive attention has been given to genetic interpretations of population interactions (Smith and Borstel, 1973; Smith, 1974; Bushland, 1974; Bush et al., 1976; Richardson et al., 1982; McInnis et al., 1983). Few published works, other than reports of field tests of new strains, have dealt with population dynamics of released plus native screwworm adults (Krafsur et al., 1980; Krafsur and Garcia, 1978; Brenner, 1984). The temporary interruption of reproductive activity demonstrated in the tests discussed here may, however, prove useful if integrated into the dispersal schedule and pattern for reaching and maintaining a screwworm barrier.

ACKNOWLEDGMENTS

In compiling these data I made use of extensive archival materials from the USDA-APHIS and USDA-ARS files in Mission, Texas. I thank William L. Sudlow and O. H. Graham for access to this material. Discussions and data provided by C. J. Whitten, D. O. McInnis, J. W. Mackley, R. J. Brenner and H. C. Hofmann were incorporated into this report. The phenomenon discussed here has long been a topic of discussion among screwworm program researchers; I have used many of their observations and ideas in compiling this paper. I am grateful to J. W. Mackley, R. J. Gagné and J. B. Welch for reviewing this manuscript.

LITERATURE CITED

Barrett, W. L. 1937. Natural dispersion of *Cochliomyia americana*. J. Econ. Entomol. 30: 873–76.

Baumhover, A. H. 1965. Sexual aggressiveness of male screw-worm flies measured by effect on female mortality. J. Econ. Entomol. 58: 544–548.

Baumhover, A. H., A. J. Graham, B. A. Bitter, D. E. Hopkins, W. D. New, F. H. Dudley, and R. C. Bushland. 1955. Screw-worm control through release of sterilized flies. J. Econ. Entomol. 48: 462–466.

Baumhover, A. H., C. N. Husman, C. C. Skipper, and W. D. New. 1959. Field observations on the effects of releasing sterile screw-worms in Florida. J. Econ. Entomol. 52: 1202–1206.

Brenner, R. J. 1984. Dispersal, mating, and oviposition of the screwworm (Diptera: Calliphoridae). Ann. Entomol. Soc. Am. 77: 779–788.

Bush, G. L. 1978. Planning a rational quality control program for the screwworm fly, pp. 37–47. *In* R. H. Richardson, ed., The screwworm problem. U. Texas Press, Austin.

Bush, G. L. and R. W. Neck. 1976. Ecological genetics of the screwworm fly, *Cochliomyia hominovorax* (Diptera: Calliphoridae) and its bearing on the quality control of mass reared insects. Environ. Entomol. 5: 821–826.

Bush, G. L., R. W. Neck, and G. B. Kitto. 1976. Screwworm eradication: Inadvertent selection for noncompetitive ecotypes during mass rearing. Science 193: 491–493.

Bushland, R. C. 1974. Screwworm eradication program. Science 184: 1010–1011.

Costello, W. G. and H. M. Taylor. 1973. Mathematical models of the sterile male technique of insect control, pp. 318–359. *In* A. Charnes and W. R. Lynn, ed., Mathematical analysis of decision problems in ecology. Springer-Verlag, N.Y. 421 pp.

Crystal, M. M. and R. Ramirez. 1975. Screwworm flies for sterile-male release: Laboratory tests of the quality of candidate strains. J. Med. Entomol. 12: 418–422.

Crystal, M. M. and C. J. Whitten. 1976. Screwworm flies for sterile-male releases: Laboratory observations of the quality of newer candidate strains. Ann. Entomol. Soc. Am. 69: 621–624.

Davis, R. B., B. G. Hightower, D. A. Alley, J. E. Turner, and E. Lopez. 1968. Releases of sterile screwworm flies in northern Veracruz, Mexico, measured by recovery of sterile egg masses. J. Econ. Entomol. 61: 96–101.

Guillot, F. S., H. E. Brown, and A. B. Broce. 1978. Behavior of sexually active male screwworm flies. Ann. Entomol. Soc. Am. 71: 199–201.

Guillot, F. S., J. R. Coppedge, J. L. Goodenough, T. S. Adams, and E. Ahrens. 1977a. Behavior and reproductive status of native female screwworms attracted to a host. Ann. Entomol. Soc. Am. 70: 588–590.

Guillot, F. S., J. R. Coppedge, J. L. Goodenough, E. Ahrens, and T. S. Adams. 1977b. Reproductive status of female screwworms captured from hosts or in traps. Southwestern Entomol. 2: 49–52.

Hightower, B. G., D. A. Alley, and J. Contreras. 1968. Observations on the effects of releasing sterile screwworm flies in Northern Veracruz, Mexico. Folia Entomol. Mexicana. No. 17. 16 pp.

Krafsur, E. S. 1978. Aggregations of male screwworm flies, *Cochliomyia hominivorax* (Coq.) in south Texas (Diptera: Calliphoridae). Proc. Entomol. Soc. Wash. 80: 164–170.

Krafsur, E. S. and L. Garcia. 1978. Responses of the screwworm, *Cochliomyia hominivorax* to two sterile male release methods in south Texas, 1975–1976. J. Med. Entomol. 14: 687–697.

Krafsur, E. S. and B. G. Hightower. 1979. Field tests of sterile screwworm flies, *Cochliomyia hominivorax* (Diptera: Calliphoridae) against natural populations in three coastal areas of Mexico. J. Med. Entomol. 16: 33–42.

Krafsur, E. S., B. G. Hightower, and L. Leira. 1979. A longitudinal study of screwworm populations, *Cochliomyia hominivorax* (Diptera: Calliphoridae), in northern Veracruz, Mexico. J. Med. Entomol. 16: 470–481.

Krafsur, E. S., B. G. Hightower, and M. Vargas. 1980. Responses of screwworm (Diptera: Calliphoridae) populations to sterile male challenge in Veracruz. J. Med. Entomol. 17: 235–241.

Lloyd, M. 1967. Mean crowding. J. Anim. Ecol. 36: 1–30.

Mackley, J. W. and G. L. Long. 1983. Behavior of sterile adult screwworms (Diptera: Calliphoridae) on flowering trees and shrubs. Ann. Entomol. Soc. Am. 76: 839–843.

McInnis, D. O., C. J. Whitten, J. W. Mackley, R. D. Peterson II, and J. P. Spencer. 1983. Cytogenetic studies of the screwworm, *Cochliomyia hominivorax*, (Diptera: Calliphoridae), from Chiapas, Mexico. Ann. Entomol. Soc. Am. 76: 628–640.

Makela, M. E. and R. H. Richardson. 1978. Hidden, reproductively isolated populations: One of natures countermeasures to genetic pest control, pp. 49–66. *In* R. H. Richardson, ed., The screwworm problem. Univ. Texas Press, Austin.

Monro, J. 1966. Population flushing with sexually sterile insects. Science 151: 1536–1538.

Parker, G. A. 1974. Courtship persistance and female-guarding as male time investment strategies. Behaviour 48: 157–183.

Pielou, E. C. 1977. Mathematical ecology. Wiley-Interscience, John Wiley & Sons, N.Y. 385 pp.

Richardson, R. H. 1982. Phyletic species packing and the formation of sibling (cryptic) species clusters. *In* J. S. F. Barker and W. T. Starmer, eds., Ecological genetics and evolution. Acad. Press, Sydney.

Richardson, R. H., J. R. Ellison, and W. W. Averhoff. 1982a. Autocidal control of screwworm in North America. Science 115: 361–370.

———. 1982b. Mating types in screwworm populations? Reply. Science 218: 1143–1145.

Smith, R. H. 1973. Screwworm control. Science 182: 775.

Smith, R. H. and R. C. von Borstel. 1972. Genetic control of insect populations. Science 178: 1164–1174.

Southwood, T. R. E. 1978. Ecological methods. 2nd ed., Chapman and Hall, Halstead Press, John Wiley & Sons, N.Y. 524 pp.

Spencer, J. P., J. W. Snow, J. R. Coppedge, and C. J. Whitten. 1981. Seasonal occurrence of the primary and secondary screwworm (Diptera: Calliphoridae) in the Pacific coastal area of Chiapas, Mexico during 1978–1979. J. Med. Entomol. 18: 240–243.

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, pp. 740–745

BAUMANNELLA, A NEW PERLODINE GENUS FROM CALIFORNIA (PLECOPTERA: PERLODIDAE)[1]

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Abstract.—*Perla alameda* Needham & Claassen is removed from *Kogotus* and placed in a new monotypic genus, *Baumannella*. The new genus is distinctive in all life stages and differs markedly from known perlodine genera in having a flattened, biconcave egg. The apparent sister group of *Baumannella* is the western nearctic endemic genus, *Osobenus*.

Perla alameda Needham & Claassen has remained an enigmatic species since the original description by Needham and Claassen (1925). Ricker (1952) studied the holotype male and found the epiproct suggestive of *Kogotus*, but the unproduced paragenital plates along with poor condition of the specimen prohibited definitive placement. Jewett (1954) studied seven specimens, including two females from several California localities, and assigned the species to *Kogotus*. No additional information has appeared for the species since that time.

Recently R. W. Baumann and W. D. Shepard collected a series of specimens which were identified as *Kogotus alamedus*, but reared nymphs were found to be atypical of *Kogotus* in having bidentate rather than unidentate laciniae; these specimens were referred to us for detailed study. Our study from available material indicates this species is distinct from *Kogotus* and other perlodine genera in all life stages; consequently, we are assigning *P. alameda* to a new monotypic genus, *Baumannella*. Methods follow Stark and Stewart (1981).

Baumannella Stark and Stewart, New Genus

Type species.—*Perla alameda* Needham & Claassen.

Male genitalia.—Lateral stylets absent. Paragenital plates partially sclerotized, terminating in membranous hairy lobes. Epiproct short and slightly sclerotized, ventral margin coiled inward and covered with fine brown setae giving a sclerotized aspect (Figs. 1, 4). Hemitergal lobes broadly rounded and covered with peg-like setae (Fig. 1). Tergum 9 unmodified; sternum 7 with well developed mesal lobe (Fig. 2).

Female genitalia.—Subgenital plate broadly rounded, extending over ca. ⅔ ster-

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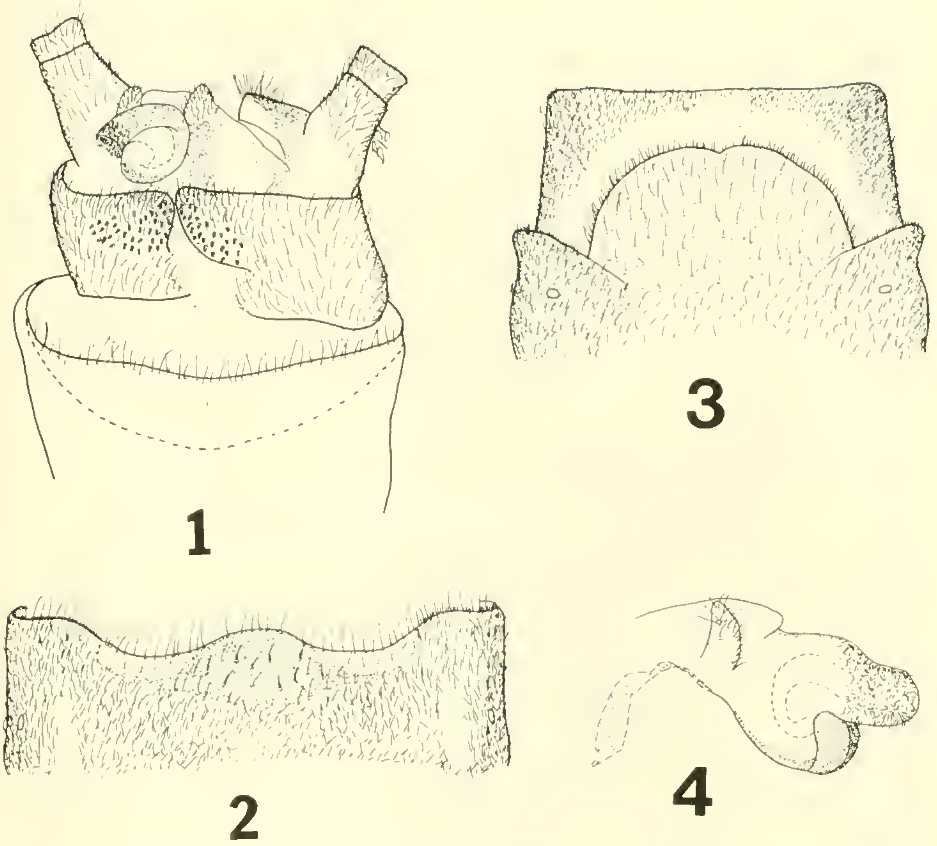


Figs. 1–4. *Baumannella alameda* genitalia. 1, Male terminalia, oblique dorsolateral aspect. 2, Male sternum 7. 3, Female sterna 8 and 9. 4, Epiproct, lateral.

num 9; typically with small apical notch. Sternum 9 with dense apical patch of short setae (Fig. 3).

Nymph.—Body yellow with brown markings; legs, antennae and cerci yellow. Head with pair quadrangular dark spots connected at anterior ocellus, forming an M-shaped anterior margin; frontoclypeal area light except pair small oval dark spots and dark marginal band; pair broken oval dark spots between eyes, and irregular reticulate dark markings on occiput; spinules around posterior half of eye and as indistinct partial occipital band not extending to midline (Fig. 6). Laciniae triangular, bidentate, with 2 or 3 stout axillary hairs and 2–4 stout hairs below base of subapical tooth; only 1 or 2 inner marginal short setae, if present, and scattered short basal setae; terminal tooth about 0.5 outer lacinial length and subapical tooth about 0.45 length of terminal tooth (Fig. 7). Mandibles somewhat flattened, not deeply cleft and with distinct serrations on inner margin of major ventral tooth (Fig. 8). Gills absent. Pronotum yellow with scattered, reticulate discal markings; fine spinules along anterior and posterior margins; hairs absent laterally; sparse median dorsal fringe fine hairs down pronotum (Fig. 6) and entire

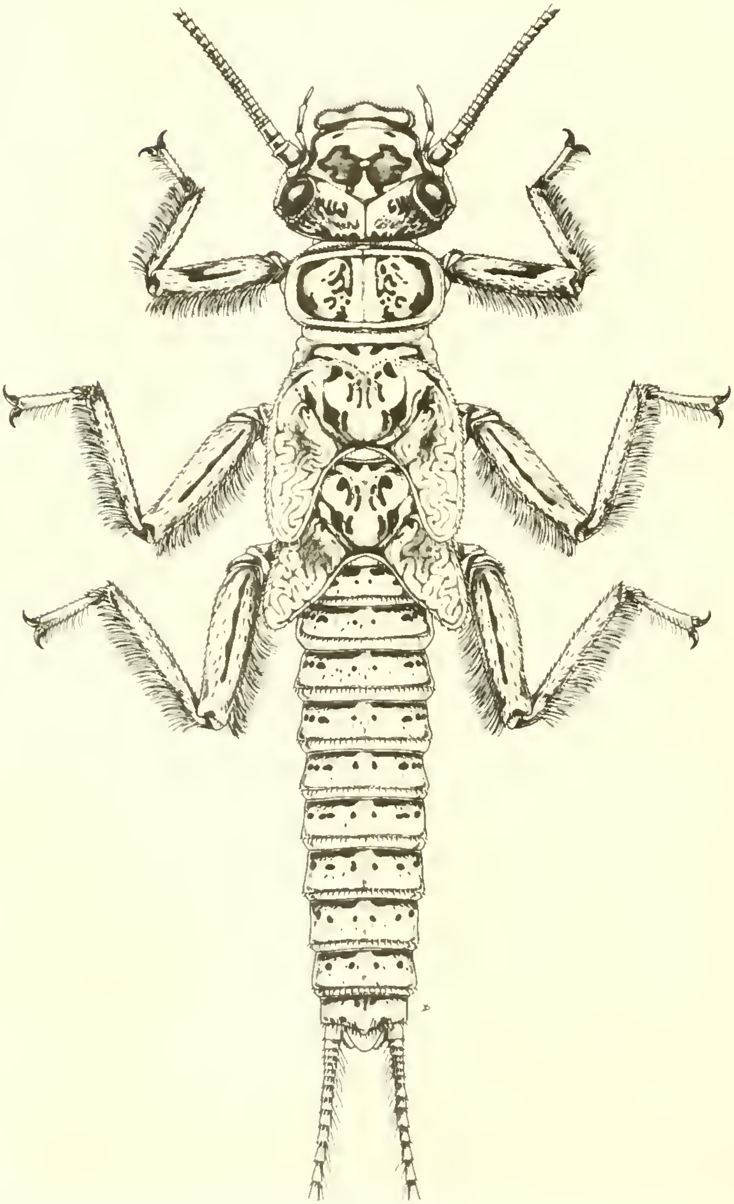
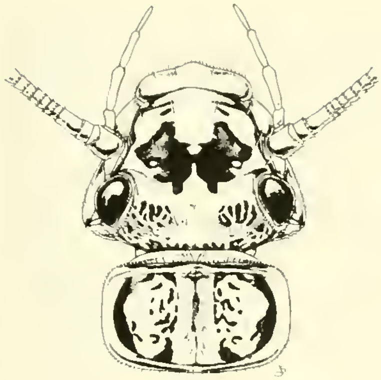


Fig. 5. *Baumannella alameda* nymphal habitus.

length of body. Y-arms of mesosternum meet posterior corners of furcal pits, with indistinct transverse suture (Fig. 9). Wingpads yellow, with scattered irregular brown spots (Fig. 5). Femora and tibiae with scattered dorsal surface spinules and a white, silky hair fringe (Figs. 5, 10). Abdominal tergae yellow, with incomplete anterior transverse dark band, pair of medial spots and 2–3 lateral spots; fewer than 20 intercalary spinules and with posterior fringe of hairs (Fig. 5). Male 8th



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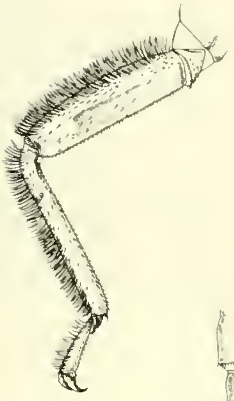

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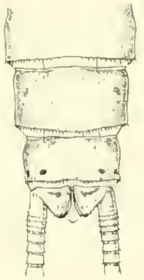

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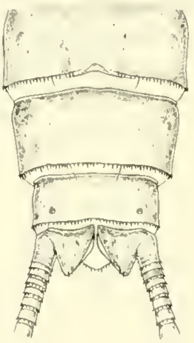

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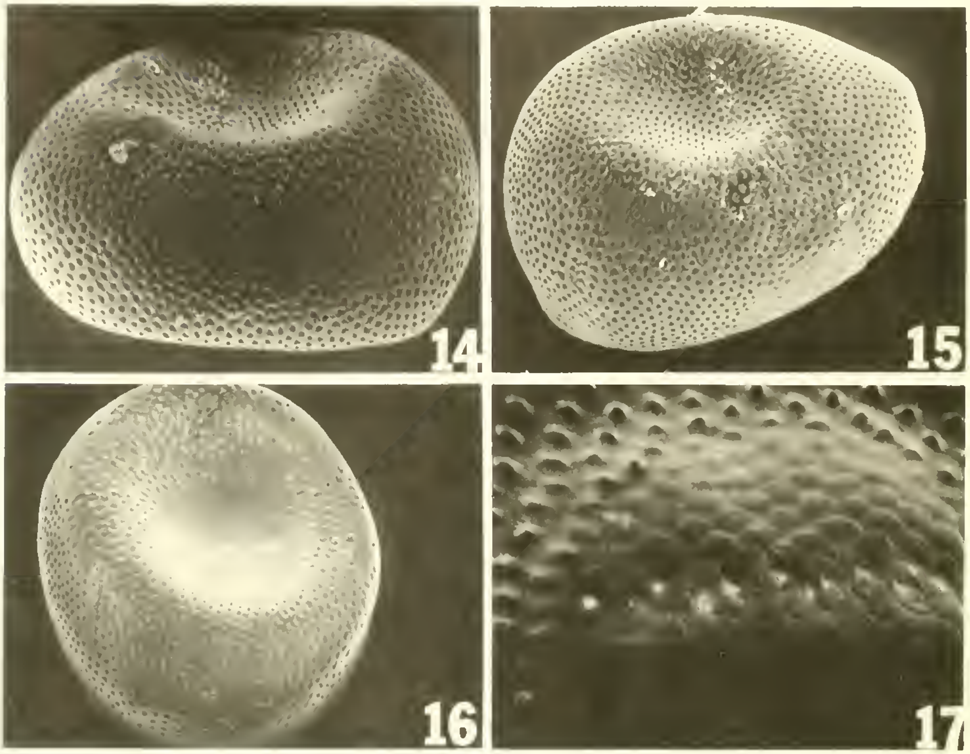
Figs. 6–13. *Baumannella alameda* nymphal structures. 6, Head and pronotum. 7, Right lacinia, ventral. 8, Right mandible, ventral. 9, Mesosternum. 10, Right foreleg, dorsal. 11, Sterna 8–10, male. 12, Sterna 8–10, female. Cerci, basal, mesal and apical (dorsal view).

and 9th sternum with mesal gap in posterior setal row (Fig. 11); female 8th sternum with mesal gap and developing subgenital plate, and 9th sternum with complete posterior setal row (Fig. 12). Cercal segments with posterior whorl of short setae and sparse dorsal fringe of silky white hairs (Fig. 13).

Egg.—Asymmetrically biconcave. Collar absent. Chorion coarsely punctate except for median ventral disc which is covered with hexagonal follicle cell impressions; irregular micropylar row of ca. 12–15 small orifices bisects ventral disc (Figs. 14–17).



Figs. 14–17. *Baumannella alameda* eggs. 14, Lateral aspect, 270×. 15, Dorsal aspect, 230×. 16, Ventral aspect, 230×. 17, Ventral aspect, 950×.

Etymology.—The generic name, *Baumannella*, honors our friend and colleague Richard W. Baumann.

Material examined.—CALIFORNIA: *Alameda Co.*, San Antonio Crk, 21-V-22, B.C. Cain, 1 ♂ (Holotype #1143, Cornell Univ.). *Napa Co.*, Pope Valley, 3-V-30, E. C. Van Dyke, 1 ♀ (Cal. Acad. Sci.). *San Benito Co.*, Pinnacles Nat. Mon., 3-V-46, H. P. Chandler, 1 ♂, 1 ♀ (Allotype #8609, Cal. Acad. Sci.). *Solano Co.*, Cold Crk., 8 mi W Winters, abv. Lk. Berryessa, 17-V-83, R. W. Baumann & W. D. Shepard, 3 ♂, 8 ♀, 18 nymphs (Monte L. Bean Museum; W. D. Shepard collection).

Diagnosis.—Male *Baumannella* will key to *Kogotus* in Ricker (1952) but are distinguished from *Kogotus* by the absence of peg-like spinules on abdominal tergum 9 and by the membranous, hairy paragenital lobes and reduced sclerotization of the paragenital plates. The coiled epiproct structure appears to have arisen independently in these genera (a parallel case exists for "whip-like" epiprocts in *Remenus, Isogenoides* and *Arcynopteryx*); *Osobenus* which shares both the coiled epiproct and the hairy paragenital lobe characters with *Baumannella* would appear to be a potential sister group within Diploperlini (Stark and Szczytko, 1984) but these genera are distinguished in nymph and adult by the mesosternal groove pattern noted by Ricker (1952) and most readily in the male by the upturned apical process of the *Osobenus* epiproct (Ricker 1952). *Rickera* is the apparent sister group of *Kogotus* (Szczytko and Stewart, 1984).

Females are distinguished from related western nearctic perlodids by the long, apically notched subgenital plate and by the distinctive biconcave egg which is unique among known Diploperlini. Nymphs will key to the *Pictetiella-Chernokrilus* couplet in Stewart and Stark (1984) or to *Cultus* if the short occipital and anterolateral prothoracic setae are overlooked, but *Baumannella* nymphs are readily distinguished from these genera by the conspicuous serrations present along the inner margins of the major mandibular teeth and by the distinctive color pattern of the mature nymph.

Although egg shape is atypical of other Diploperlini we are referring *Baumannella* to this group on the basis of reduced setation on the nymphal lacinia and on the basis of the produced male 7th sternal lobe.

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LITERATURE CITED

Jewett, S. G. 1954. New stoneflies from California and Oregon (Plecoptera). Pan-Pac. Entomol. 30: 167–179.

Needham, J. G. and P. W. Claassen. 1925. A monograph of the Plecoptera or stoneflies of America North of Mexico. Thomas Say Found. Entomol. Soc. Am. 2: 1–397.

Ricker, W. E. 1952. Systematic studies in Plecoptera. Indiana Univ. Publ. Sci. Ser. 18: 1–200.

Stark, B. P. and K. W. Stewart. 1981. The nearctic genera of Peltoperlidae (Plecoptera). J. Kans. Entomol. Soc. 54: 285–311.

Stark, B. P. and S. W. Szczytko. 1984. Egg morphology and classification of Perlodinae (Plecoptera: Perlodidae). Ann. Limnol. 20: 99–104.

Stewart, K. W. and B. P. Stark. 1984. Nymphs of North American Perlodinae genera (Plecoptera: Perlodidae). Great Basin Nat. 44: 373–415.

Szczytko, S. W. and K. W. Stewart. 1984. Descriptions of *Calliperla* Banks, *Rickera* Jewett, and two new western nearctic *Isoperla* species (Plecoptera: Perlodidae). Ann. Entomol. Soc. Am. 77: 251–263.

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87(4), 1985, pp. 746–750

A NEW SPECIES OF *PSAMMATHODOXA* DYAR FROM COSTA RICA (LEPIDOPTERA: NOCTUIDAE: CATOCALINAE

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Abstract.—The new species, *Psammathodoxa natadoides*, the second species of its genus, is described from Santa Rosa National Park, Costa Rica.

In 1921 Dyar described the strange noctuid, *Psammathodoxa cochlidioides*, from Brownsville, Texas. Recently, Daniel H. Janzen brought to me for identification some of the Lepidoptera that he and W. Hallwachs had collected in Costa Rica; among the many specimens were several of a new species of *Psammathodoxa*. He asked that it be described so a name would be available when he wished to refer to the species in his studies on the Lepidoptera of Costa Rica. The discovery of a second species of *Psammathodoxa* with exaggerations in the development of some of the structures of the genitalia does not help to determine the relationships of this odd genus. Its position after *Gonodonta* Hübner in the (McDunnough, 1938) check list seems incorrect; after some study, I am inclined to suggest a closer association with *Hypsoropha* Hübner.

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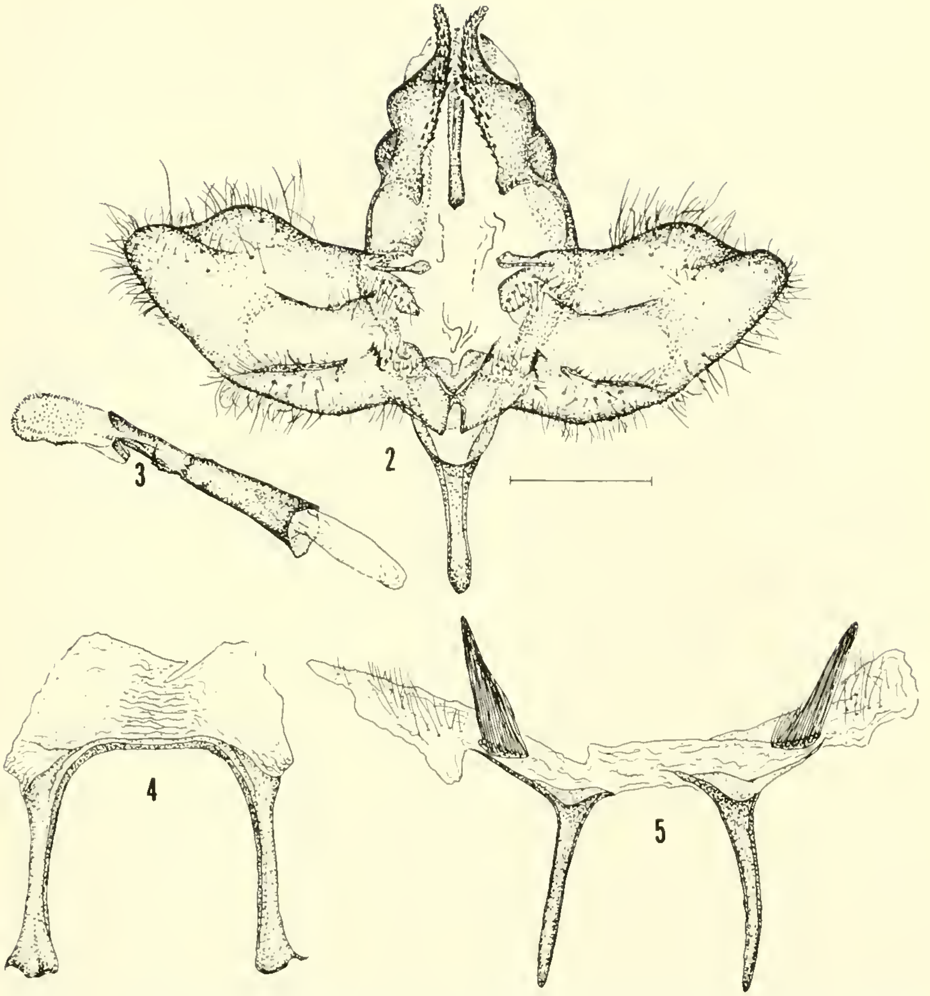
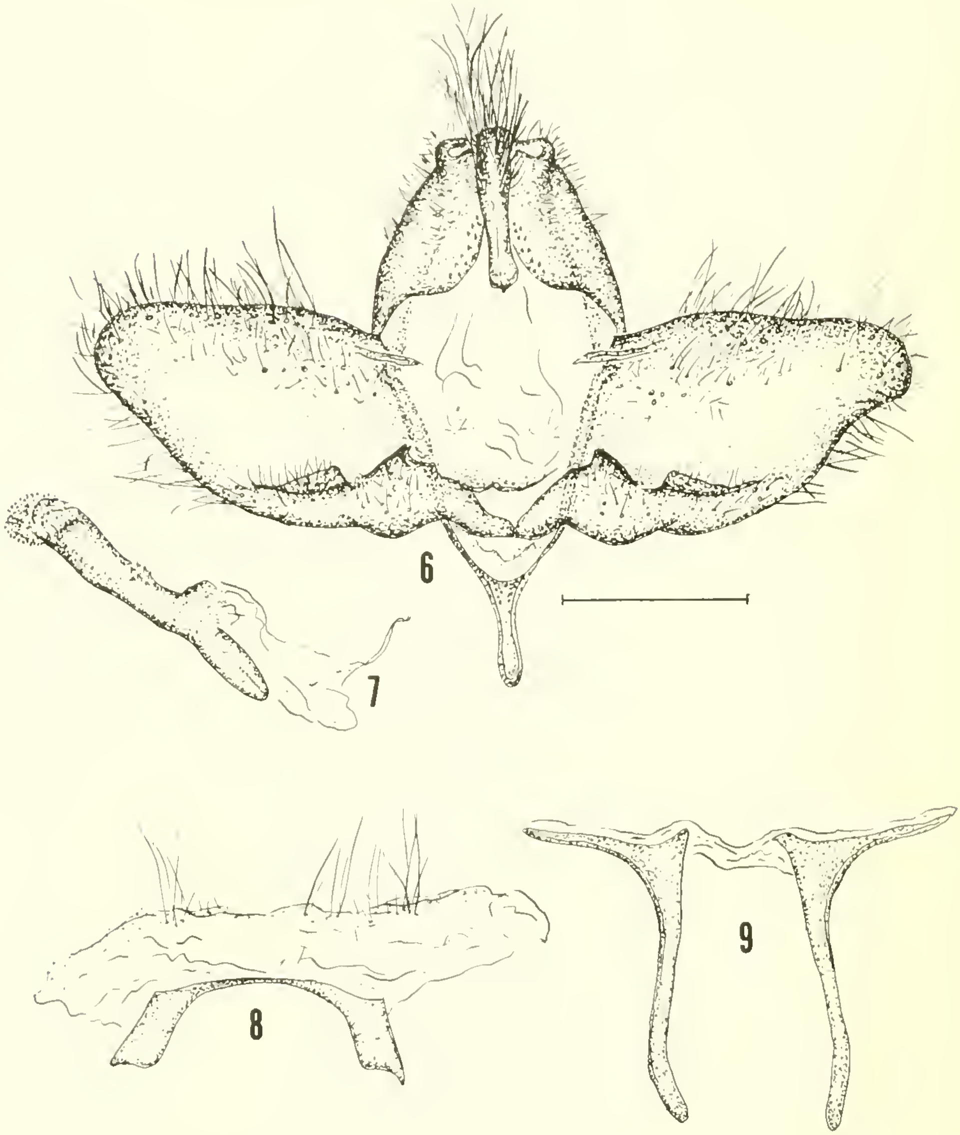
Fig. 1. *Psammathodoxa natadoides*. Male, holotype.



Figs. 2–5. *Psammathodoxa natadoides.* 2, Male genitalia with aedeagus removed. 3, Aedeagus. 4, Tergum, eighth abdominal segment. 5, Sternum, eighth abdominal segment. Scale of drawings = 1 mm.

Psammathodoxa natadoides Franclemont, New Species

Diagnosis.—This species is superficially very similar to *cochlidioides,* but it differs in the somewhat larger size and the course of the postmedial line, which at its inception on the costa is farther inset from the apex of the fore wing. The genitalia of both sexes differ in many ways from those of *cochlidioides.* The male has the lateral lobes of the tegumen produced caudad into bluntly pointed projections; the spines on the lobes are stronger and more numerous; and the valves have the coastal margins expanded beyond their middles and appearing somewhat sinuate. The female has the ventral plate of the ostium one-third wider from side to side, the anterior apophyses shorter and thicker, the posterior apophyses longer and thicker, the ductus bursae approximately four times as long, and the bursa three times as large with two long, linear signa; *cochlidioides* has a single, small



Figs. 6–9. *Psammathodoxa cochlidioides.* 6, Male genitalia with aedeagus removed. 7, Aedeagus. 8, Tergum, eighth abdominal segment. 9, Sternum, eighth abdominal segment. Scale of drawings = 1 mm.

lunulate signum. The modifications of the last sternum and tergum (Figs. 4, 5), the eighth segment, of the male differ between the two species; *natadoides* has a lateral cluster of heavy setae on each side of the apical (caudal) margin of the sternum, absent in *cochlidioides,* and the apophyses of the tergum much longer than those of *cochlidioides.*

Description.—Head, thorax, and fore wings whitish gray with a slight brownish tint; fore wing paler beyond postmedial line and along costa, crossed by many, fine, pale, outwardly diagonal lines, postmedial line brownish black, straight, inset from apex, angled to inner margin, antemedial line less well defined, diffuse, curved

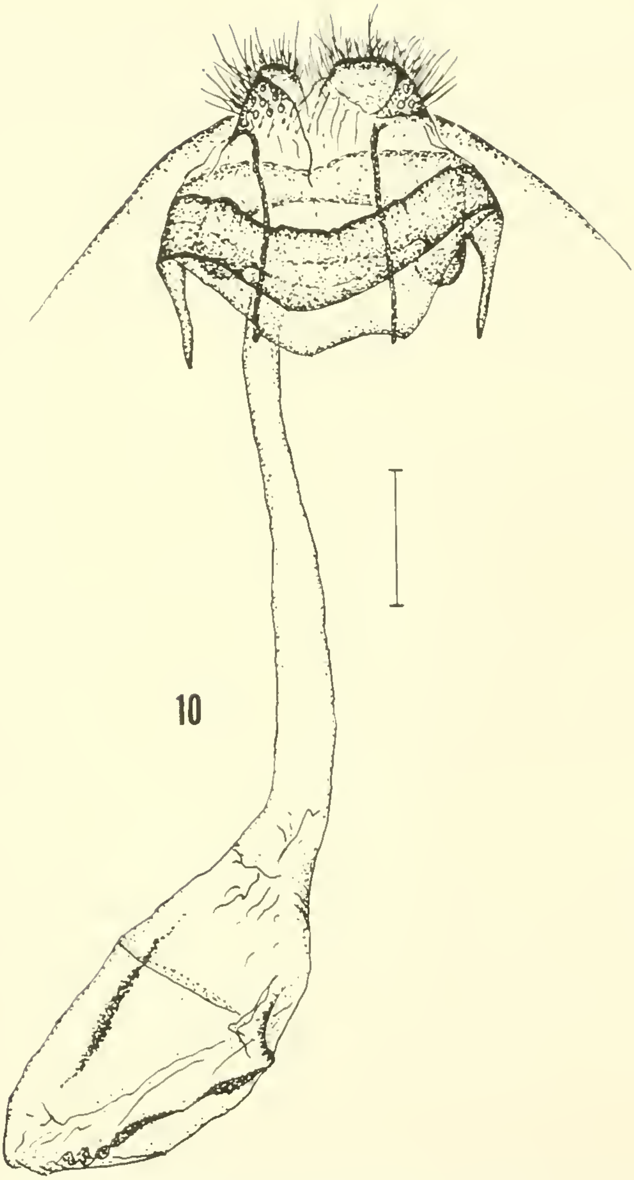


Fig. 10. *Psammathodoxa natadoides.* Female genitalia. Scale of drawings = 1 mm.

outwardly from costa to upper part of discal cell, then more or less straight to inner margin and parallel to postmedial line; one specimen with a small, black, subcircular reniform, other 35 specimens without an indication of reniform or orbicular; hind wing light fuscous, paler toward base; abdomen fuscous; below uniform fuscous, fore wing darker than hind wing.

Length of fore wing, males.—13–15 mm, most 15 mm; females: 18–20 mm, most 20 mm.

Male genitalia.—Figs. 2, 3.

Female genitalia.—Fig. 10.

Holotype.—Male. Santa Rosa National Park, Guanacaste Prov., Costa Rica, 20–22 June 1980, D. H. Janzen and W. Hallwachs. Collection United States National Museum of Natural History courtesy of Daniel H. Janzen.

Paratypes.—25 males, 10 females. Santa Rosa National Park, Guanacaste Prov., Costa Rica, May, June, July, August, November, and December, 1979, 1980, and 1981, those collected in 1979 by D. H. Janzen, those in 1980 and 1981 by D. H. Janzen and W. Hallwachs. Two in collection United States National Museum, 3 in collection J. G. Franclemont, 30 returned to D. H. Jansen.

The moth bears a likeness to some of the species of the genus *Natada* in the Cochlidiidae (= Limacodidae), thus the species name.

Robert W. Poole is thanked for reading a draft of this paper. The drawings are by James S. Miller, the photograph by the author.

LITERATURE CITED

Dyar, H. G. 1921. New American Noctuidae and notes. Insec. Insc. Menst. 9: 40–45.

McDunnough, J. 1938. Check list of the Lepidoptera of Canada and the United States, Part 1, Macrolepidoptera. Mem. South Calif. Acad. Sci. 1: 1–272.

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LARINUS PLANUS (F.) IN NORTH AMERICA (COLEOPTERA: CURCULIONIDAE: CLEONINAE) AND COMMENTS ON BIOLOGICAL CONTROL OF CANADA THISTLE

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Abstract.—*Larinus planus* (F.), a palearctic weevil known previously in North America from a single locality in Maryland, is well established in the northeastern U.S.: Pennsylvania (35 counties), Maryland (6), Ohio (3), and New York (2). The earliest available records, from Ohio (1968) and New York (1969), suggest that the weevil has been present for some time as an accidental immigrant. *L. planus* thus extends a growing list of natural enemies of the alien weed, Canada thistle, *Cirsium arvense* (L.) Scop., and its biocontrol potential against this weed is briefly discussed. Because it superficially resembles the deliberately introduced thistle weevil *Rhinocyllus conicus* (Froelich), we give characters to distinguish *L. planus* from this weevil and from other North American Cleoninae.

Larinus planus (F.) (= *carlinae* Olivier), a cleonine weevil of the tribe Lixini, belongs to a large genus (180+ species) well represented in the Palearctic Region. *Larinus* spp. typically develop in flower heads of composites of the tribe Cardueae (= Cynareae) (Zwölfer et al., 1971; Ter-Minasyan, 1978; Zwölfer and Harris, 1984). The rostrum of females in this genus is either curved for depositing eggs through a tunnel into the interior of a bud, or conical for pushing eggs through florets from above (Zwölfer and Harris, 1984).

Larinus planus ranges throughout much of Europe and central Asia (Hoffmann, 1954; Ter-Minasyan, 1978). Larvae of this species, described as "endophytic in flower heads and buds" of their hosts (Zwölfer, 1965), destroy ovarioles and other floral structures. Adults feed on host foliage without causing conspicuous damage (Batra et al., 1981). This apparently univoltine weevil overwinters in the adult stage and develops mainly in *Carduus* and *Cirsium* spp. having small capitula, especially Canada thistle, *Cirsium arvense* (L.) Scop., although local European populations may use *Centaurea* spp. as hosts (Zwölfer et al., 1971; Morris, 1983).

The only published Western Hemisphere record of *L. planus* (White, 1972; O'Brien and Wibmer, 1982) was a specimen collected from *Cirsium* sp. at Maugansville, Maryland in 1971. Our survey work in 1984 shows that this species is widespread in much of Pennsylvania and northern Maryland, and it occurs also in New York and Ohio. Its distribution partly overlaps the eastern range of

Rhinocyllus conicus (Froelich), a related palearctic weevil released for biocontrol of *Carduus* and *Silybum* thistles (Zwölfer and Harris, 1984). Allen (1975) commented on the similarity of these sympatric species of the British fauna: "*L. planus* invites comparison with another lixine similar in size, coloration, habits, distribution, and incidence, namely *Rhinocyllus conicus* Fröl." Here, we comment on the potential of *L. planus* to help control adventive thistles and contrast its apparent host preferences with those of *R. conicus*, illustrate morphological differences between these two weevil species and give characters allowing them to be distinguished from other North American cleonines, and provide a key to genera of native and immigrant Cleoninae occurring in America north of Mexico.

Materials and Methods

Collection of *L. planus* on Canada thistle at Philadelphia on 11 July 1984 prompted a survey to determine the weevil's distribution in Pennsylvania. From mid-July to late August colonies of the plant were sampled with a standard sweep net, or stems were tapped over a net or small tray to obtain adults. The eastern counties were surveyed most extensively, with emphasis on delimiting the area of sympatry with *R. conicus* in the southcentral region. Musk or nodding thistle, *Carduus nutans* L., and plumeless thistle, *C. acanthoides* L., also were sampled, as were other *Cirsium* and *Centaurea* species. Additional collections of *L. planus* were made from thistles in Maryland, New York, and Ohio; surveys in Berkeley Co., West Virginia were negative for *L. planus* but yielded specimens of *R. conicus* at several localities.

Records given for *L. planus* include specimens other than those taken in our 1984 surveys. Sources for unpublished records are the insect collections of Cornell University, Ithaca, New York (CUIC), National Museum of Natural History, Washington, D.C. (NMNH), Pennsylvania Department of Agriculture, Harrisburg (PDAH), and Charles W. O'Brien, Tallahassee, Florida (CWOB).

North American Distribution

The known North American distribution of *L. planus* now includes Pennsylvania (35 counties), Maryland (6), Ohio (3), and New York (2) (Fig. 1). All Maryland and Pennsylvania records prior to our survey and all records from New York and Ohio are listed below. Unless stated otherwise, all collections were from Canada thistle. Localities for the 1984 Maryland and Pennsylvania collections are mapped (see Fig. 1); more precise data are available from the authors.

MARYLAND. *Washington Co.*: Maugansville, 15 June 1971, on *Cirsium* sp., R. E. & J. White (NMNH). NEW YORK. *Monroe Co.*: Scottsville, 23 Aug. 1973, on *Carduus nutans*, R. H. Ward (NMNH). *Tompkins Co.*: Taughannock Falls, April 1969, Lenezy (NMNH); N. Lansing, 2 May 1983, N. M. Downie (CWOB); Ithaca, 9 Sept. 1984, E. R. Hoebeke (CUIC). OHIO. *Stark Co.*: nr. Alliance, 10 Aug. 1984, K. Valley (PDAH). *Tuscarawas Co.*: 2 mi. n. Dover, 17 Aug. 1968, M. Druckenbrod (NMNH). *Wayne Co.*: Wooster, 15 Dec. 1980, on Norway spruce (NMNH). PENNSYLVANIA. *Cumberland Co.*: rt. 11 nr. Carlisle, 17 April 1974, on *Pinus virginiana*, T. J. Henry & A. G. Wheeler, Jr. (PDAH). *Dauphin Co.*: Paxtang, 13 July 1971, G. B. Sleesman (PDAH); Middletown, 14 May 1979, G. Laudermilch (PDAH, NMNH).

The Dover, Ohio and Taughannock Falls, New York records predate White's (1972) record from Maryland. These earlier records and the widespread occurrence

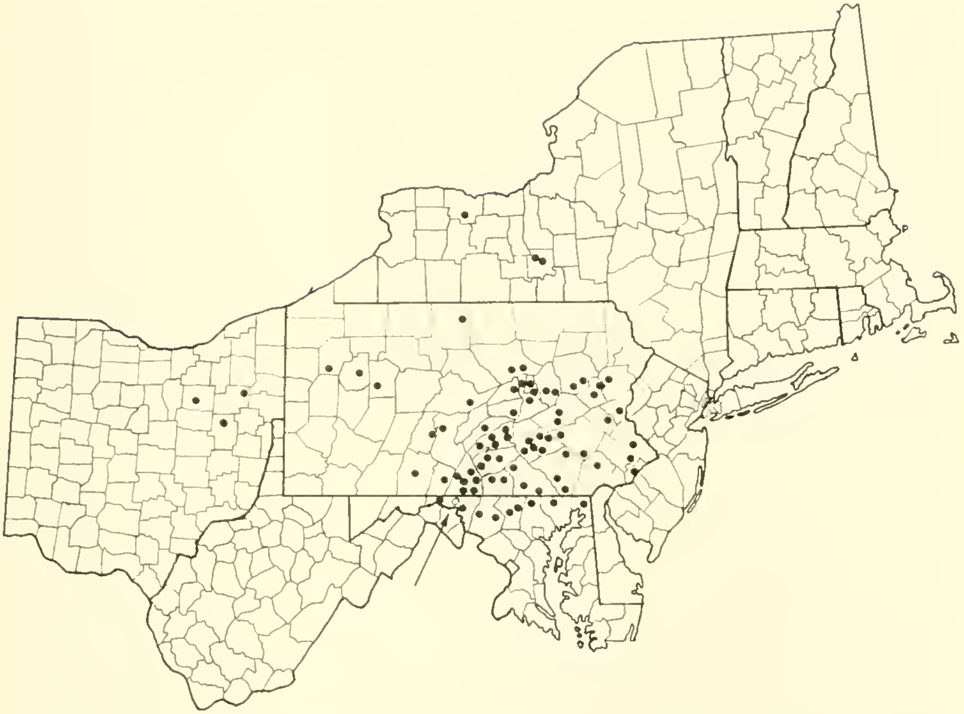


Fig. 1. Known distribution of *Larinus planus* in North America. The open circle (arrow) represents the original detection site in Washington Co., Maryland (White, 1972); closed circles are new records. Stippling indicates the observed area of sympatry with *Rhinocyllus conicus*.

in Pennsylvania indicate that *L. planus* has been well established in eastern North America for some time.

Host Plants

Of the 75 collections of *L. planus* made from Maryland, New York, Ohio, and Pennsylvania in 1984, all but four were from Canada thistle. Our survey was based only on adults, but from the consistent occurrence of the weevil on this plant, we think that this thistle serves as the principal host in eastern U.S.

We also collected adults of *L. planus* twice on musk thistle and twice on plumeless thistle. At two of these sites, however, the weevil was more common in nearby colonies of Canada thistle. Whether *Carduus* spp. and other thistles having large capitula serve as true hosts in eastern North America needs verification.

Near Hagerstown, Maryland and Greencastle, Pennsylvania, we found *L. planus* coexisting on *Carduus* thistles with *R. conicus*, a similar-appearing cleonine weevil released and established at these locales (Batra, 1980). We note that although *R. conicus* was not encountered on Canada thistle during our surveys, in Montana under high densities on musk thistle it has shifted to this alien weed and to one native *Cirsium* species (Rees, 1977).

Immigrant Status

An overlooked immigrant, *L. planus* now can be included among natural enemies of Canada thistle in North America. Among Coleoptera, these species include two accidental immigrants—another cleonine weevil, *Cleonis piger* (Scopoli), and the chrysomelid *Cassida rubiginosa* Muller—and a weevil, *Ceutorhynchus litura* (F.), which has been released and subsequently established. The chrysomelid *Altica carduorum* Guérin-Méneville, released in Canada and the United States, apparently has not become established (Maw, 1976; Batra et al., 1981; Peschken, 1981).

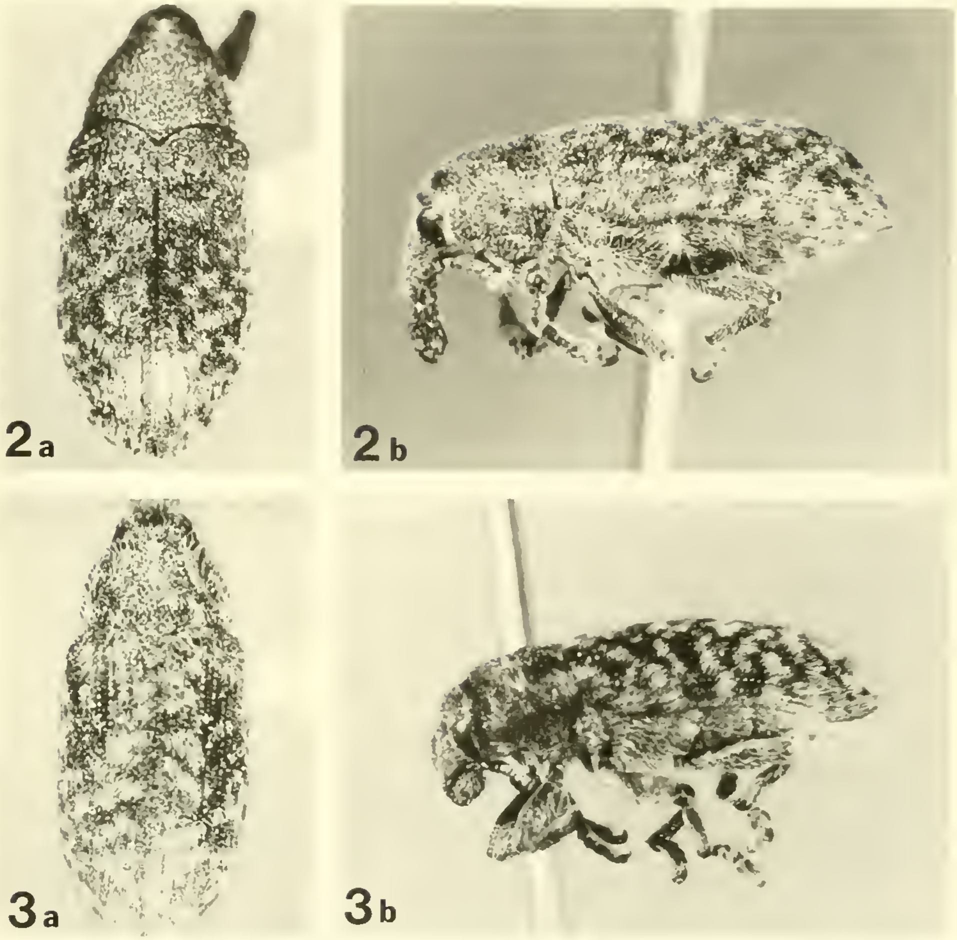
Larinus planus was evaluated for possible release in North America by the Commonwealth Institute of Biological Control, Canada Department of Agriculture (now Agriculture Canada), and U.S. Department of Agriculture, and in 1962 and 1964 small numbers of adults were shipped to Canada for additional testing but not released (Batra et al., 1981). At that time, however, *L. planus* already may have been present in North America. Although the first published record of *L. planus* (as *L. carlinae*) in the Western Hemisphere was from a Maryland field in which *Altica carduorum* had been released to suppress Canada thistle (White, 1972), two unpublished records of the weevil (New York, Ohio) predate the Maryland releases of *A. carduorum* in 1970–1971 (see Batra et al., 1981). It is improbable that *L. planus* was a contaminant in releases of *R. conicus* (P. Harris, in litt.). We therefore conclude that the occurrence of *L. planus* in North America represents an accidental introduction with man's commerce.

BIOCONTROL POTENTIAL

Canada thistle, a Eurasian native, is naturalized in southern Canada and the northern United States. This long-day plant, intolerant of high summer temperatures, is uncommon south of 37°N and thrives between 40° and 49°N latitude. *Cirsium arvense* is a perennial, functionally dioecious herb that spreads mainly by deepseated, horizontal, creeping roots that give rise to aerial shoots (Detmers, 1927; Moore, 1975; Hill, 1983). The continual growth of roots, year after year, allows plants to survive indefinitely (Moore, 1975). This insect-pollinated plant also is dispersed by wind-blown seeds, but seed production is limited and depends primarily on whether male and female plants are sufficiently near to effect pollination (Detmers, 1927).

Two characteristics of Canada thistle—dioeciousness and propensity for vegetative propagation—render it less suited to biocontrol by seed-feeding insects than are thistle species bearing perfect flowers and reproducing only by seed. Forsyth and Watson (1985), among others, have emphasized the problem of controlling perennial, asexually propagating weeds and the complexity of evaluating herbivore stress on such species.

Assuming that *L. planus* feeds primarily on ovarioles and other reproductive structures, its impact on Canada thistle may be minimal. That this plant flourishes in areas where the weevil is present suggests that weevil populations exert little herbivore pressure. In recognizing potentially effective agents in the biocontrol of weeds, Goeden (1983) severely downgrades an insect that has been accidentally introduced and established on the target weed, as is the case with *L. planus*. To detect such fortuitous immigrants, he advocates a "pre-introduction faunistic survey" of the weed species requiring control. Rather than dismiss *L. planus* as a possible biocontrol agent of Canada thistle, however, we suggest that its widespread occurrence in the eastern United States allows it to be studied for possible release in other areas of North America where the plant is a pest.



Figs. 2, 3. Dorsal (a) and lateral (b) habitus of adult weevils. 2, *Larinus planus*. 3, *Rhinocyllus conicus*.

LARINUS PLANUS AND *RHINOCYLLUS CONICUS*

In northern Maryland and southern Pennsylvania, *L. planus* and *R. conicus* may be found in mixed stands of Canada, musk, and plumeless thistles. Beyond the range limits here given for *L. planus*, we do not know how extensive the area of sympatry is, or may become. The two weevils are superficially similar in size, form, color, and dorsal vestiture pattern, but they are easily distinguished by rostral form and vestiture (Figs. 2, 3). No other similar weevils are likely to be encountered on thistles in North America, but several other native cleonine weevils (in "*Cleonis*" and *Lixus*) have a similar general habitus. The rostrum in *L. planus* is much more slender (not less than 2.5 times as long as wide) than in any of the *Lixus*-like "*Cleonis*." *Larinus planus* differs from native *Lixus* spp. by having broadly rounded postocular lobes on the pronotum. Further details are in the following key.

KEY TO GENERA AND IMMIGRANT SPECIES OF CLEONINAE IN AMERICA NORTH OF MEXICO

In the following key, we accept as Cleoninae the taxa listed in O'Brien and Wibmer (1982), except that *Lepyrus* has been transferred to Hylobiinae (Morimoto, 1982; O'Brien and Wibmer, 1984). With the arrival of *L. planus* and *R. conicus* in North America, Kissinger's (1964) key to genera is obsolete. Moreover, members of still other palearctic cleonine genera are being considered for importation. According to S. Clement (pers. comm.), one species of *Bangasternus* is in final developmental stages as a biological control agent for yellow starthistle, *Centaurea solstitialis* L.; another *Bangasternus* species is under consideration for control of diffuse knapweed, *Centaurea diffusa* Lam., as is a species of *Eustenopus* for control of yellow starthistle. *Cyphocleonus achates* (Fahraeus) is another potential biocontrol agent for diffuse knapweed (R. S. Anderson, pers. comm.); this species will trace to "*Cleonis*" in the following key.

In addition to these taxa, various other species of *Larinus* are potential biological control agents, but we know of none scheduled for imminent release. Some such species may not key properly; our key is intended to aid only in identification of thistle Cleoninae in North America, not to solve generic problems. The native species keyed below as "*Cleonis*" include numerous taxa of undecided generic affinities, some of them difficult to distinguish from *Lixus*.

1. In dorsal view, rostrum from apex of epistoma to anterior margin of eye about as long as greatest width 2
– In dorsal view, rostrum from apex of epistoma to anterior margin of eye much longer than greatest width 5
2. Elytral intervals each with conspicuous row of erect setae (*Microlarinus*; 2 species, deliberately introduced for control of puncturevine, *Tribulus* spp.) 3
– Elytral intervals without row of erect setae 4
3. Elytral interval 2 widened and elevated at base; body generally more slender, pronotum generally conspicuously narrowed behind middle (reported from AZ, CA, & WA (O'Brien and Wibmer, 1982), seen also from NM, TX, Chihuahua, & St. Kitts (NMNH)) .... *Microlarinus lypriformis* (Wollaston)
– Elytral interval 2 not widened or elevated at base; body generally less slender (i.e., pronotum tends to be wider than long, elytra tend to be less than twice as long as wide), pronotum generally not conspicuously narrowed behind middle (reported from AZ, CA, NM, TX, & WA (O'Brien and Wibmer, 1982), seen also from KS, OK, Chihuahua, Sonora, & Yucatan (NMNH)) .... *Microlarinus lareynii* (Jacquelin du Val)
4. Prosternum sharply bicarinate and deeply excavate in front of coxae; not presently in North America, but some palearctic species are potential candidates for importation as biological control agents .... *Bangasternus*
– Prosternum neither bicarinate nor excavate in front of coxae (deliberately introduced for control of *Carduus* and *Silybum* thistles, now widespread in North America) .... *Rhinocyllus conicus* (Froelich)
5. Rostrum deeply, longitudinally trisulcate (adventive in North America,

known from MI, NY, ON, PA, & PQ (Batra et al., 1981); develops in roots of Canada thistle and bull thistle, *Cirsium vulgare* (Savi) Ten. (Anderson, 1957)) . . . . *Cleonis piger* (Scopoli)

– Rostrum not longitudinally trisulcate (with or without narrow median carina, without median sulcus) 6

6\. Rostrum robust, in dorsal view from apex of epistoma to anterior margin of eye less than twice as long as greatest width; or, if rostral length slightly greater (up to 2.2 times as long as wide), then flanks of pronotum with broadly rounded postocular lobes and short vibrissae, or elytra strongly vittate dorsally; with or without prominent antecoxal prosternal tubercles; with or without prominent median rostral carina; with or without distinct adhesive pads on hind tarsus (numerous species of varied form and undecided taxonomic status; under study by R. A. Anderson) . . . . "*Cleonis*"

– Rostrum slender, in dorsal view from apex of epistoma to anterior margin of eye at least twice as long as greatest width; if rostral length less than 2.3 times as long as wide, then flanks of pronotum with feebly developed or denticulate postocular lobes and long vibrissae, and elytra not vittate dorsally (may have lateral vittae); without prominent antecoxal prosternal tubercles; without prominent median rostral carina; with distinct adhesive pads on tarsomeres 1–3 of hind tarsus 7

7\. Pronotum and elytra with long, erect, hairlike setae (not presently in North America, but some palearctic species are potential candidates for importation as biological control agents) . . . . *Eustenopus*

– Pronotum and elytra without long, erect, hairlike setae 8

8\. Flanks of pronotum with feebly developed or denticulate postocular lobes and long vibrissae (numerous native species) . . . . *Lixus*

– Flanks of pronotum with broadly rounded postocular lobes and fringe of short vibrissae (adventive in North America, known from MD, NY, OH, PA; presumably develops in flower buds and heads of Canada thistle) . . . . *Larinus planus* (F.)

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LITERATURE CITED

Allen, A. A. 1975. *Larinus planus* F. (Col., Curculionidae) in West Sussex, etc. Entomol. Mon. Mag. 110: 66.

Anderson, D. M. 1957. Notes on *Cleonus piger* (Scop.) in the United States (Coleoptera, Curculionidae). Coleopt. Bull. 10: 81–85.

Batra, S. W. T. 1980. First establishment of *Rhinocyllus conicus* (Froelich) in Maryland and Pennsylvania for thistle control (Coleoptera: Curculionidae). Proc. Entomol. Soc. Wash. 82: 511.

Batra, S. W. T., J. R. Coulson, P. H. Dunn, and P. E. Boldt. 1981. Insects and fungi associated with *Carduus* thistles (Compositae). U.S. Dep. Agric. Tech. Bull. No. 1616. 100 pp.

Detmers, F. 1927. Canada thistle, *Cirsium arvense* Tourn.; field thistle, creeping thistle. Ohio Agric. Exp. Stn. Bull. 414. 45 pp.

Forsyth, S. F. and A. K. Watson. 1985. Stress inflicted by organisms on Canada thistle. Proc. VI Int. Symp. Biol. Contr. Weeds, Vancouver, 1984 (in press).

Goeden, R. D. 1983. Critique and revision of Harris' scoring system for selection of insect agents in biological control of weeds. Prot. Ecol. 5: 287–301.

Hill, R. J. 1983. Canada thistle, *Cirsium arvense* (L.) Scop. Regul. Hortic. 9(1–2): 27–34.

Hoffmann, A. 1954. Faune de France. 59, Coléoptères Curculionides (Part 2). P. Lechevalier, Paris, pp. 487–1208.

Kissinger, D. G. 1964. Curculionidae of America north of Mexico: a key to the genera. Taxonomic Publications, South Lancaster, Massachusetts. 143 pp.

Maw, M. G. 1976. An annotated list of insects associated with Canada thistle (*Cirsium arvense*) in Canada. Can. Entomol. 108: 235–244.

Moore, R. J. 1975. The biology of Canadian weeds. 13. *Cirsium arvense* (L.) Scop. Can. J. Plant Sci. 55: 1033–1048.

Morimoto, K. 1982. The family Curculionidae of Japan. I. Subfamily Hylobiinae. Esakia (19): 51–121.

Morris, M. G. 1983. Abundance of *Larinus planus* (F.) and *Rhinocyllus conicus* (Frölich) (Col., Curculionidae) in Dorset and adjacent counties. Entomol. Mon. Mag. 119: 42.

O'Brien, C. W. and G. J. Wibmer. 1982. Annotated checklist of the weevils (Curculionidae *sensu lato*) of North America, Central America, and the West Indies (Coleoptera: Curculionoidea). Mem. Am. Entomol. Inst., Ann Arbor, Michigan. No. 34. 382 pp.

———. 1984. Annotated checklist of the weevils (Curculionidae *sensu lato*) of North America, Central America, and the West Indies (Coleoptera: Curculionoidea)—Supplement 1. Southw. Entomol. 9: 286–307.

Peschken, D. P. 1981. *Cirsium arvense* (L.) Scop., Canada thistle (Compositae), pp. 139–146. *In* J. S. Kelleher and M. A. Hulme, eds., Biological Control Programmes Against Insects and Weeds in Canada 1969–1980. Commonwealth Agricultural Bureaux, Slough, England.

Rees, N. E. 1977. Impact of *Rhinocyllus conicus* on thistles in southwestern Montana. Environ. Entomol. 6: 839–842.

Ter-Minasyan, M. E. 1978. Weevils of the subfamily Cleoninae in the fauna of the USSR. Tribe Lixini. (Transl. from Russian.) Amerind Publ. Co., New Delhi. 166 pp.

White, J. C. 1972. A European weevil, *Larinus carlinae* Olivier, collected in Maryland. U.S. Dep. Agric. Coop. Econ. Insect Rep. 22(26): 418.

Zwölfer, H. 1965. Preliminary list of phytophagous insects attacking wild Cynareae (Compositae) species in Europe. Commonw. Inst. Biol. Control Tech. Bull. No. 6, pp. 81–154.

Zwölfer, H., K. E. Frick, and L. A. Andres. 1971. A study of the host plant relationships of European members of the genus *Larinus* (Col.: Curculionidae). Commonw. Inst. Biol. Control Tech. Bull. No. 14, pp. 97–143.

Zwölfer, H. and P. Harris. 1984. Biology and host specificity of *Rhinocyllus conicus* (Froel.) (Col., Curculionidae), a successful agent for biocontrol of the thistle, *Carduus nutans* L. Z. Angew. Entomol. 97: 36–62.

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THE GENERA *XENOLIMOSINA* AND *TERRILIMOSINA* (DIPTERA: SPHAEROCERIDAE: LIMOSININAE) IN NORTH AMERICA

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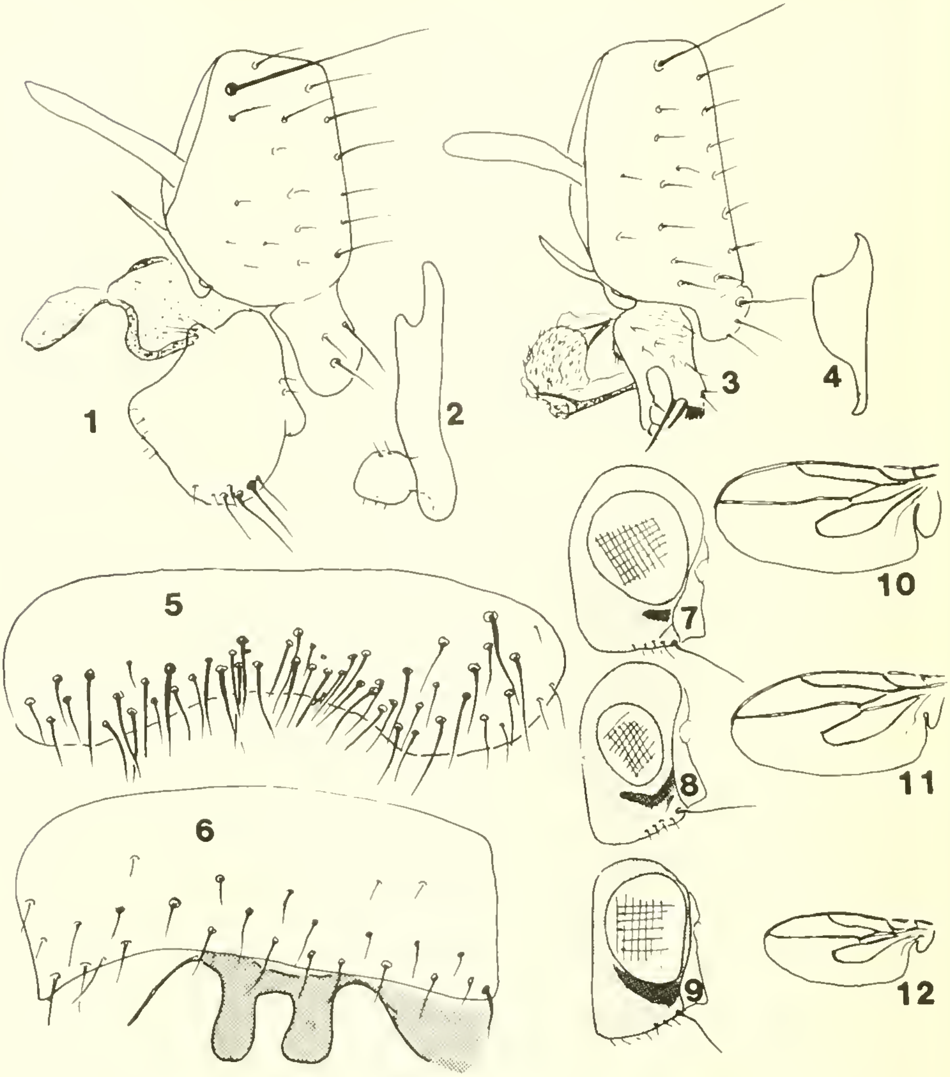
Abstract.—The genus *Terrilimosina* Roháček 1983 includes three species from North America. *Terrilimosina racovitzai* (Bezzi) is common in European caves and has been found in a few eastern North American caves. *Terrilimosina pexa* new species is described from Ontario, Arkansas and Oklahoma. *Terrilimosina* otherwise includes only the European species *T. sudetica* Roháček, and the holarctic *T. schmitzi* (Duda). The genus *Xenolimosina* Roháček is recorded from North America for the first time. Two new species are described, *X. sicula* from Ontario, Quebec, Arkansas, and California and *X. phoba* from Ontario and Quebec. *Xenolimosina* otherwise includes only the type species, *X. setaria* (Villeneuve) from Europe. Keys to the world species of both genera are provided.

Terrilimosina Roháček and *Xenolimosina* Roháček are small genera of the sphaerocerid subfamily Limosininae, probably related to the large genus *Minilimosina* Roháček. All three genera are characterized by a long, telescoping female abdomen and relatively small size.

This paper provides keys and descriptions for the North American species of *Terrilimosina* and *Xenolimosina*, most of which are new species or new North American records.

Terrilimosina Roháček

The genus *Terrilimosina* was described by Roháček (1983) with *Limosina racovitzai* Bezzi as type species. He included only two other species in the genus, *T. sudetica* (Roháček) and *T. schmitzi* (Duda). *Terrilimosina sudetica* is still known only from Czechoslovakia, but *T. racovitzai* and *T. schmitzi* are now known also from North America, along with a new species, *T. pexa*. Members of this genus can be separated from other Limosininae by the rounded posterior outer corner of wing cell dm and the presence of a surstylar comb. Because the females have long, telescoping terminalia they are superficially similar to other genera that retain this plesiomorphic character state, especially *Minilimosina*. In addition to the above diagnostic characters, *Terrilimosina* species differ from other Limosininae with telescoping female terminalia in having a broad alula and, with the exception of *T. racovitzai*, a mid ventral bristle on the mid tibia. The addition of one new species to *Terrilimosina* necessitates only one minor change to Roháček's (1983)



Figs. 1–12. *Terrilimosina* spp. 1, 2, 5, 7, 10, *T. schmitzi.* 1, Male terminalia, left lateral. 2, Left paramere, lateral. 5, Sternite 5 of male. 7, Head, side. 10, Wing. 3, 4, 6, 8, 11, *T. racovitzai.* 3, Male terminalia, left lateral. 4, Left paramere, lateral. 6, Sternites 5 and 6 of male. 8, Head, side. 11, Wing. 9, 12, *T. pexa.* 9, Head, side. 12, Wing.

generic description. *T. pexa* has only 3 interfrontals, rather than the 4 or 5 previously thought to be diagnostic for the genus.

KEY TO THE SPECIES OF *TERRILIMOSINA*

1. Eye small, height about 1.5× genal height (Fig. 8). Mid tibia ventrally with only an apical bristle. Sternite 6 of male with a large, bifurcate posteromedial process (Fig. 6); Europe and northeastern North America . . . . *racovitzai* (Bezzi)
– Eye height greater than or equal to 2.0× genal height. Mid tibia with a

mid ventral bristle (Fig. 17). Sternite 6 of male not projecting posteromedially 2

2. Wing short, always shorter than body in dried specimens. Sternite 5 of male with a prominent posteromedial lobe. Epiproct bare; Europe .... *sudetica* (Roháček)

– Wing always longer than body length in dried specimens. Posteromedial part of male sternite 5 on the same plane as the rest of the sternite. Epiproct with 2 bristles 3

3. Alula as broad as cell dm, cleft separating alula from wing longer than 0.5× length of alula (Fig. 10). Gena with a small triangular shining area restricted to anterodorsal corner of gena (Fig. 7). Sternite 5 of male simple posteromedially (Fig. 5); paramere broadly bilobed at apex (Fig. 2); holarctic .... *schmitzi* (Duda)

– Alula narrower than cell dm, cleft shorter than 0.5× length of alula (Fig. 12). Gena with a large shining area extending along ventral margin of eye (Fig. 9). Sternite 5 of male with a posteromedial patch of small, flat spines (Fig. 13); paramere simply lobate at apex (Fig. 16); North America .... *pexa*, new species

Terrilimosina pexa Marshall, New Species

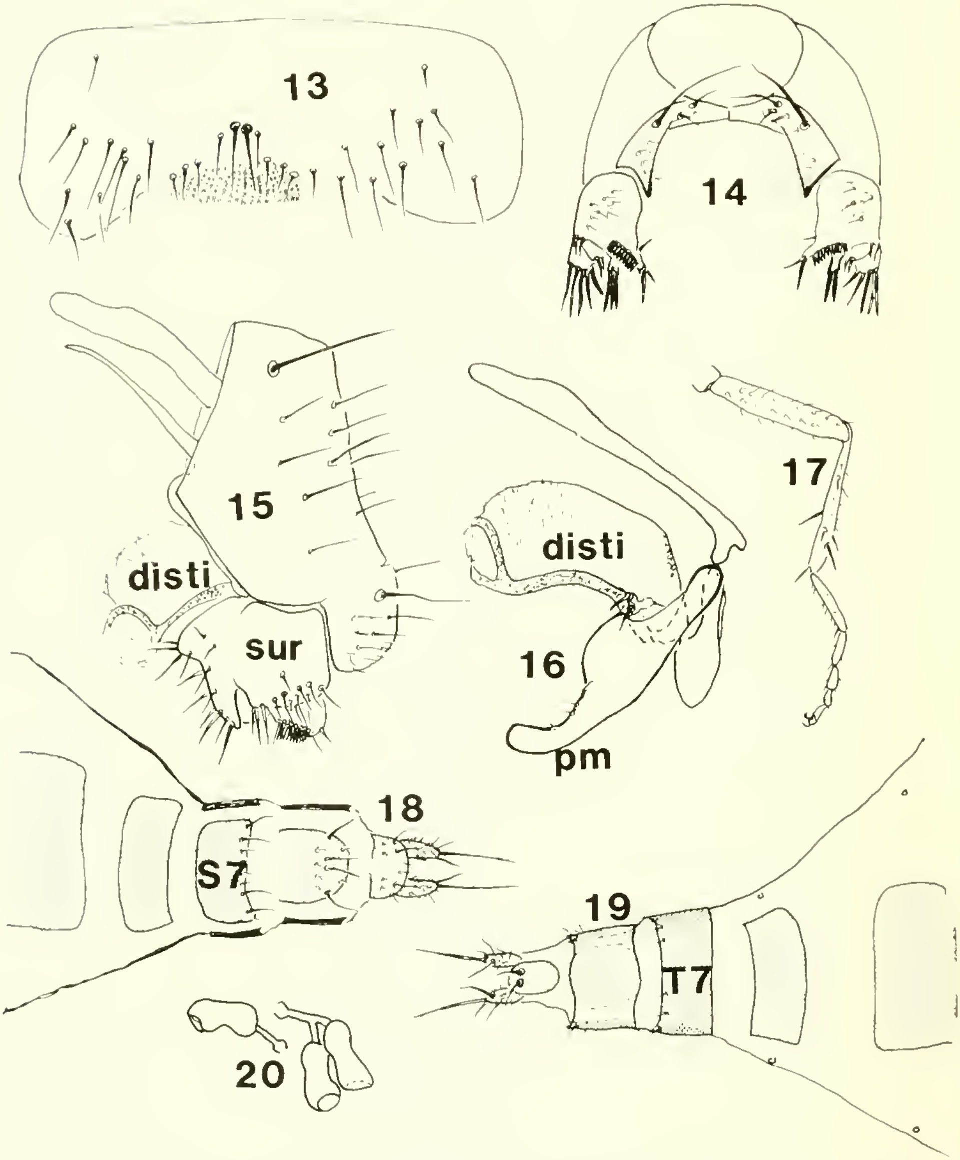
Figs. 9, 12–20

Description.—Length 1.4–1.7 mm. Colour brown, pruinose, tibiae and tarsi lighter brown. Interfrontal plate slightly higher than wide, bordered by 3 long, subequal interfrontal bristles. Postocellar bristle absent. Eye height 2.0–2.2× genal height. Gena with a large shining area below eye, widest anteriorly (Fig. 9). Scutum with 8 or 9 rows of small acrostichal setulae between dorsocentral lines. Dorsocentral bristles in 2 pairs; anterior pair weak, half as long as posterior pair; 2 pairs of small prescutellar acrostichal bristles present between posterior dorsocentral bristles. Katepisternum pruinose, with 2 posterodorsal bristles, the anterior one minute. Mid tibia with an anteroventral bristle near middle, an apicoventral bristle, a proximal anterodorsal, distal dorsal, distal anterodorsal and smaller posterodorsal bristles (Fig. 17). Halter light brown, stem yellow to light brown. Wing (Fig. 12) with costa surpassing tip of vein R_{4+5} and cell dm broadly rounded on posterior outer corner; second costal sector 0.7–0.9× as long as third. Alula narrow-oval, distance over which alula fused to wing longer than 0.5× length of alula (Fig. 12).

Male abdomen.—Sternite 5 with a posteromedial patch of small, flat bristles, at least the apical row bifurcate (Fig. 13). Surstylus complex, with 3 major lobes, posterior lobe with a straight comb-like row of bristles (Figs. 14, 15). Paramere simply lobate (Fig. 16). Basiphallus short, frame-like; distiphallus largely membranous, with a sclerotized dorsal process expanded distally into a ring (Fig. 16).

Female abdomen.—Tergites 3–5 progressively narrowed; tergite 6 wider and darker; tergite 8 with tripartate pigmentation; epiproct oval, with 2 bristles (Fig. 19). Sternite 8 subequal in length and width; sternite 8 and hypoproct uniformly pigmented (Fig. 18). Spermathecae peanut-shaped (Fig. 20).

Types.—Holotype ♂ and 34 paratypes (14 ♂, 20 ♀): CANADA. *Ontario*: Deux Rivieres, 2–30.ix.1979, mixed forest, carrion trap, S. & J. Peck (13 ♂, 19 ♀, BRI,



Figs. 13–20. *Terrilimosina pexa.* 13–17, Male. 13, Sternite 5. 14, External terminalia, posteroventral. 15, Terminalia, left lateral. 16, Aedeagus and associated structures, left lateral. 17, Mid leg, anterior. 18–20, Female. 18, Terminalia, ventral. 19, Terminalia, dorsal. 20, Spermathecae. Abbreviations: disti—distiphallus; sur—surstylus; pm—paramere; T7—tergite 7; S7—sternite 7.

1 ♂, 1 ♀, J. Roháček collection, Opava, Czechoslovakia). Other paratypes: CANADA. *New Brunswick*: St. Andrews, Gibson Lake, viii.1978, pitfall traps, S. A. Marshall (1 ♂, author's collection). *Ontario*: Alfred, Alfred Bog, 25.ix.1983, sifted moss under fungi and moose dung (Berlese funnel), S. Peck (1 ♂, author's collection); Constance Bay, 26.viii.1980, on mushroom, S. A. Marshall (1 ♂, author's collection). UNITED STATES. *Arkansas*: Garland Co., 1.2 mi N Crystal Springs,

Hwy. 270, 6–8.iii.1977, Woodruff and Wiley, pig dung traps (135 ♂, 177 ♀, most in FSC but some retained for distribution at the author's discretion); Scott Co., 7 mi E Y City, Jct. Hwy. 270 & Rt. 71 on 270, 6–8.iii.1977, Woodruff & Wiley, pig dung trap (7 ♂, 14 ♀, FSC). *Oklahoma*: Latimer Co., 5 mi W Red Oak, 9.iii.1977, pig dung trap, K. Stephen (2 ♂, 3 ♀, FSC).

Comments.—Although large numbers of specimens are available, this species is known from very few collections. It has been collected from dung, fungi, and carrion. Nothing further is known of its life history. *Terrilimosina pexa* is probably most closely related to *T. racovitzai*, which also has the dorsal process of the distiphallus expanded distally into a ring, and the surstylus divided into separate lobes.

Etymology.—The name of this species is from the Latin for comb, and refers to the comb-like row of bristles on the posterior surstylar lobe.

***Terrilimosina racovitzai* (Bezzi)**

Figs. 3, 4, 6, 8, 11

Limosina racovitzai Bezzi, 1911: 66.
Terrilimosina racovitzai: Roháček, 1983: 23, complete synonymy and description.

Diagnosis.—Eye small, height 1.4–1.5× genal height; gena with a long shining area beneath eye (Fig. 8). Mid tibia of male with a double row of short spinules ventrally, apicoventral bristle reduced; mid tibia of female ventrally with an apical bristle only. Second costal sector subequal to third (Fig. 11). Male abdomen: Sternite 5 simple, sternite 6 with a large bifurcate posteromedial process (Fig. 6). Surstylus divided into 2 lobes on ventral half, posterior lobe with comb-like row of bristles (Fig. 3). Paramere narrowed apically (Fig. 4). Basiphallus short, frame-like; distiphallus similar to *T. pexa* (Fig. 3). Female abdomen: Epiproct wider than long. Spermathecae conical, short.

Material examined.—Eighteen specimens from the following localities. CANADA. *Ontario*: Mt. Nemo Cave, Burlington, 10.vi.1971, G. Muller. UNITED STATES. *Illinois*: Henderson Co., Goose Hollow Cave, 13.xi.1965, S. B. Peck. *Iowa*: Jackson Co., Maquoketa St. Pk., Barred Cave, 1–14.xi.1965, S. B. Peck. *New York*: Schoharie Co., Onesquethaw Cave, Clarkesville, under rotting wood, 6.xi.1982, S. A. Marshall. *Pennsylvania*: Berks Co., Wernersville, Hobo Cave, 3.xii.1937, Dierholf Coll.; York Co., Lisburn Cave, Dierholf Coll. *Wisconsin*: Pierce Co., Crystal Cave, July KC379c, side pass, mud floor, K. Christanson.

Comments.—*Terrilimosina racovitzai* is a common, polysaprophagous species in European caves, occasionally found in cellars and mammal burrows (Roháček, 1983). It appears to be restricted to northeastern North America, and has not been found in the many well studied caves of the southeast where it is replaced by *Spelobia tenebrarum*. The distribution of cave-dwelling Sphaeroceridae of eastern North America is discussed by Marshall and Peck (1985).

***Terrilimosina schmitzi* (Duda)**

Figs. 1, 2, 5, 7, 10

Limosina (*Scotophilella*) *schmitzi* Duda, 1918: 27.
Terrilimosina schmitzi: Roháček, 1983: 26, complete synonymy and description.

Diagnosis.—Eye height 2.5–3.4× genal height; gena with a small, triangular shining area at anterodorsal corner (Fig. 7). Mid tibia of both sexes with mid ventral and apicoventral bristles. Second costal sector 0.9× as long as third; alula broad (Fig. 10). Male abdomen: Sternite 5 simple, strongly setose along posterior margin (Fig. 5). Surstylus large, flattened; comb-like row of bristles present but not visible in lateral view (Fig. 1). Paramere distinctive, with a large inner, preapical lobe (Fig. 2). Female abdomen: Epiproct longer than wide. Spermathecae elongate cylindrical.

Material examined.—255 specimens from the following localities. CANADA. *Alberta*: Lake Louise; Hinton; Coleman; Elkwater. *British Columbia*: Chetwund; Kledo Creek Pk.; Kiskatinaw Public Campground; Glacier Nat. Pk.; Ainsworth; Skagit; Buckinghorse Provincial Campground; Terrace; Vancouver; Hixon; Bowser; Mission City; Tunjony Lake; Hope. *New Brunswick*: St. Andrews. *Newfoundland*: Port Saunders. *North West Territories*: Aklavik. *Nova Scotia*: Cape Breton Highlands Nat. Pk. *Quebec*: Laniel; Camp LeRelais, Laurentide Pk.; Old Chelsea; Indian House Lake. *Saskatchewan*: Cypress Hills. *Yukon*: Wolf Creek Territorial Campground; North Fork Pass, Ogilvie Mts.; North Fork Crossing. UNITED STATES. *Alaska*: Matanuska; Isabel Pass; Tickel River; Valdez; King Salmon, Naknek River; Savonoski, Naknek Lake. *New Hampshire*: Passoconaway. *New York*: Whiteface Mt. *North Carolina*: Wayah Gap. *Oregon*: Marion Co. *Washington*: Lewis Co.; Seattle.

Comments.—*Terrilimosina schmitzi* is widespread throughout the Holarctic Region, and is commonly collected in association with decaying vegetation in wooded areas. Roháček (1983) records it as terricolous and probably phytosaprophagous. Richards (1930) recorded it only from rabbit and mouse runs. The majority of the specimens examined were collected in June, July and August, but there are a few October (Quebec) and May (New Brunswick) records.

Xenolimosina Roháček

Xenolimosina was described by Roháček (1983) to contain a single rare species, *X. setaria* (Villeneuve), known from England, Belgium and Germany. Members of this genus can be recognized by the following combination of characters: hind tibia with a long exserted preapical dorsal bristle; scutum with two pairs of long dorsocentral bristles; mid tibia ventrally with only an apical bristle; female terminalia narrow and retractile into abdomen. Other diagnostic characters include a basiphallus with a pre-epiphallus, male sternite 5 with two separate patches of small flat bristles posteromedially, and a single katepisternal bristle. Roháček's (1983) description of the genus, although based on only one species, needs very little alteration to fit the 2 new species. Two of his generic characters, the shining katepisternal spot and the simple, flat surstylus, are now seen as diagnostic of subgroups within *Xenolimosina*.

KEY TO THE SPECIES OF *XENOLIMOSINA*

1. Eye small, height less than 1.5× genal height. Size over 2.0 mm. Katepisternum pruinose; North America .... *sicula*, new species
– Eye height over 1.5× genal height. Size less than 2.0 mm. Katepisternum with a large shining spot 2
2. Anterior lobe of surstylus with a tuft of flat bristles (Fig. 21). Female unknown; Ontario and Quebec .... *phoba*, new species

– Anterior lobe of surstylus with setulae only (similar to Fig. 22); Europe . . . . *setaria* (Villeneuve)

Xenolimosina sicula Marshall, NEW SPECIES

Figs. 22–27

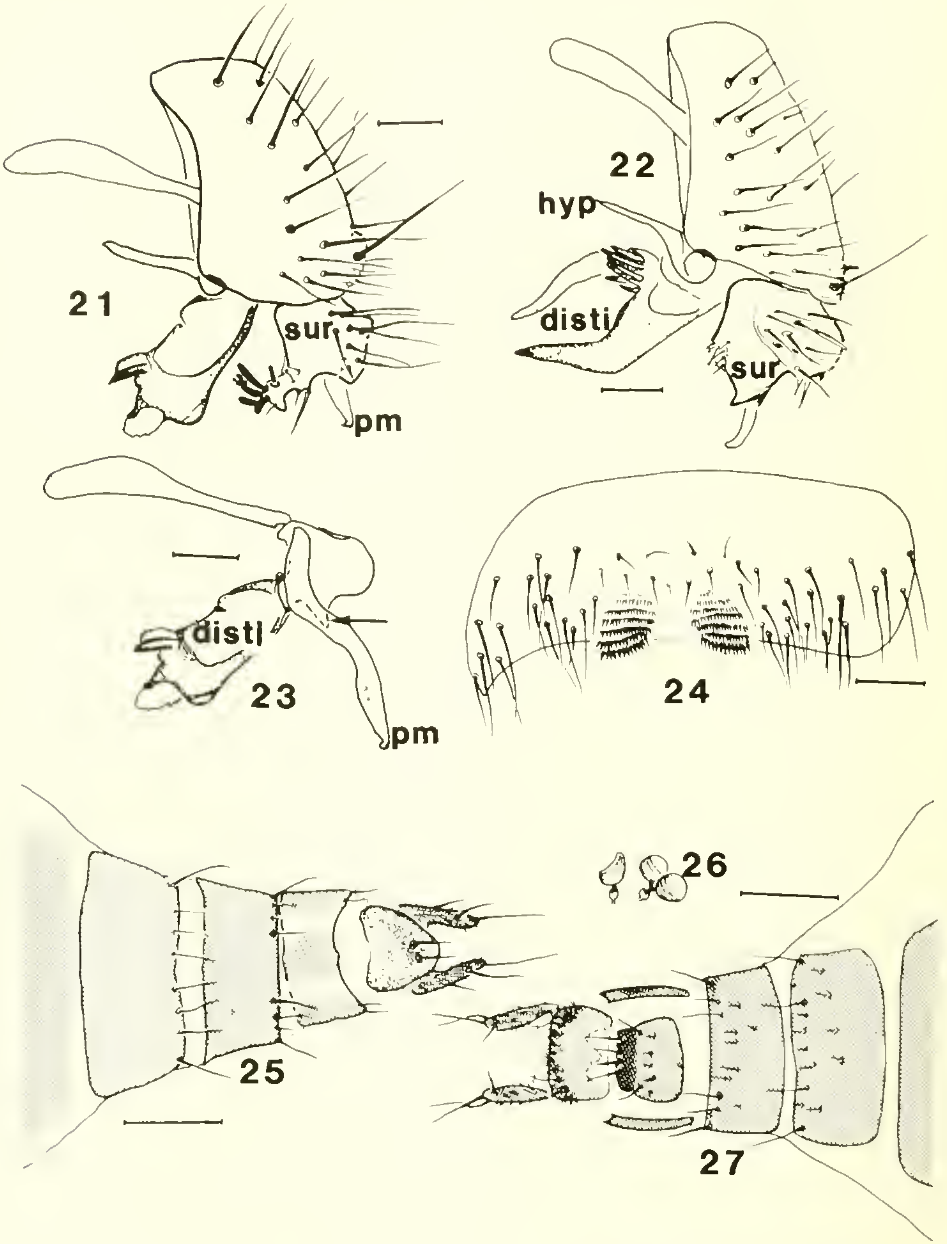
Description.—Length 2.0–2.4 mm. General colour pruinose-brown, lower frons, gena, and legs reddish brown. Interfrontal plate 1.6× as high as width at middle, bordered by 3–5 pairs of long, thin, barely cruciate interfrontal bristles. Postocellar bristles absent. Eye small, height 1.1–1.3× genal height, anterodorsal part of gena bare and shining. Scutum with 5–6 rows of acrostichal setulae between anterior dorsocentral bristles. Dorsocentral bristles in 2 pairs, anterior pair 0.6× as long as posterior pair, posterior pair equal to scutellar length. Prescutellar acrostichal bristles in a single pair twice as long as acrostichal setulae. Katepisternum pruinose, with one small dorsal bristle. Fore femur with a row of 2–4 very long posteroventral bristles. Mid tibia with long proximal anterodorsal, distal anterodorsal and distal dorsal bristles. Halter uniformly yellow-brown. Wing length 2.5× width; second costal sector 1.3–1.4× as long as third in male, 1.5–1.7× as long in female; costa indistinctly surpassing R_{4+5}. Alula small.

Male abdomen.—Sternite 5 with 2 posteromedial spinose patches (as in *X. phoba*, Fig. 4). Surstylus swollen and setose posteriorly, ventrally angulate and with a setose patch anteriorly (Fig. 22). Paramere long, thin. Basiphallus with a long pre-epiphallus (slightly longer than Fig. 23). Distiphallus with a long, pointed dorsal process, the basal ventral angle of which curves posteriorly and supports a distinctive row of long, flat processes (Fig. 22).

Female abdomen.—Tergites 6 and 7 uniformly pigmented; tergite 8 with tripartate pigmentation (Fig. 25). Epiproct bare except for 2 bristles and a patch of setulae between them. Cerci long, narrow, with a long apical bristle. Sternite 8 subquadrate, setulose except for a bare anteromedial patch; posterior margin with a row of 4 long, straight bristles (Fig. 27). Hypoproct pigmented such that it appears to have 3 anterior lobes; setulae restricted to a narrow posterior band. Each spermatheca almost spherical, ridged on basal half; distal half smooth and usually invaginated (Fig. 26). Internal sclerite (spectacles-shaped sclerite) well developed, 2–3× as large as spermatheca, median part ridged and wider than rings.

Types.—Holotype ♂ and 1 ♂ paratype (both BRI). Meaford, on compost heap, 11.x.1981, S. A. Marshall. Other paratypes: CANADA. *Ontario*: Meaford, 20.v.1981, on raccoon dung, S. A. Marshall (1 ♀, author's collection); Stittsville, 3.x.1978, B. A. Jenkinson (1 ♀, BRI). *Quebec*: Camp Fortune, 5–13.x.1982, J. Denis, low intercept trap (2 ♂, BRI). UNITED STATES. *Arkansas*: Scott Co., 7 mi E Y City, Jct. Hwy. 270 & Rt. 71 on 270, 6–8.iii.1977, Woodruff and Wiley, pig dung trap (7 ♂, 4 ♀, FSC; author's collection). *California*: Trinity Co., Forest Glen Cave, 28.xi.1959, R. Graham, #1533 (1 ♀, AMNH).

Comments.—Although *X. sicula* is very similar to the European *X. setaria* in the general structure of both male and female terminalia, these species differ widely in external features such as eye size, pollinosity of the pleuron, and wing venation. Like its European counterpart, *X. sicula* appears to be rare, and its life history is unknown. The reduced eyes and relatively large size of *X. sicula* suggest a hypogean habitat, a possibility supported by only one of the above records. Most of the type series was collected in late fall or early spring, from a variety of substrates.



Figs. 21–27. *Xenolimosina* spp. 21, 23, 24, *Xenolimosina phoba*, male. 21, Terminalia, left lateral. 23, Aedeagus and associated structures, left lateral. 24, Sternite 5. 22, 25, 26, 27, *Xenolimosina sicula*. 22, Male terminalia, left lateral. 25, Female terminalia, dorsal. 26, Spermathecae. 27, Female terminalia, ventral. Abbreviations: sur—surstylus; pm—paramere; hyp—hypandrium; disti—distiphallus; pe—pre-epiphallus. All scales 0.5 mm.

Etymology.—The name *sicula* is from the Latin for dagger, and refers to the dagger-like processes of the distiphallus.

Xenolimosina phoba **Marshall**, NEW SPECIES

Figs. 21, 23, 24

Description (male only).—Length ca. 1.5 mm (both available specimens have the abdomen removed). General colour pruinose-brown, head darker except reddish lower frons (paratype teneral). Interfrontal plate 1.5× as high as width at middle, bordered by 3 pairs of weak, subequal interfrontal bristles. Postocellar bristles absent. Eye 1.7–1.8× as high as gena, anterodorsal part of gena bare and shining. Fore femur with a row of 2–4 very long posteroventral bristles. Mid tibia with long proximal anterodorsal, distal anterodorsal, and distal dorsal bristles. Scutum with 5–6 rows of acrostichal setulae between anterior dorsocentral bristles. Dorsocentral bristles in 2 pairs, anterior pair 0.7× as long as posterior pair, posterior pair equal to scutellar length. Prescutellar acrostichal bristles in a single pair twice as long as acrostichal setulae. Katepisternum with a large, bare, shining area on anterodorsal half; one posterodorsal bristle arising on pruinose part of katepisternum. Halter dark brown with a yellow stem. Wing twice as long as wide; second costal sector 1.4× as long as third; costa slightly surpassing tip of R_{4+5}. Alula small.

Male abdomen.—Sternite 5 with 2 posteromedial spinose patches (Fig. 24). Surstylus with a tuft of large, flat bristles on a narrow anterior lobe, posterior lobe broad and setose (Fig. 21). Paramere long, thin; apex constricted. Basiphallus with a well developed pre-epiphallus (Fig. 23). Distiphallus with a rounded dorsal process, the distal ventral angle of which supports a single pair of dark, flat processes (Fig. 23).

Types.—Holotype: CANADA. *Quebec*: Old Chelsea, 15.x.1964, J. R. Vockeroth (♂, BRI). Paratype: UNITED STATES. *Maryland*: near Plummer's I., at light, 10.x.1914, R. C. Shannon (♂, USNM).

Comments.—*Xenolimosina phoba* is externally very similar to the European *X. setaria*, but these two species differ widely in features of the male terminalia. The tuft of flat surstylar bristles is a particularly distinctive feature of *X. phoba*. The biology of this species is unknown, but it is interesting that both type specimens were collected in late fall. The other North American *Xenolimosina*, *X. sicula*, is also known almost exclusively from late fall or early spring collection records. The European *Xenolimosina setaria* is known exclusively from September, October, and November records.

Etymology.—The specific name *phoba* is from the Latin for tuft, and refers to the tuft of flat surstylar bristles.

RELATIONSHIPS

Roháček (1982) defined a "*Minilimosina* genera-group," to include *Xenolimosina*, *Terrilimosina*, and the large genus *Minilimosina* which includes 32 nearctic species (Marshall, 1985). The females of each genus in this group exhibit a superficial similarity due to the possession of a long, retractile abdomen, which is a plesiomorphic character. Roháček lists small size, a short basiphallus, and a costa extending beyond R_{4+5} as putative synapomorphies linking these three genera on his cladogram (1982, p. 247). An additional character, "often a narrow T9" is cited in his text characterization of this group (1982, p. 22). I cannot agree that any of these characters provides evidence for a monophyletic "*Minilimosina* genera-group." Species of *Terrilimosina*, *Xenolimosina*, and many *Minilimosina* are larger than common species in most other genera of the Limosininae, such as *Pullimosina* Roháček, *Telomerina* Roháček, and *Opalimosina* Roháček, and are much larger than any species in other genera such as *Trachyopella* Duda and *Elachisoma* Rondani. In any case, average size is a very poor cladistic character. Similarly, the "short basiphallus" of *Xenolimosina* and many *Minilimosina* is a widespread character state in almost all genera of Limosininae, as can be seen by comparing Roháček's own figures of *Xenolimosina* with figures of *Spelobia*, *Pullimosina*, or most other Limosininae. The greatly shortened basiphallus found in *Terrilimosina* is similar to that found in *Telomerina*, and has probably developed convergently in each genus. The character "costa bypassing R_{4+5}" is also found to some degree in many other genera such as *Pullimosina*, *Telomerina*, *Halidayina* Duda, and *Aptilotus* Mik. The last character, "narrow female T9" (T9 of Roháček = epiproct of this paper) is invalid since all *Xenolimosina* have a very wide epiproct, and in fact Roháček lists "female T9 large, broad" as a diagnostic character of *Xenolimosina* (1983, p. 47).

Roháček suggests a sister-group relationship within the "*Minilimosina* genera-group" between *Xenolimosina* and *Minilimosina*, based on the absence of an anteroventral bristle on the mid tibia, reduced male cerci, and a reduced male sternite 8. The latter two characters can be discounted since a large sternite 8 is in the ground plan of *Minilimosina* (as recognized by Roháček), and cerci of male *Xenolimosina* and *Minilimosina* are not consistently or significantly reduced with respect to the condition found in most other genera in the subfamily. The absence of an anteroventral mid tibial bristle is a more unusual character and could reflect cladistic relationship, but this simple character is also found in part of *Terrilimosina* and occasionally in other genera such as *Aptilotus* and male *Pullimosina*.

In conclusion, *Terrilimosina* and *Xenolimosina* are well defined genera with no clear affinities to other Limosininae. Roháček's evidence for a monophyletic *Minilimosina* genera-group including these two genera is rejected, but his hypothesis that such a group exists is not disproved. Falsification of a cladistic hypothesis requires the discovery of synapomorphies supporting an alternative cladistic hypothesis. At the present time there are no defensible synapomorphies suggesting relationships between *Terrilimosina* or *Xenolimosina* and any other subgroup of the Limosininae.

ACKNOWLEDGMENTS

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LITERATURE CITED

Bezzi, M. 1911. Biospeologica. XX. Dipteres (Premiere serie). Arch. Zool. Exp. Gen. (5) 8: 1–87.

Duda, O. 1918. Revision der europaischen Arten der Gattung *Limosina* Macquart (Dipteren). Abh. Zool.-Bot. Ges. Wien 10: 1–240.

Marshall, S. A. 1985. A revision of the New World species of *Minilimosina* Roháček. Proc. Entomol. Soc. Ont. (in press).

Marshall, S. A. and S. B. Peck. 1985. Distribution of cave dwelling Sphaeroceridae of eastern North America. Proc. Entomol. Soc. Ont. (in press).

Richards, O. W. 1930. The British species of Sphaeroceridae (Borboridae, Diptera). Proc. Zool. Soc. Lond. 18: 261–345.

Roháček, J. 1982–3. A monograph and reclassification of the previous genus *Limosina* Macquart (Diptera, Sphaeroceridae) of Europe. Part 1, Beitr. Entomol. 32: 195–282 and Part 2, Beitr. Entomol. 33: 3–195.

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, p. 769

NOTE

Further Evidence of Nuptial Feeding in *Sepedon* (Diptera: Sciomyzidae)

We had already submitted our manuscript on nuptial feeding in *Sepedon* (Berg and Valley, 1985, Proc. Entomol. Soc. Wash. 87, pp. 622–633) when R. E. Orth alerted us to a relevant paper that we had overlooked. It is: Barraclough, D. A., 1983. The biology and immature stages of some *Sepedon* snail-killing flies in Natal (Diptera: Sciomyzidae). Ann. Natal Mus. 25: 293–317.

That author reported (p. 312) that the copulating male of *Sepedon neavei* Steyskal "... extends his proboscis downwards, between the bases of the female's antennae, and makes contact with the female's partially extended proboscis. The male's labellum everts and preens the female's labellum—the male possibly passing regurgitated food to the female." His illustrations include a figure of this labellar contact during copulation.

If Barraclough's interpretations are correct, three conclusions pertinent to points raised in our paper are inescapable.

(1) Males of *S. neavei* must be included among those that expel nuptial food orally.

(2) Means of transmission of nuptial food are even more varied than we indicated; they include direct oral contact and may include regurgitation. We cannot assume that nuptial food was secreted by the salivary glands simply because it is transmitted orally.

(3) If this Ethiopian species practices nuptial feeding, this mating system almost certainly is used by some species of the *Sepedon* group in all zoogeographic regions. The species mentioned in our previous paper occupy parts of all zoogeographic regions except the Ethiopian. The ranges of the four "Asiatic" species discussed there are primarily Oriental, not Palearctic, as we indicated. However, *Sepedon aenescens* Wiedemann extends northward well into the Palearctic Region, and *S. plumbella* Wiedemann occurs throughout most of both the Oriental and the Australian Regions. The widespread occurrence of nuptial feeding in *Sepedon* and related genera may suggest that it evolved in primitive ancestral stock, and was then carried along by several species that descended from that stock when they dispersed to occupy their present ranges.

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87(4), 1985, pp. 770–776

ASSIMILATION OF RADIOACTIVE PHOSPHORUS BY *LIRIOMYZA TRIFOLII* (BURGESS) (DIPTERA: AGROMYZIDAE) FROM FEEDING AT DIFFERENT TEMPERATURES ON DIFFERENT CHRYSANTHEMUM CULTIVARS

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Abstract.—Measurements of whole-body retention of ^{32}P by *Liriomyza trifolii* (Burgess) from feeding on tagged *Chrysanthemum morifolium* Ramat cultivars indicated that assimilation of ^{32}P was greatest from feeding on 'Capri' and 'Sunny Mandalay' and less from 'Spice', 'Mandarin', 'Dramatic', 'Garland', and 'Minute Man'. Females assimilated at least 13% more ^{32}P than males at 20, 25, 30, and 35°C. Metabolic rates doubled with each 10 degree increase in temperature; larval developmental rates varied with temperature while gross assimilation and amount of leaf tissue consumed were identical at all temperatures.

Agromyzid leafminers are found throughout the world, with 206 described North American species, represented in 15 genera and 11 subgenera (Spencer, 1981). The genus *Liriomyza*, with 233 described species, is the third largest in the world (Spencer, 1981). Several species of *Liriomyza* are of particular economic importance in the United States and elsewhere due to their destructive nature and status as economic pests. *Liriomyza trifolii* (Burgess) has a wide host range feeding primarily on the Compositae (23 host genera), followed by Fabaceae (6 genera) (Powell, 1981). Over 47 genera in 10 families are utilized as a food source in Florida alone (Spencer, 1981).

Liriomyza trifolii first-instar larvae hatch after several days and immediately begin to mine. The leaf mine varies depending on the host plant but is generally long, linear, narrow and not greatly widening at the ends, with strips of frass on alternate sides of the tunnel or in granular patches or connected threads (Spencer, 1973). Feeding on the leaves of the upper part of the chrysanthemum plant reduces salability of the crop. Mines may also reduce photosynthesis (Parrella et al., 1985) or provide infection sites for pathogens (Schuster and Harbaugh, 1979). Two molts and three larval instars take place within the leaf tissue. The third-instar larva emerges from the leaf after about a week, generally drops to the ground, and molts a final time within the puparium. The adult emerges from the puparium in 9 to 18 days, depending upon the temperature.

The female fly lays an egg by first selecting a site on a suitable leaf, elevates her head and lowers the abdomen. The body is held almost perpendicular to the leaf and by rapid piercing movements of the abdomen, the epidermis is punctured.

A rotary movement of the abdomen enlarges the opening to 0.35 mm in diameter, and an egg is laid parallel to the leaf surface in the cellular tissue. Regardless of oviposition or not, the female backs up and feeds on the cellular fluid that exudes from the stipple. Males also feed at these wounds or on exudations from leaf axils.

Liriomyza trifolii exhibits an intercultivar preference when feeding on Chrysanthemum (*Chrysanthemum morifolium* Ramat) (Oetting, 1982). A determination of host plant suitability is needed, so that the most resistant cultivars can be identified for use in integrated pest management schemes or used in breeding programs. This experiment was performed to determine assimilation at varying temperatures and then, using an optimum developmental temperature, determine assimilation of phosphorus in different chrysanthemum cultivars. Assimilation by larvae of an essential and readily absorbed plant and insect element, phosphorus, was used to determine host utilization. Assimilation, in this study, is defined as the whole-body retention of phosphorus-32 (^{32}P). Insect health determinations were then used to rank chrysanthemum cultivars by feeding assimilation to attain the objective of determining the suitability of hosts.

MATERIALS AND METHODS

Assimilation studies were performed during the spring of 1982 in Athens, Georgia. A total of 50 cuttings, 10 cuttings per temperature treatment, of *Chrysanthemum morifolium* Ramat, cultivar 'Mandarin', were used for measurements of ^{32}P assimilation at 20, 25, 30, 35, and 40° C ± 2° C. Plastic 29 ml rearing cups with cardboard tops were used to maintain plants throughout the study. A 6 mm diameter hole was punched through each lid and the bare-rooted cutting inserted through this into the cup. Two millicuries of ^{32}P, as phosphoric acid, were added to 250 ml of water. Twenty-five ml were placed in each cup and the roots were suspended in it. Plants were allowed to absorb this solution for 1–3 days in order to assimilate as much ^{32}P as possible. Plants were then transferred to and maintained in uncontaminated, water-filled cups so that absorption of tagged water ceased and radioactive decay could be followed. Groups of 5 plants were placed in 3.8 liter cylindrical cardboard tubs and the tops were sealed with clear 12 mil polyethylene. Flies were collected with an aspirator from a stock colony maintained in a greenhouse of chrysanthemums. These flies were immediately immobilized by chilling in a refrigerator. Groups of 10 females and 1 male were sorted and placed into 20 dram vials. One vial of flies per tub was then screwed into a port in the side of the tubs to introduce insects to plants. After 24 hours, flies were anesthetized with CO_2 and killed. A 6.35 mm diameter leaf disc was removed from the bottom-most leaf of each plant with a paper punch to act as a standard for measurements of radioactivity. The plants in their water filled cups were individually placed on 14.7 cm diameter petri dishes and transferred to their respective environmental chambers. One Percival, two Environator and one Precision environmental chamber were used throughout this experiment. A 14:10 L:D hr photoperiod was maintained in each.

Leaf discs were assayed for radioactive decay over time by 1 minute counts of Bremsstrahlung on a Tracor Northern TN-1705 multichannel pulse height analyzer (Willis et al., 1975). Samples were placed in a well-type, solid scintillation detector with a NaI(Tl) crystal. Counts were summed over channels 10–40 at 1091 volts 7nd gain of 4.0. When all surviving last-instar larvae emerged from the leaves, they were placed seperately into test tubes, placed into the detector well, and assayed for radioactivity. Background counts of 5 minutes were converted to counts per minute and subtracted from leaf and larval counts to correct for natural emissions. Disintegrations per minute (dpm) were determined by dividing by the counting efficiency (2.44%). Each dried leaf and larva or pupa was weighed to the nearest 0.0001 mg on a Cahn/Ventron Cahn 21 automatic electrobalance. This value was used to standardize data as dpm/wt. The leaf disc data were transformed (ln) and least squares regression performed to approximate a slope of −14.3 (days), the half-life of ^{32}P. Percent of ^{32}P in the leafminer was determined by identifying the point on the decay line that corresponded to the point for the leafminer at the time the leafminer was assayed. The dpm/wt of the line point was subtracted from the dpm/wt of the larva and divided by the larva dpm/wt, then multiplied by 100 to give a value for percent retention.

Leaf area consumed was digitized in mm^2 by a Hewlett Packard 9825A computer with a 9864A Digitizer attachment, for correlation between area consumed, weight consumed and retention of ^{32}P. Area consumed per larva was determined by tracing the leaf portion skeletonized by each larva on a light table and digitizing it. Weight consumed was determined by correlating the mean area of 20 6.35 mm diameter leaf discs (30.6 ± 1.2 mm^2) with the mean weight of leaf discs for each set of 5 replicates. This value was then multiplied by the area consumed per larva to provide individual consumption values. Five plants for each temperature of 20, 25, 30 and 35° C were counted from 17 April 1982 to 9 May 1982. The second replicate of 5 plants was counted from 3 May 1982 to 22 May 1982. Plants were monitored from 15 May to 27 May for assimilation studies at 40° C. Data were analyzed by analysis of variance and comparisons of means were made using the Student-Newman-Keuls test at the 0.05 level.

Six additional cultivars, 5 replicates each of 'Capri', 'Dramatic', 'Garland', 'Minute Man', 'Spice', and 'Sunny Mandalay' were used for inter-cultivar assimilation studies. Flies were allowed to feed and oviposit as above for 32 hours; counting then started on 8 June 1982 until 23 June 1982. Because of low level of infestation, a second exposure of flies (>15 females) was allowed on the same plant 24 June 1982 for 32 hours, followed by a third exposure for 32 hours on 1 July 1982 (>30 females). All cultivars were maintained at 30° C ± 2° C.

Percent gross ^{32}P assimilation per larva was determined as described above. The number of mines initiated and realized natality for each group of cultivars were determined by actual count. Data were analyzed by analysis of variance and comparisons of means were made using Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

Percent gross assimilation of ^{32}P was not significantly different but shows a tendency to increasing with increase of temperature, but the mean leaf area consumed, the mean weight consumed and the mean weight per larva are not significantly different (Table 1). Only rate of assimilation would be expected to increase with increasing temperature because of biochemical, especially enzymatic, activity. At high temperatures, proteins denature and the efficiency of physiological processes is reduced. For this reason assimilation would be expected to decrease sharply. This occurred at 40° C in this experiment. Under this condition, eggs were observed to hatch and an increase in mine length noted for one

Table 1. Percent assimilation/larva of ^{32}P, mean area and weight consumed/larva, mean larval weight, days to larval drop, and sex ratio of *Liriomyza trifolii* (Burgess) reared on *Chrysanthemum morifolium* Ramat 'Mandarin' containing ^{32}P.

Parameter Measured	Temperature			
	20° C	25° C	30° C	35° C
Gross Assimilation (%)	89.42ab[1]	83.52b	90.71ab	93.98a
Female Assimilation (%)	93.79a	92.37a	94.48a	97.37a
Male Assimilation (%)	80.69a	68.76b	80.02a	78.75ab
$\bar{x}$ Leaf Area Consumed (mm^2)	164.03a	170.82a	184.08a	161.24a
$\bar{x}$ Weight Consumed (mg)	4.86a	5.36a	6.65a	5.08a
$\bar{x}$ Larval Weight (mg)	0.2369a	0.2055a	0.1683a	0.2086a
$\bar{x}$ Days to Larval Drop	13.67a	11.57a	7.60b	7.00b
Sex Ratio (Female : Male)[2]	2:1	1.6:1	2.8:1	4.5:1

[1] Means are compared horizontally; those followed by a letter in common are not significantly different ($P = 0.05$) using the Student-Newman-Keuls test.

[2] Number of adults to emerge in respective temperatures was 20° C (18), 25° C (16), 30° C (25), and 35° C (11).

day before death occurred. The physiological state of the host plant may also have had detrimental effects on leafminer development, as death of all leafminers occurred and death of all plants was accelerated when maintained at 40° C.

Temperature significantly affects developmental time from egg to pupation (Leibee, 1984). Time from egg hatch to pupation, in our tests, was almost two times greater at low temperatures than the higher temperatures. The Q_{10} law, that for every 10 degree increase in temperature there is a doubling of biochemical reaction rate (King, 1965), is complied with. Since each larval stadia has a fixed number of cells and growth occurs only by cell enlargement and cell elongation, assimilation rate increases while total assimilation at all temperatures is the same.

Possibly correlated with temperature are the sex ratios of females to males. As temperature increased, female survivorship was favored. This was possibly due to the detrimental effects high temperatures have on all the developmental stages. Under stressful environmental conditions, females, with the potential for reproductive success, need to survive in order to maintain the species. Males are not as necessary since even with lower numbers their polygamous nature insures that the majority of females will be mated.

A drop in gross assimilation occurred at 25° C. Female leafminers, in all treatments, assimilated the same amount of ^{32}P, and assimilated at least 13% more than their male counterparts. Extremely low assimilation by males at 25° C accounted for the low gross assimilation value, otherwise gross assimilation and assimilation by males was the same in all treatments.

Females assimilate more ^{32}P, due not only to a greater body weight, but also to an intrinsically higher uptake (Srinivasan et al., 1980), which was also observed by Chamberlain (1979) in *Stomoxys calcitrans*, Quraishi et al. (1966) in *Anopheles stephensi mysorensis*, and by Quraishi (1968) in *Aedes aegypti*. Controversy over utilization of phosphorus exists. Whittaker (1961) generalizes that much of the ^{32}P that is ingested by an organism is not assimilated while Suzuki (1978) found that conversion efficiency by *Locusta migratoria* was 52%. Phosphorus is one of the chief constituents of insect protoplasm and phosphorylated imtermediates are

Table 2. Percent gross assimilation of ^{32}P, initial natality, and realized natality of *Liriomyza trifolii* (Burgess) reared at 30° C on 7 cultivars of *Chrysanthemum morifolium* Ramat.

	Cultivar						
	Sunny Mandalay	Capri	Spice	Mandarin	Dramatic	Garland	Minute Man
Gross Assimilation (%)	98.65a[1]	94.15	92.14	90.74b	90.42b	87.98b	84.43
Initial Natality[2]	33.80bc	27.20d	57.25a	36.20b	37.50b	13.67d	29.40cd
Realized Natality[3]	3	1	1	25	9	6	1

[1] Means are compared horizontally; those followed by a letter in common are not significantly different ($P = 0.05$) using Duncan's New Multiple Range Test. Those values with n = 1 cannot be tested by an analysis of variance.

[2] Initial natality based on the number of mines initiated.

[3] Realized natality based on the number of larvae to emerge from each plant.

intimately involved in nerve functions. A significant proportion of ^{32}P accumulates in the thorax and abdomen (Srinivasan et al., 1980). This need for phosphorus is basic to both sexes, but Srinivasan et al. (1980) postulate that the greater female need is due to ovarian development. This was demonstrated by Smittle and Patton (1970) when they found that female *Culex pipiens quinquefasciatus* retained only 60% of their radioactivity after ovipositing.

'Capri' and 'Sunny Mandalay' were probably the preferred chrysanthemum cultivar hosts of *L. trifolii* based on gross assimilation of ^{32}P (Table 2).

Low numbers of leafminers were reared on several of the cultivars and the assimilation value for these treatments may be inflated or deflated depending on whether the individual reared was a female or male respectively. The poor success in rearing larvae to pupation may have been due to the physiology of the host or to ^{32}P induced death. Death at hatching would account for the erratic values of the number of mines initiated for each treatment. Many workers report retarded growth or a reduced hatch rate if concentrations of ^{32}P in rearing media are high (Abdel-Malek, 1961; Dustan, 1966; Chamberlain, 1976). Lethality due to ^{32}P was unlikely, since the amount of ^{32}P utilized was small, and identical to the amount used in the preceding experiment.

The technique of determining host preference based on assimilation of ^{32}P can be utilized for a simple control program. If hosts that are poor in providing nutrients to developing leafminers are utilized in breeding programs for new chrysanthemum cultivars, this quality may be imparted to the new cultivar and aid in leafminer suppression. This technique can also be used to identify preferred hosts, of non-economic importance, to be used for trapping.

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LITERATURE CITED

Abdel-Malek, A. S. 1961. The effect of radioactive phosphorus on the growth and development of *Culex pipiens molestus* Forsk. (Diptera, Culicidae). Bull. Entomol. Res. 52: 701–708.

Chamberlain, W. F. 1976. Marking of horn flies with ^{32}P. Southwest Entomol. 1: 174–177.

———. 1979. A comparison of procedures for labeling stable flies with ^{32}P for behavior and ecological studies. Southwest Entomol. 4: 150–155.

Dustan, G. G. 1966. Effects of tagging amounts of radioactive phosphorus on adults of the Oriental Fruit Moth, *Grapholitha molesta* (Busch) (Lepidoptera: Tortricidae). Can. Entomol. 98: 305–311.

King, J. 1965. Practical clinical enzymology. D. Van Nostrand Co. Ltd., Princeton, N.J.: 31–34.

Leibee, G. L. 1984. Influence of temperature on development and fecundity of *Liriomyza trifolii* (Burgess) (Diptera: Agronmyzidae) on celery. Environ. Entomol. 13: 497–501.

Oetting, R. D. 1982. Susceptibility of selected chrysanthemum cultivars to *Liriomyza trifolii*. J. Georgia Entomol. Soc. 17: 552–558.

Parrella, M. P., V. P. Jones, R. R. Youngman, and L. M. Lebeck. 1985. Effect of leaf mining and leaf strippling of *Liriomyza* spp. on photosynthetic rates of chrysanthemum. Ann. Entomol. Soc. Am. 78: 90–93.

Powell, D. F. 1981. The eradication campaign against American serpentine leaf miner, *Liriomyza trifolii*, at Efford Experimental Horticulture Station. Plant. Pathol. 30: 195–204.

Quraishi, M. S. 1968. Uptake of P^{32} by yellow-fever mosquito larvae of equal age, and those pupating synchronously: its loss and transfer during development, mating, and oviposition. J. Econ. Entomol. 61: 530–533.

Quraishi, M. S., M. A. Faghih, and N. Esghi. 1966. Flight range, lengths of gonotrophic cycles, and longevity of P^{32}-labelled *Anopheles stephensi mysorensis*. J. Econ. Entomol. 59: 50–55.

Schuster, D. J. and D. K. Harbaugh. 1979. Chrysanthemum cultivars differ in foliar leafminer damage. Hortic. Sci. 14: 273–274.

Smittle, B. J. and R. S. Patterson. 1970. Transfer of radioactivity to eggs and larvae by female *Culex pipiens quinquefasciatus* Say treated with ^{32}P. Mosquito News 30: 93–94.

Spencer, K. A. 1973. Agromyzidae (Diptera) of economic importance. Series Entomologica Vol. 9. The Hague. 418 pp.

———. 1981. A revisionary study of the leafmining flies (Agromyzidae) of California. Univ. Calif. Div. Agric. Sci. Spec. Pub. 3273.

Srinivasan, M. N., R. Chandra, T. Koshy, S. P. Singh, and S. K. Gangully. 1980. Uptake and turnover pattern of radioactive phosphorus in 3 vector species of mosquitoes. Indian J. Expt. Biol. 18: 1248–1251.

Suzuki, N. 1978. Budgets of dry matter and phosphorus in a locust, *Locusta migratoria* Linne. Jap. J. Ecol. 28: 277–280.

Whittaker, R. H. 1961. Experiments with radiophosphorus tracer in aquarium microcosms. Ecol. Monogr. 31: 157–188.

Willis, D. L., W. D. Loveland, and C. H. Wang. 1975. Radiotracer methodology in the biological, environmental, and physical sciences. Prentice-Hall, Inc., Englewood Cliffs, N.J. 480 pp.

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, pp. 777–782

TWO NEW SPECIES OF *HEXORTHODES* (LEPIDOPTERA: NOCTUIDAE) FROM TEXAS AND ARIZONA

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Abstract.—Two new noctuid moths, *Hexorthodes emendata* and *Hexorthodes citeria* are described from material from Texas and Arizona. Imagines and male and female genitalia are figured. The closely related species, *H. accurata* (Henry Edwards), is also figured.

Two new species of *Hexorthodes* McDunnough are described from material collected in Texas by both authors. The type series of one, *Hexorthodes citeria*, also includes several Arizona specimens collected by J. G. Franclemont. The larva of *citeria* has been described and illustrated by Godfrey (1972, pp. 167, 168, and p. 265, fig. 547) from ova obtained from a female collected by Franclemont. Although Franclemont had recognized this species as new, he has graciously permitted the authors to describe it here with *emendata*. Both new species are closely related to *accurata* (Henry Edwards), which was described from Arizona. According to Franclemont (pers. com.), there is a third undescribed species in the *accurata* group, which occurs in Mexico and Central America.

Hexorthodes emendata Blanchard & Knudson, New Species

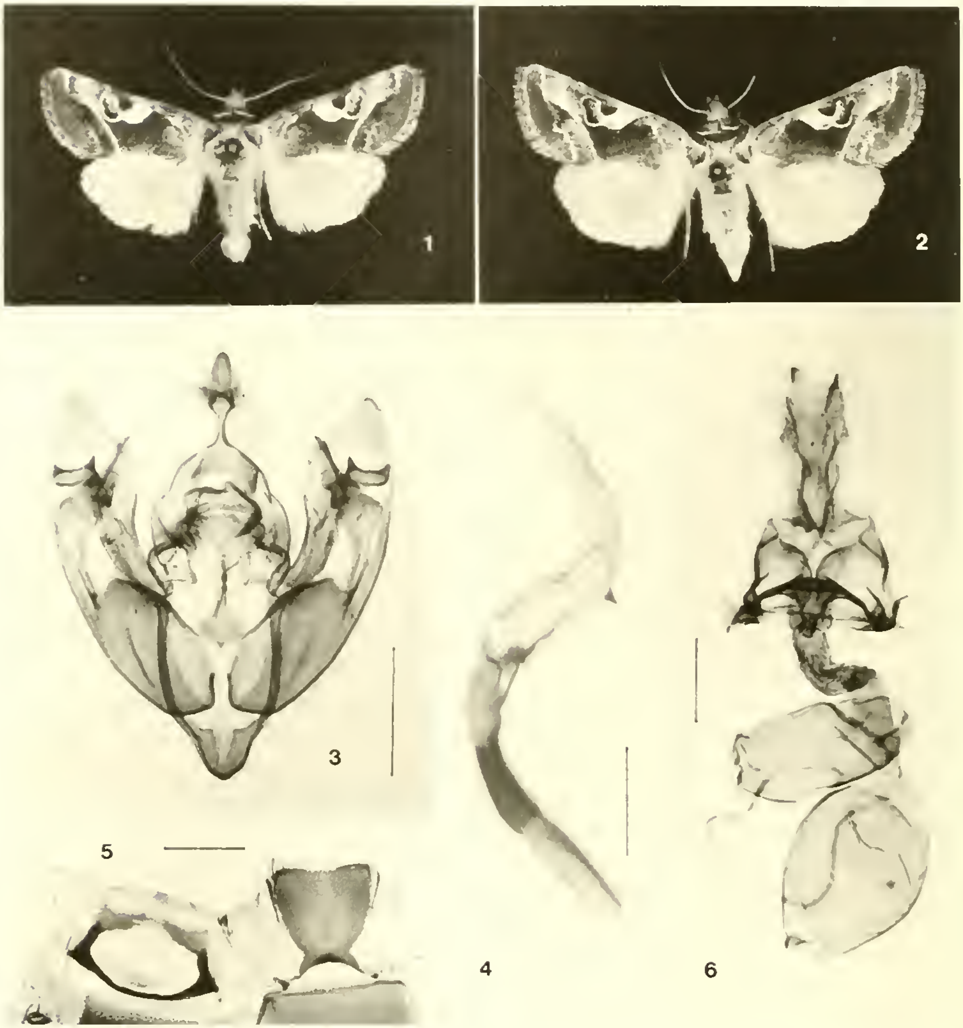
Figs. 1–6

Head.—Front smooth, grayish white (clay color). Vertex tufted, pale reddish brown. Labial palpi reddish brown, oblique, total length equal to one eye diameter. Antennae clay color, bipectinate in male, minutely bipectinate in female.

Thorax.—Anterior third pale reddish brown, with a flat fan shaped anterior tuft. Posterior ⅔ pale charcoal gray, patagia margined with white.

Abdomen buff colored, with conspicuous, copper colored dorsal tuft on 1st segment.

Forewing.—Ground color bright reddish brown (copper color), veins outlined narrowly with blackish gray. Basal half line white, angled outward from costal margin. Antemedial line obscure, apparent only at costa and near dorsal margin, angled inwardly over cell to meet basal half line. The area within the antemedial line much suffused with grayish white and blackish scales, with extreme base mainly whitish. Orbicular pale clay color, an elongate oval, extending from near costa to lower inner margin of reniform, to which it is usually narrowly joined. Reniform charcoal gray, margined with a ring of pale clay color. Postmedian line well defined, whitish, smooth and slightly outwardly convex from costal margin



Figs. 1–6. *Hexorthodes emendata.* 1, Holotype ♂. 2, Paratype ♀, same data as holotype. 3, ♂ genitalia of paratype, slide AB 3667 (aedeagus omitted). 4, Aedeagus with inflated vesica, paratype, same specimen and slide as Fig. 3. 5, Sclerotization of 8th abdominal segment (sternite on the left) of paratype, slide ECK 965. 6, ♀ genitalia of paratype, slide AB 3661. Segments in Figs. 3–6 represent 1 mm.

at ¼ the distance from apex. Subterminal line whitish, irregular and poorly defined over middle, the space between it and the postmedian line charcoal gray, suffused with whitish over costal ⅓. The space between reniform and postmedian line also suffused with whitish. Terminal line absent, fringe charcoal gray, with bases of scales clay color.

Hindwing white, semitranslucent, suffused with dull reddish brown along termen and with a narrow brownish terminal line. Veins slightly darkened. Fringe whitish.

Length of forewing.—Males: N = 11, 12.5–15.8 mm, average 13.9 mm. Females: N = 10, 13.7–16.3 mm, average 14.8 mm.

Male genitalia (Figs. 3–5).—Valva with well developed clasper, basal sclerite expanded posteriorly, clasper proper directed dorsally. Costa well sclerotized, with weak editum; digitus well developed, with short, equal sized, dorsal and ventral processes. Costal lobe of sacculus oblique, unarmed. Juxta a well sclerotized, elongate plate, expanded anteriorly, pointed posteriorly. Aedeagus elongate, slightly curved. Vesica with small thornlike cornutus at base and single larger thornlike cornutus near middle. Sclerotized sternite and tergite of eighth segment shown in Fig. 5.

Female genitalia (Fig. 6).—Sterigma with well sclerotized, crescent shaped lamina antevaginalis. Apophyses anteriores minute. Ductus bursae sigmoid, well sclerotized. Corpus bursae membranous, with large diverticulum, bearing ductus seminalis; signum absent.

Holotype (Fig. 1).—♂, Texas, Jeff Davis Co., Ft. Davis 11-VI-69, collected by A. & M. E. Blanchard and deposited in the U.S. National Museum of Natural History.

Paratypes.—Same data as holotype, 3 ♂ (genitalia on slide AB 3663), 2 ♀; same locality, 12-VII-64, 2 ♀; 25-VI-65, 1 ♂, 1 ♀; 11-VII-69, 1 ♂. Jeff Davis Co., Ajuga Canyon, 18-V-68, 2 ♀ (genitalia on slide AB 3661; Mt. Locke, 10-VI-69, 2 ♀. Presidio Co., Ruidosa-Hot Spring, 8-VII-69, 1 ♀. Culberson Co., Guadalupe Mts., McKittrick Canyon, 23-V-68, 2 ♂; Sierra Diablo Wildlife Mgmt. Area, 5-VI-69, 1 ♂; 6-VI-69, 1 ♂; 7-VI-69, 3 ♂, 1 ♀; 8-VI-69, 1 ♂; 11-VII-71, 1 ♂; 14-VII-71, 1 ♂, 1 ♀; 15-VII-71, 2 ♂, 6 ♀ (genitalia on slide AB 3659). Brewster Co., Big Bend Nat'l. Park, Chisos Basin, 8-VII-64, 1 ♂; 29-VI-65, 2 ♂ (genitalia on slide AB 3665); Green Gulch, 27-VI-65, 1 ♂; 1-VII-65, 2 ♂ (genitalia on slides AB 394 and AB 3667); Oak Spring, 11-V-66, 1 ♂. All the above collected by A. & M. E. Blanchard. Jeff Davis Co., Davis Mt. State Park, 4-VII-76, 1 ♂, 1 ♀ (genitalia on slide ECK 965). Brewster Co., Big Bend Nat'l. Park, Green Gulch, 28-V-81, 1 ♂, collected by E. Knudson.

Hexorthodes citeria **Blanchard & Knudson, NEW SPECIES**

Figs. 7–12

Head.—Similar to preceding, somewhat paler, palpi pale orange.

Thorax.—Similar to preceding, but lacking charcoal gray scaling posteriorly. General coloration pale orange.

Abdomen pale orange, posterior margins of segments whitish. Dorsal tuft on 1st segment hardly contrasting.

Forewing.—Ground color pale orange, darker in median area; veins not perceptibly darkened. Basal half line white, margined inwardly with orange brown, not angled. Antemedial line well defined, white, margined inwardly and outwardly with orange brown. The basal area, within antemedial line suffused with whitish. Orbicular and reniform much as in *emendata*, but more broadly joined, and reniform nearly as pale as orbicular. Postmedial line white, from costal margin at ⅓ the distance from apex, extending outwardly nearly parallel to costa for a short distance and thence sharply angled downward to dorsal margin. Subterminal line white, slightly irregular, but well defined throughout its length; the space between it and the postmedial line lightly suffused with whitish inwardly, and grayish outwardly. Terminal line absent. Fringe pale orange, bases of scales darker.

Hindwing opaque, pale orange, with darker terminal line. Veins not darkened. Fringe whitish.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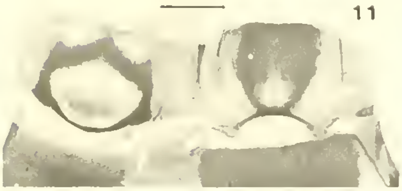
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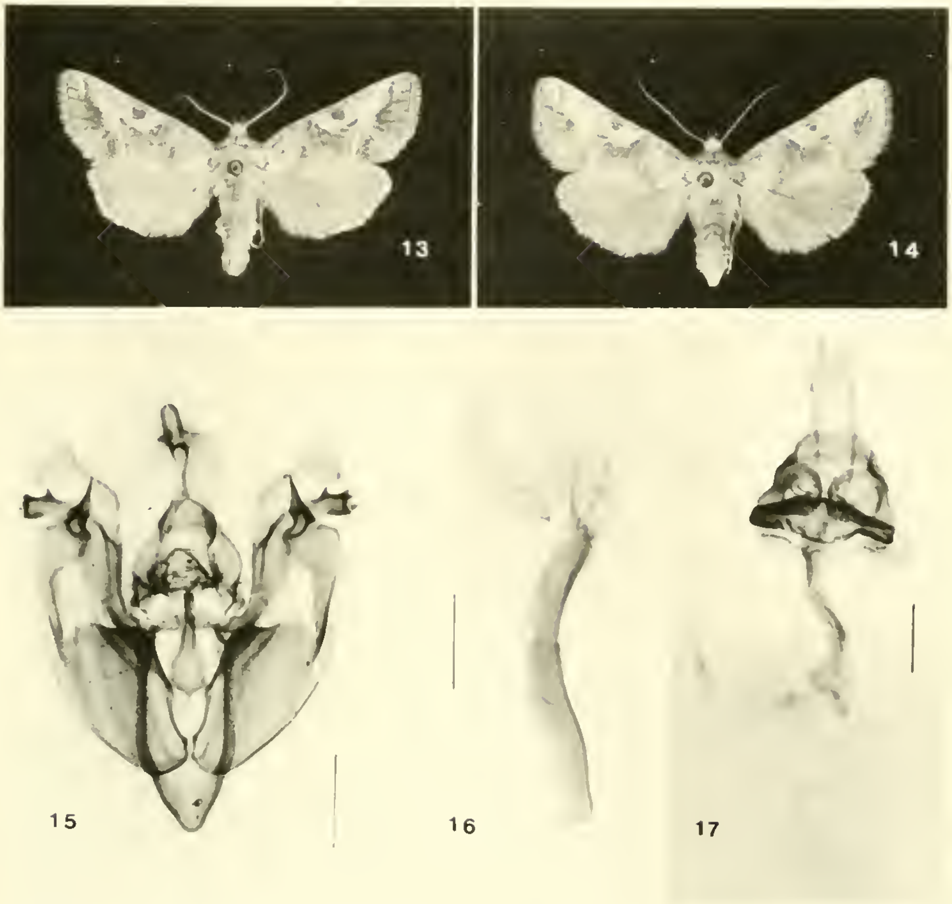
Figs. 7–12. *Hexorthodes citeria.* 7, Holotype ♂. 8, Paratype ♀, same data as holotype. 9, ♂ genitalia of paratype, slide AB 3668 (aedeagus omitted). 10, Aedeagus with inflated vesica, paratype on slide AB 5392 (by ECK). 11, Sclerotization of 8th abdominal segment (sternite on the left), slide AB 5391 (by ECK). 12, ♀ genitalia of paratype, slide AB 5390 (by ECK). Segments in Figs. 9–12 represent 1 mm.

Length of forewing.—Males: N = 10, 13.6–15.5 mm, average 14.5 mm. Females: N = 7, 14.5–16.3 mm, average 15.6 mm.

Male genitalia (Figs. 9–11).—Valva shorter and broader than *emendata*; clasper slightly longer, with basal sclerite shorter and less expanded posteriorly. Digitus with three processes; middle process minute, ventral process long and curved. Costal lobe of sacculus angled, armed with numerous short spines. Juxta as in *emendata*, but less sclerotized and shorter. Aedeagus with inflated vesica in Fig. 10 similar to *emendata*. Sclerotized sternite and tergite of eighth segment shown in Fig. 11.

Female genitalia (Fig. 12).—Sterigma with lamina antevaginalis a well sclerotized band, invaginated slightly at middle. Apophyses anteriores ⅓ the length of apophyses posteriores.



Figs. 13–17. *Hexorthodes accurata* (Hy. Edw.). 13, ♂, Santa Cruz Co., Arizona, Madera Canyon, 2-VII-59, J. G. Franclemont coll. 14, ♀, same locality & collector, 11-VII-59. 15, ♂ genitalia (aedeagus omitted), on slide J.G.F. 4291, same locality, 12-XII-60. 16, Aedeagus, vesica inflated, from slide J.G.F. 4291. 17, ♀ genitalia, on slide J.G.F. 4290, same data as Fig. 15. Segments in Figs. 15–17 represent 1 mm.

Holotype (Fig. 7).—♂, Texas, Jeff Davis Co., Ft. Davis, 11-VI-69, collected by A. & M. E. Blanchard and deposited in the U.S. National Museum of Natural History.

Paratypes.—Texas, all Jeff Davis Co., same data as holotype, 9 ♂ (genitalia on slides AB 3664, and AB 5389), 3 ♀; same locality, 12-VII-64, 1 ♀; 13-VII-64, 1 ♂; 25-VI-65, 3 ♂ (genitalia on slide AB 395); 26-VI-65, 1 ♂; 11-VII-69, 1 ♂ (genitalia on slide AB 3668), 1 ♀ (genitalia on slide AB 3660); 21-V-71, 1 ♀; Ajuga Canyon, 18-V-68, 1 ♀ (genitalia on slide AB 5390); Mt. Locke, 25-V-68, 1 ♀ (genitalia on slide AB 3662); 10–VI-69, 1 ♂ (genitalia on slide AB 5391), all collected by A. & M. E. Blanchard. Davis Mountains State Park, 4-VII-76, 1 ♂, collected by E. Knudson. Arizona, all Cochise Co., Cave Creek Canyon, 4800′, Chiricahua Mts., 2-VIII-66, 1 ♀ (genitalia on slide J.G.F. 5367); 21-VII-67, 1 ♀ (genitalia on slide J.G.F. 7140); 1-VIII-67, 1 ♂ (genitalia on slide J.G.F. 5414); Silver Creek Wash, 5140′, 2.2 m. NW of Portal, 29-VII-67, 1 ♀, all collected by J.G. Franclemont. Portal Ranger Station, Chiricahua Mts., 9-VIII-66, 1 ♀, collected by Robert G. Beard (in Coll. Franclemont).

Life history.—Last instar larva described and illustrated by Godfrey (1972, pp. 167, 168, 252 (figs. 448, 449), 265 (fig. 547), reared from ova obtained from a female collected by Franclemont at Cave Creek Canyon, Cochise Co., Arizona. Foodplant: *Brickellia* sp. (Compositae).

Remarks.—These two new species are closely related to *Hexorthodes accurata* (Henry Edwards) (Figs. 13–17). All three species can be distinguished by wing color and pattern, as well as male and female genitalia. *H. accurata* is most similar to *citeria* in coloration of the forewings, but the veins are darkened as in *emendata* and the subterminal line is poorly defined over middle, as in *emendata.* The hindwings of *accurata* are semitranslucent white, with brown veins. *H. emendata* is readily distinguished from the other two species by its rich coppery brown color and contrasting charcoal gray shade between the postmedial and subterminal lines. In male genitalia (Figs. 15, 16), *accurata* differs from the other two species in the digitus, which is more complex, with two dorsal spines and branched ventral process, each branch with several small thorn-like processes. The costal lobe of the sacculus of *accurata* resembles that of *citeria.*

The female genitalia differ chiefly in the size and shape of the lamina antevaginalis. In *accurata* (Fig. 17), this structure is well sclerotized, broadly subtriangular, with a broad central posterior protrusion and rounded lateral edges. In *accurata,* the ductus bursae is about twice the length of those of the other two species. *H. citeria* may also be distinguished by the relatively long apophyses anteriores, which are extremely small in the other two species. At this writing, it appears that *emendata* occurs only in west Texas, having been collected in the Chinati, Chisos, Davis, Guadalupe, and Sierra Diablo mountains, whereas *citeria* is known to occur only in the Davis Mountains of Texas, as well as the Chiricahua mountains of Arizona. *H. accurata* is known only from Arizona. It has also been reared on *Brickellia* sp. in Arizona (Godfrey, 1972), and is more common in the Chiricahua Mountains than *citeria* (Franclemont, pers. comm.). A large series of *H. accurata* in the U.S. National Museum of Natural History has been studied by R. W. Poole, who reports (pers. comm.) a considerable degree of variability in color and markings of this species. In the authors' series of the two new species, however, relatively little variation is noted.

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We are extremely grateful to J. G. Franclemont for providing specimens of *accurata* and *citeria* from Arizona, for providing much helpful information and encouragement, and for examining the plates and manuscript. We are also grateful to the National Park Service and to Texas Parks and Wildlife Dept. for providing access to collecting sites in Texas.

LITERATURE CITED

Godfrey, G. L. 1972. A review and reclassification of larvae of the Subfamly Hadeninae (Lepidoptera, Noctuidae) of America North of Mexico. U.S.D.A. Tech. Bull. 1450: 1–265.

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THE LARVA AND PUPA OF *BERAEA GORTEBA* ROSS (TRICHOPTERA: BERAEIDAE)

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Abstract.—The larva and pupa of *Beraea gorteba* Ross, one of three North American species of *Beraea*, are described for the first time. Comparisons are made to *B. nigritta* Banks and *B. fontana* Wiggins, both species of northeastern North America. Larvae of *B. nigritta* and *B. fontana* have five to seven spines on the anterolateral process of the pronotum whereas *B. gorteba* has three to four slightly larger spines on this process. Larvae of *B. gorteba* are burrowing detritivores and were collected along the margins of a small, spring-feed pool. Adults emerge from early May to early June and appear to be day active.

North American beraeids are rare, elusive caddisflies, with extremely local distributions. Beraeidae are a small family with five genera, and most of the 38 extant species are found in the western Palaearctic Region (Fischer, 1970; Malicky, 1983). Only three species occur in North America (Wiggins, 1977), all in the nominate genus, *Beraea*, which comprises 21 species worldwide.

Beraea nigritta Banks 1897, was described based on two female specimens from Nassau County, New York. A fragmented female specimen was reported by Betten (1934) from a locality near Ithaca, New York. Recently, Lake (1984, pers. com.) has reported *B. nigritta* from extensive seepages in the Blackbird Creek drainage area, New Castle County, Delaware. Lake's collections represent the first larvae and males of this species to be found.

Ross (1944) described a second species of North American *Beraea* from central Georgia, *Beraea gorteba*. Unpublished records of H. H. Ross indicate that a male and female of *B. gorteba* were collected in north Georgia in 1946. The immature stages and habitat of this species have remained unknown until now and are described herein.

Beraea fontana Wiggins, 1954, was found in Leskard, Ontario, Canada (ca. 65 km NE of Toronto). Wiggins noted that this species was very close to *B. nigritta*, but considered it distinct based on some small differences in the female genitalia. No males of *B. nigritta* were known at the time. This paper included the first description of the larva, pupa, and habitat of a *Beraea* species from North America. I have seen males, females, and larvae of supposed *B. nigritta* from Delaware and an unreported locality in Pennsylvania. The adults appear to be distinguishable from *B. fontana* based on details of the male and female genitalia, but the larvae of the two species appear to be inseparable.

During the summer of 1981 I collected an empty case containing larval sclerites of *B. gorteba* at or near its type locality published as "five miles southeast Roberta, Georgia" (Ross, 1944). In the spring of 1982 and 1983 I collected adults and located the larval habitat of this species.

METHODS

Larvae and pupae were collected by sifting substrate material through a large screen sieve. Specimens were immediately preserved in Kahle's fluid and transferred to 80% ethanol in the lab. Some larvae were cleared in hot 10% KOH, placed in glycerin, and examined with a compound microscope to study details of the head capsule, mouthparts, legs, and anal segments. Setal and sensory pit nomenclature of the head capsule and labrum follows that of Williams and Wiggins (1981).

Gut contents were studied by dissecting the digestive tract and squeezing the contents into a drop of glycerin on a glass microscope slide. The samples were examined under a compound microscope at magnifications up to ca. 300×.

Beraeidae

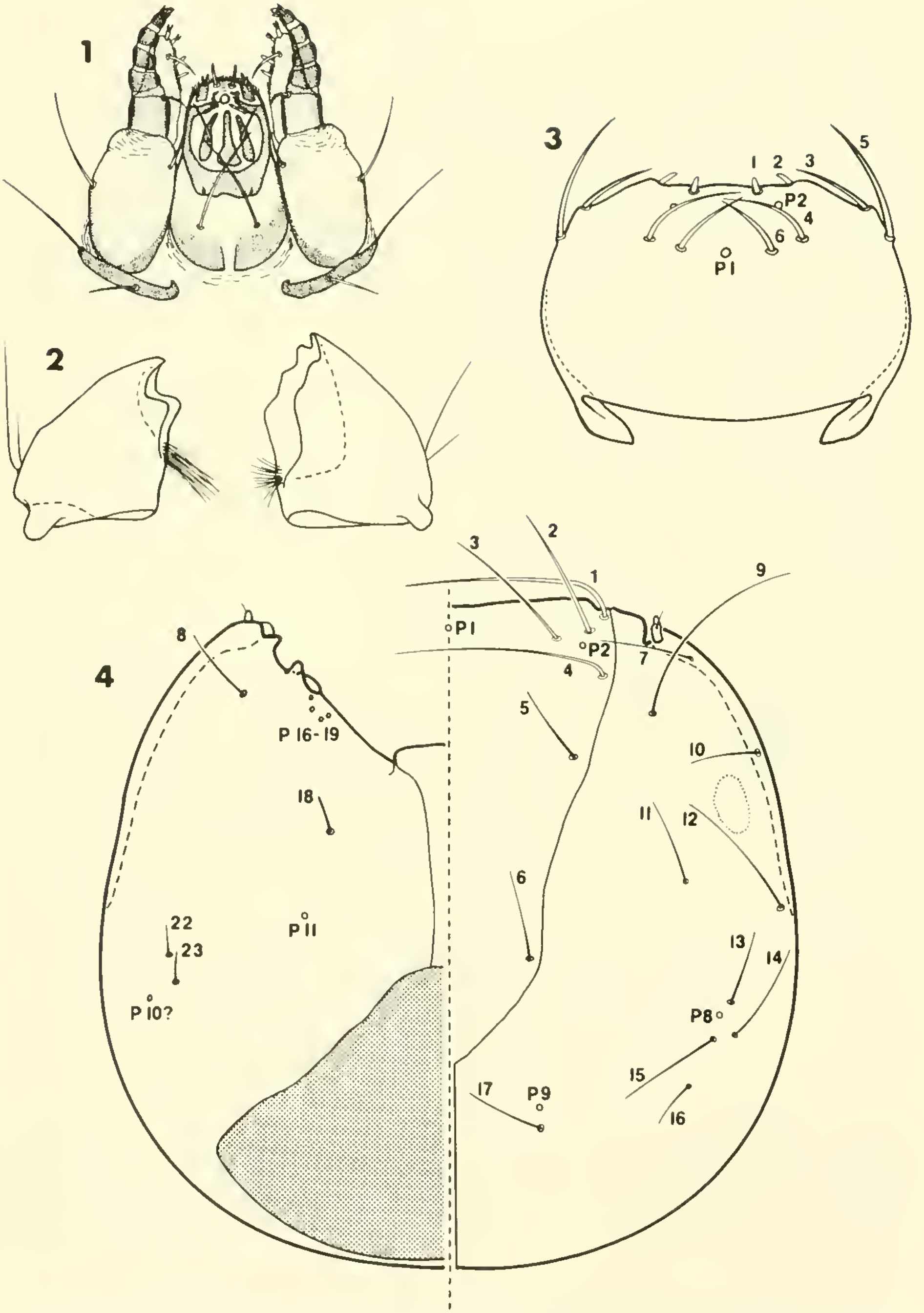
Beraeid larvae can be separated from those of other North American families by the following characters (Wiggins, 1977): anterolateral carina of head capsule with antenna at anterior end (Figs. 4, 20); diagonal carina on pronotum ending in anterolateral process (Figs. 7, 8, 20); lateral sclerite produced posteriorly over anal proleg and bearing long seta (Figs. 5, 6); brush of about 30 setae on mesoventral surface of anal proleg (Fig. 6). The case is constructed of small sand grains and is relatively smooth, slightly curved, and tapered posteriorly (Fig. 19).

North American beraeid pupae may be characterized as follows (Wiggins, 1984): mandibles simple, toothless (Fig. 18); lateral fringe lacking (Fig. 16); anterior hook-plates on segments III–VI each bearing single posteriorly directed hook; segment V also having posterior hook-plate with two anteriorly directed hooks (Fig. 17a); anal processes divergent in dorsal aspect, bifurcate apically (Figs. 16a, 17b).

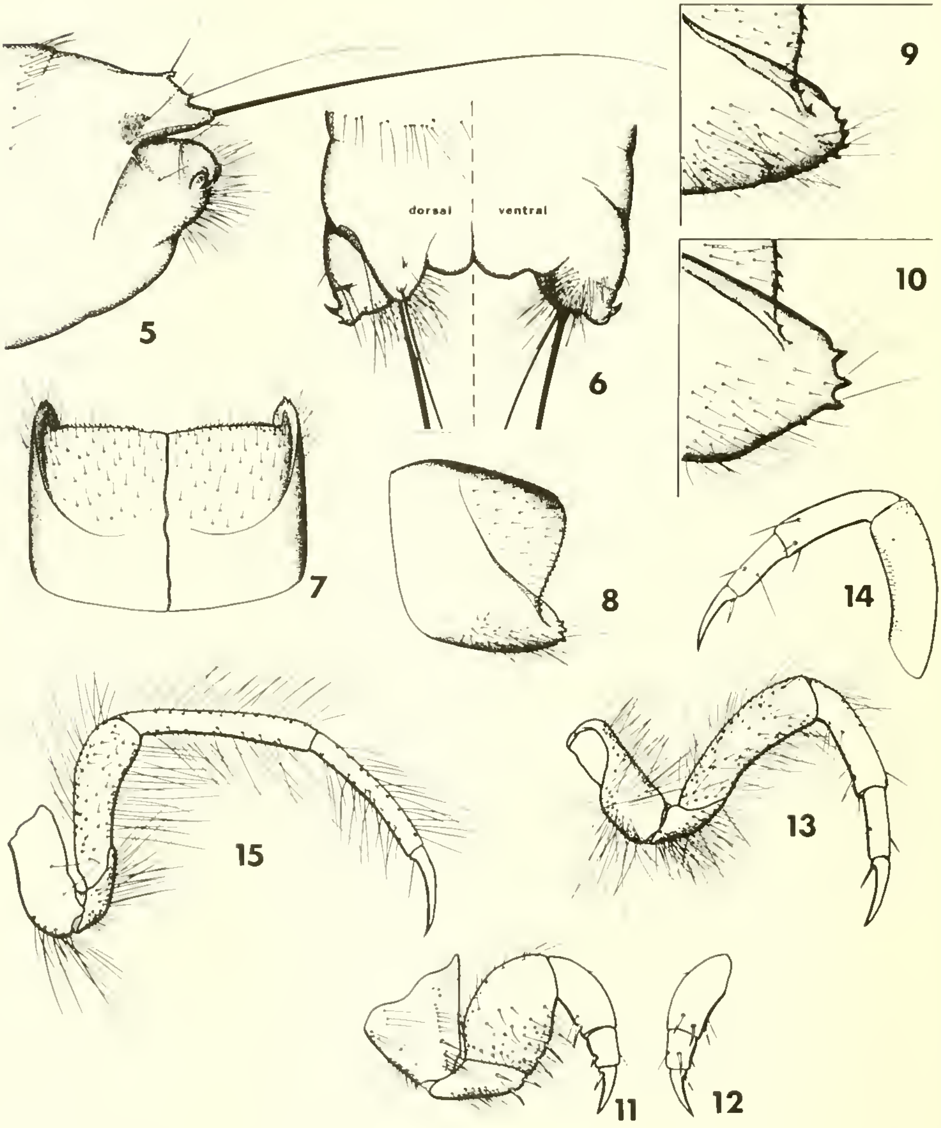
Beraea gorteba Ross

Diagnosis.—Larvae of *Beraea gorteba* can be distinguished from larvae of *B. fontana* and *B. nigritta* based on the number of spines on the anterolateral process of the pronotum. *Beraea fontana* and *B. nigritta* bear 5 to 7 medium-sized spines along the anterior margin of the process (Fig. 9), whereas *B. gorteba* larvae have 3 to 4 slightly larger spines with an occasional small accessory spine more ventral on the process (Figs. 10, 21, 24). No other characters have been found to separate the larvae of these two species nor have any characters been found to separate the pupae.

Description.—Larva (Figs. 1–8, 10–15, 19–24). Overall length of 5th (final) instar 5.5–6.6 mm. Case: 8.0–10.0 mm in length (Fig. 19). Head: width 0.65–0.76 mm; with sharp, dorsolateral carina extending from notch near anterior corner of frontoclypeus to point near base of seta 12; antenna at anterior end of carina; setae and sensory pits as in Fig. 4; color reddish-brown, paler around eye and at back of head; dorsum of head with pebbled texture, lateral area with scale-like texture; concolorous muscle scars visible due to lack of texture (Fig. 20). Labral setation as in Fig. 3. Mandibles, maxillae, and labium as in Figs. 1 and 2. Pronotum: width 0.76–0.90 mm; well developed diagonal, dorsolateral carina

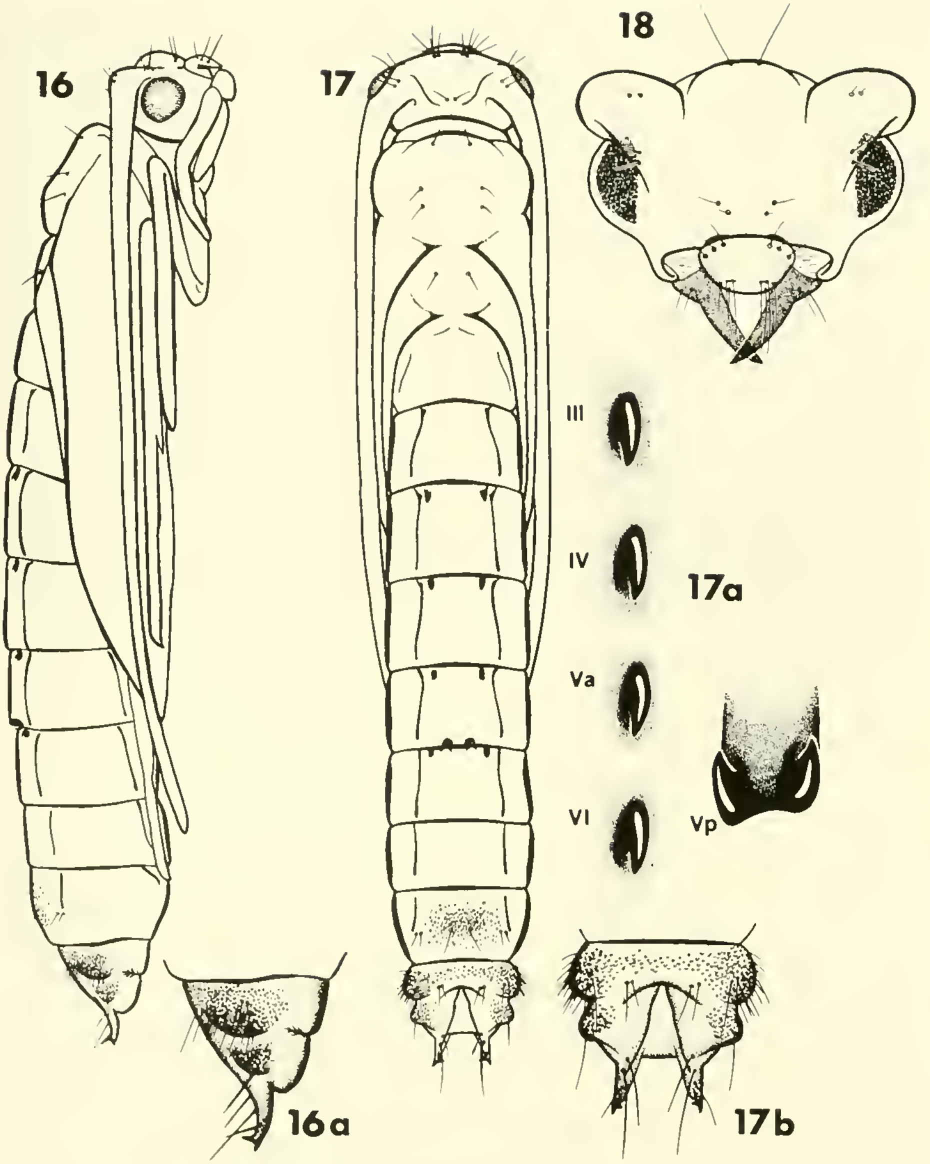


Figs. 1–4. *Beraea gorteba* Ross, larva. 1, Maxillae and labium, ventral. 2, Mandibles, ventral. 3, Labrum, dorsal. 4, Head capsule chaetotaxy, right = dorsal, left = ventral.



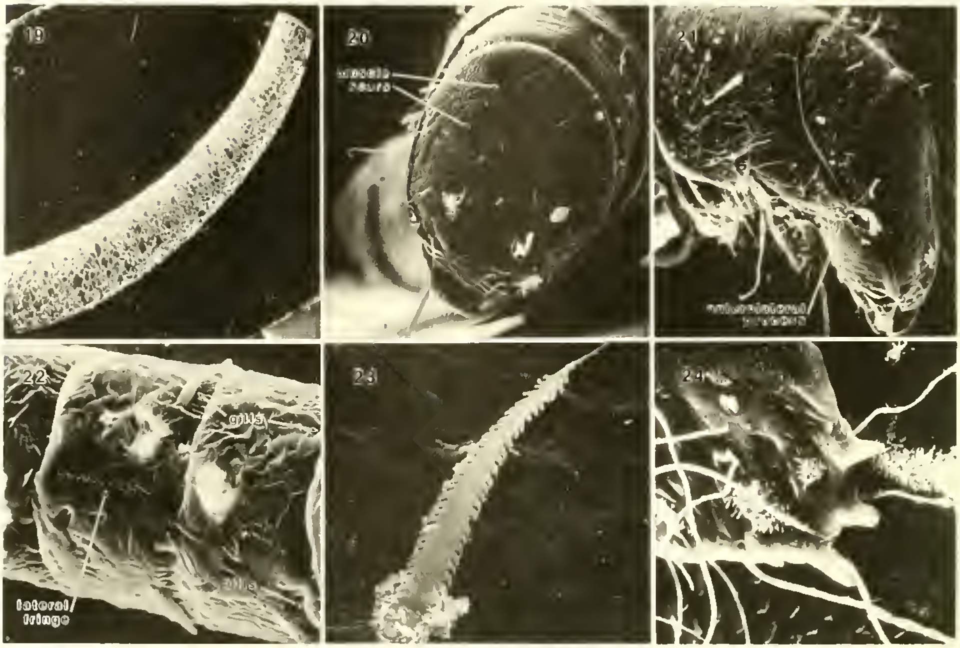
Figs. 5–15. *Beraea gorteba* Ross, larva, 5–8, 10–15. 5, Abdominal segments VIII–X, left lateral. 6, Same, left = dorsal, right = ventral. 7, Pronotum, dorsal. 8, Pronotum, right lateral. 10, Anterolateral process of pronotum, right lateral. 11, Left foreleg, anterior. 12, Left foreleg (tibia and tarsus only), posterior. 13, Left midleg, anterior. 14, Left midleg (femur, tibia, and tarsus only), posterior. 15, Left hindleg, anterior. *Beraea fontana* Wiggins, larva, 9. 9, Anterolateral process of pronotum, right lateral.

present, ending in anterolateral process bearing 3–5 spines; anterior margin of pronotum with about 15–20 spine-like setae on each side; numerous setae on dorsal surface anterior to diagonal carina and on ventrolateral surface (Figs. 7, 8, 10, 21). Color light brown, slightly paler than head capsule; posterior margin unpigmented. Mesonotum: completely sclerotized, unpigmented; with sparse vestiture of fine, elongate setae. Metanotum: unsclerotized, unpigmented; patch of



Figs. 16–18. *Beraea gorteba* Ross, pupa. 16, Right lateral. 16a, Detail of abdominal segments IX and X, right lateral. 17, Dorsal. 17a, Detail of dorsal hooks. 17b, Detail of abdominal segments IX and X, dorsal. 18, Head, anterior.

fine, elongate setae across anterolateral margin. Thoracic legs: Pale reddish-brown to yellowish-brown, prothoracic legs darkest, meso- and metathoracic legs paler; setation as in Figs. 11–15. Abdomen: anterior margins of segments II and III each with a pair of dorsolateral and ventrolateral gills; lateral line of specialized setae present on segments II–VIII (Figs. 22, 23); sclerites of segments IX and X brown to yellowish-brown; setation as in Figs. 5 and 6.



Figs. 19–24. *Beraea gorteba* Ross, larva, scanning electron micrographs. 19, Case (8×). 20, Head, anterior (40×). 21, Head and prothorax, right lateral (40×). 22, Abdomen, segments II, III, and IV, right lateral (40×). 23, Specialized seta of lateral fringe, abdominal segment III (1000×). 24, Anterolateral process of pronotum, right lateral (330×).

Pupa (Figs. 16–18). Setation sparse, confined to head, thorax, and abdominal segments VIII–X; lateral fringe lacking (Figs. 16, 17). Mandibles simple, toothless, darkly pigmented (Fig. 18). Pattern of dorsal hook-plates typical for genus, hooks stout and claw-like (Figs. 17, 17a). Minute spines present on segments VIII, IX, and X (Figs. 16a, 17b). Anal processes of segment X short, divergent in dorsal aspect, apices bifurcate (Figs. 16a, 17b).

Material Examined.—All collections were made at the following locality. Georgia: Crawford Co., Spring Creek, 5 mile SSE of Roberta, ca. 32°40′N, 83°59′W. 3 ♂♂, UV light trap, 7 May 1982; 2 ♂♂, 1 ♀, Malaise trap, 21 May 1983; 11 ♂♂, 11 ♀♀, Malaise trap, 28 May 1983; 1 ♂, 2 ♀♀, Malaise trap, 11 June 1983; 12 pupae, 18 April 1982; 6 larvae, 26 February 1983; 55 larvae, 20 March 1984.

Habitat and Life History

The larva and pupa of *B. gorteba* were collected in a small, side-channel of Spring Creek, a small, 2nd order, blackwater stream near Roberta, Georgia. The side channel (ca. 1.5 m wide × 10 m long × 0.5 m deep) does not normally receive flow from the stream, but instead receives ground water and seepage from hillside springs. It is heavily shaded (ca. 90% canopy cover). Riparian vegetation includes *Nyssa aquatica, Quercus, Pinus, Calmia, Rhododendron, Smilax,* and *Arundinaria* spp. The only aquatic macrophyte is *Orontium aquaticum.*

The larvae and pupae are associated with the sand and organic matter at the interface of the water and the shore. This material is bound together by masses of rootlets and is covered with mosses and liverworts. The larvae are found most commonly, but not exclusively, in the area of the main seepage into the side-channel. The pupae appear to be more generally distributed along the margin of the side-channel. Larvae are apparently burrowing detritivores. Gut analysis revealed small bits of vascular plant material, numerous pieces of fungal mycelia, and many pieces of unrecognizable material. No animal parts were found. The habitat and habits of *B. gorteba* appear to be very similar to those reported for *B. fontana* (Wiggins, 1954, 1977) and palaearctic species of *Beraea* (Wiberg-Larsen, 1979; Lepneva, 1966).

In central Georgia, larvae apparently overwinter as 5th instars, pupate in April, and emerge as adults during May and early June. Three adult males were collected in an ultraviolet light trap on 7 May 1982. No additional adults were captured at UV lights operated biweekly during 1983. All other adults were collected in a Malaise trap placed directly over the larval habitat. Adult *Beraea* appear to be primarily day active and fly only very short distances (Wiggins, 1954).

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LITERATURE CITED

Banks, N. 1897. New North American neuropteroid insects. Amer. Entomol. Soc. Trans. 24: 21–31.

Betten, C. 1934. The caddis flies or Trichoptera of New York State. Bull. N. Y. St. Mus. no. 292, 576 pp.

Fischer, F. C. J. 1970. Trichopterorum Catalogus, vol. XI. Nederlandse Entomologische Vereniging, Amsterdam. 316 pp.

Lake, R. W. 1984. Distribution of caddisflies (Trichoptera) in Delaware. Entomol. News. 95: 215–224.

Lepneva, S. G. 1966. Fauna of USSR., Trichoptera. Vol. 2, no. 2. Larvae and pupae of Integripalpia. Israel Program for Scientific Translation, Jerusalem (1971), 560 pp.

Malicky, H. 1983. Atlas of European Trichoptera. Series Entomologica, vol. 24. Dr. W. Junk Publ., The Hague. 298 pp.

Ross, H. H. 1944. The caddis flies, or Trichoptera, of Illinois. Bull. Illinois Nat. Hist. Surv. 23: 1–326.

Wiberg-Larsen, P. 1979. Revised key to larvae of Beraeidae in NW Europe (Trichoptera). Entomol. Scand. 10: 112–118.

Wiggins, G. B. 1954. The caddisfly genus *Beraea* in North America (Trichoptera). Contrib. Roy. Ontario Mus. Zool. Palaeont. 39: 1–18.

———. 1977. Larvae of the North American caddisfly genera (Trichoptera). Univ. Toronto Press, Ontario, Canada. 400 pp.

———. 1984. Trichoptera, pp. 271–311. *In* R. W. Merrit and K. W. Cummins, eds., An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publ. Co., Dubuque, Iowa. 722 pp.

Williams, N. and G. B. Wiggins. 1981. A proposed setal nomenclature and homology for larval Trichoptera, pp. 421–429. *In* G. Moretti, ed., Proc. 3rd Internat. Symp. Trichoptera. Ser. Entomol. 20, Dr. W. Junk Pub., The Hague. 472 pp.

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NEW HOST RECORDS FOR TEPHRITID FLIES (DIPTERA) FROM *CIRSIUM* AND *SAUSSUREA* THISTLES (ASTERACEAE) IN CALIFORNIA

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Abstract.—Twenty new host records are described for five species of tephritid flies (Diptera, Tephritidae) from 15 species of *Cirsium* and *Saussurea* thistles (Asteraceae, Cardueae) in California. All are adult rearing records from field populations of host thistles. The number and gender of flies reared from each host species are reported. The new records are: (i) *Chaetostomella undosa* reared from *Cirsium brevistylum* and stems of *C. occidentale.* (ii) *Orellia occidentalis* reared from *C. brevistylum* and *C. vulgare,* and from heads of *Cirsium andersonii, C. andrewsii, C. callilepis, C. cymosum, C. proteanum,* and *C. tioganum.* (iii) *Paracantha genalis* reared from root crowns or stem bases of *Cirsium cymosum* and *C. vulgare.* (iv) *Paracantha gentilis* reared from heads of *C. callilepis, C. campylon, C. ciliolatum, C. douglasii, C. hydrophilum vaseyi, C. pastoris,* and *C. proteanum.* (v) *Tephritis signatipennis* reared from heads of *Saussurea americana.* Two records are from the weedy naturalized bull thistle (*Cirsium vulgare*), and three records are from native thistles that are considered rare (*Cirsium campylon, C. ciliolatum,* and *C. hydrophilum vaseyi*). The record for *Tephritis signatipennis* is the first known host rearing record from the thistle tribe. Previous host records of these five flies are also summarized.

Native thistles (Asteraceae, Cardueae) in North America consist of species of *Centaurea, Cirsium,* and *Saussurea,* of which *Cirsium* with ca. 130 spp. is by far the largest genus (Moore and Frankton, 1974; Ownbey et al., 1975; USDA, SCS, 1982). Thistles also constitute an important group of weeds in North America including pestiferous naturalized species of *Acroptilon, Carduus, Centaurea, Cirsium, Cynara, Onopordum* and *Silybum* (USDA, SCS, 1982). Tephritid flies (Diptera, Tephritidae) in North America include many harmless native species, native and introduced pests of fruit crops, and naturalized beneficial biological control agents for weedy naturalized thistles (Cole, 1969; Foote and Blanc, 1963; Julien, 1982; Wasbauer, 1972).

We report here 20 new host records for five species of native tephritid flies from 15 species of *Cirsium* and *Saussurea* thistles (Asteraceae, Cardueae) in California. All are adult rearing records from natural populations of thistles. The number and gender of flies reared from each new host collection are recorded. The new host records are for the flies *Chaetostomella undosa* (Coquillett), *Orellia* *occidentalis* (Snow), *Paracantha genalis* Malloch, *Paracantha gentilis* Hering, and *Tephritis signatipennis* Foote. The new host records are from the host thistles *Cirsium andersonii* (Gray) Petrak, *C. andrewsii* (Gray) Jeps., *C. brevistylum* Cronq., *C. callilepis* (Greene) Jeps., *C. campylon* H. Sharsm., *C. ciliolatum* (L. Henders.) J. T. Howell, *C. cymosum* (Greene) J. T. Howell, *C. douglasii* DC., *C. hydrophilum* (Greene) Jeps. *vaseyi* (Gray) J. T. Howell, *C. occidentale* (Nutt.) Jeps., *C. pastoris* J. T. Howell, *C. proteanum* J. T. Howell, *C. tioganum* Congd., *C. vulgare* (Savi) Tenore, and *Saussurea americana* A. Eat. Previous host records for these flies were found in Cole (1969), Foote and Blanc (1963), Goeden (1983), Lamp and McCarty (1982), Steck (1984), and Wasbauer (1972). Seventeen of the new host records are a result of an entomofaunal study of native and naturalized thistles begun by the authors in 1982. We collected samples of thistles in the field and brought them back to the laboratory for the rearing of adult insects. Host material gathered in 1982 consisted of periodic collections of ten whole plants per population. Host material gathered in 1983 consisted of thistleheads only that were collected at a stage between flowering and seed dissemination. The numbers of heads that were collected for each 1983 thistlehead sample are specified. Three of the new host records result from collections made by L. A. Andres of our laboratory, and K. E. Frick and R. B. Hawkes, formerly affiliated with this laboratory.

The host plants of these five species of flies appear to be restricted to species of composites (Asteraceae). *Chaetostomella undosa* and *Paracantha genalis* appear to pupate in the stems or roots of their hosts, while *Orellia occidentalis*, *Paracantha gentilis*, and *Tephritis signatipennis* pupate in the heads of their hosts. All new host records are from native thistles except for the records of *Orellia occidentalis* and *Paracantha genalis* from the weedy naturalized bull thistle, *Cirsium vulgare*. *Paracantha gentilis* was reared from the heads of three *Cirsium* species that are considered rare: *Cirsium campylon*, *C. ciliolatum*, and *C. hydrophilum vaseyi* (Federal Register, 1980, 1983). The host record for *Tephritis signatipennis* is the first known host rearing record from the thistle tribe, Cardueae.

R. W. Pemberton determined the tephritid species, and the identity of representative specimens of these was confirmed by F. L. Blanc. C. E. Turner determined the thistle species, and these determinations were confirmed by G. D. Barbe. Voucher specimens of flies and thistles are retained in our laboratory.

HOST RECORDS

Plant names preceded by asterisk are new records.

***Chaetostomella undosa* (Coquillett)**

(*Orellia undosa* Coquillett)

Artemisia tridentata Nutt., *Artemisia* sp., (Asteraceae, Anthemideae) (Cole, 1969); but see Steck, 1984.

Cirsium cymosum and *C. scariosum* Nutt., (Steck, 1984, and pers. comm.). Steck (pers. comm.) also has electrophoretic identification of larvae from *C. coloradoense* (Rydb.) Cockll.

**Cirsium brevistylum*. Fandango Pass Rd., Modoc Co., CA, by L. A. Andres, host material coll. 17-V-61; 1 ♂ emerged by 14-VIII-61.

**Cirsium occidentale.* Abbotts Lagoon, Pt. Reyes, Marin Co., CA, by RWP[1], SSR[1] and CET[1], host stems coll. 22-VI and 13-VII-82; 1 ♀, 2 ♂ emerged by 1-X-83.

***Orellia occidentalis* (Snow)**

Cirsium canescens Nutt., *C. edule* Nutt., *C. hydrophilum, C. occidentale, C. parryi* (Gray) Petrak, *C. pastoris, C. quercetorum* (Gray) Jeps., (Wasbauer, 1972). *C. flodmanii* (Rydb.) Arth., *C. ochrocentrum* Gray, and *C. undulatum* (Nutt.) Spreng. (Lamp and McCarty, 1982). *C. scariosum* Nutt., (Steck, 1984, and pers. comm.).

**Cirsium andersonii.* Hwy. 49 at Bassetts, Sierra Co., CA, by RWP and CET, 71 host heads coll. 17-VIII-83; 2 ♀, 1 ♂ emerged by 1-X-83, 14 ♀, 9 ♂ emerged by 2-VII-84. Scott Mt. Pass, Hwy. 3, Trinity Co., CA, by CET and RWP, 100 host heads coll. 11-IX-83; 1 ♀ emerged by 1-X-83, 1 ♂ emerged by 7-VI-84.

**Cirsium andrewsii.* Abbotts Lagoon, Pt. Reyes, Marin Co., CA, by SSR, RWP and CET, host heads coll. 13-VII-82; 1 ♀, 1 ♂ emerged by 1-X-83. Host heads coll. 3-VIII-82; 9 ♀, 11 ♂ emerged by 11-I-83, 18 ♀, 22 ♂ emerged by 11-V-83, 13 ♀, 6 ♂ emerged by 1-X-83. Host heads coll. 24-VIII-82; 2 ♀, 4 ♂ emerged by 1-X-83. Host heads coll. 14-IX-82; 2 ♂ emerged by 1-X-83. By RWP and CET, 100 host heads coll. 21-VI-83; 1 ♀, 1 ♂ emerged by 1-X-83.

**Cirsium brevistylum.* Fort Bragg, Mendocino Co., CA, by K. E. Frick, host material coll. 7-II-62; 2 ♂ emerged. 8 km W. of Fort Bragg, Mendocino Co., CA, by R. B. Hawkes, host material coll. 30-VII-70; 3 ♀ emerged by 27-VIII-70.

**Cirsium callilepis.* Coffee Creek Rd., 24 km W. of Hwy. 3, Trinity Co., CA, by SSR and CET, host heads coll. 17-VIII-82; 1 ♂ emerged by 1-X-83.

**Cirsium cymosum.* Slough Rd., S. of Louie Rd. exit I-5, Siskiyou Co., CA, by SSR and CET, host heads coll. 8-VII-82; 3 ♀, 1 ♂ emerged by 11-I-83.

**Cirsium proteanum.* Blackbird Valley off Mines Rd. N.E. of Mt. Hamilton, Santa Clara Co., CA, by SSR, RWP, and CET, host heads coll. 19-VII-82; 4 ♀, 4 ♂ emerged by 1-X-83. By CET and RWP, 100 host heads coll. 21-VII-83; 1 ♀, 2 ♂ emerged by 1-X-83, 3 ♀, 2 ♂ emerged by 29-V-84, 2 ♀, 1 ♂ emerged by 1-X-84. Highway 198, 8.5 km E. of Hwy. 25, Monterey Co., CA, by RWP and CET, 100 host heads coll. 12-VII-83; 2 ♀, 4 ♂ emerged by 2-VII-84, 1 ♀, 2 ♂ emerged by 31-XII-84.

**Cirsium tioganum.* Sagehen Creek research station road off Hwy. 89, Nevada Co., CA, by RWP and CET, 106 host heads coll. 18-VIII-83; 1 ♀ emerged by 7-VI-84. Note: *Cirsium tioganum* has often been called *Cirsium acaulescens* Gray, *C. drummondii* Torr. and Gray, and *C. foliosum* (Hook.) DC. in California.

**Cirsium vulgare.* Westwood, Lassen Co., CA, by K. E. Frick, host material coll. 8-28-62; 1 ♂ emerged.

***Paracantha genalis* Malloch**

Cirsium californicum Gray, (Goeden, 1983).

**Cirsium cymosum.* Frontage Rd., Edgewood exit I-5, 5.6 km N. of Weed, Siskiyou Co., CA, by CET, SSR and RWP, 2 larvae (each in the crown of a rosette) coll.

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[1] The authors' names are abbreviated when cited as collectors of specific records. RWP = Robert W. Pemberton; SSR = Sara S. Rosenthal; CET = Charles E. Turner.

25-V-82; 2 ♂ emerged by 9-VI- and 1-VII-82. 1 puparium (in the crown of a rosette) and 5 puparia and 1 larva (in the stem bases of a headed plant) coll. 14-VI-82; 3 ♀, 1 ♂ emerged by 3-VII-82.

**Cirsium vulgare.* Callahan, Siskiyou Co., CA, by CET, SSR and RWP, 1 larva (in the crown of a rosette) coll. 27-VII-82; 1 ♀ emerged by 17-XI-82.

Paracantha gentilis **Hering**

Cirsium centaureae (Rydb.) K. Schum., *C. sierrae-bernardino* (invalid and uncorrelated name, possibly *C. californicum, C. edule* Nutt., and *C. vulgare* (Wasbauer, 1972). *C. cymosum,* and *C. scariosum* (Steck, 1984, and pers. comm.). Steck (pers. comm.) also has electrophoretic identification of larvae from *C. coloradoense.*

**Cirsium callilepis.* Coffee Creek Rd. 19.9 km W. of Hwy. 3, Trinity Co., CA, by RWP and CET, 100 host heads coll. 5-VIII-83; 1 ♀, 2 ♂ emerged by 1-X-83.

**Cirsium campylon.* Blackbird Valley off Mines Rd. N.E. of Mt. Hamilton, Santa Clara Co., CA, by SSR, RWP and CET, host heads coll. 19-VII-82; 1 ♀ emerged by 18-VIII-82 and 1 ♂ emerged by 17-XI-82.

**Cirsium ciliolatum.* York Rd. at Mulloy Rd., N.E. of Montague, Siskiyou Co., CA, by CET and RWP, 100 host heads coll. 23-VI-83; 30 ♀, 31 ♂ emerged by 1-X-83, 1 ♀, 1 ♂ emerged by 22-XII-83, 1 ♀, 3 ♂ emerged by 15-VI-84.

**Cirsium douglasii.* Cecilville Rd., 8 km S.W. of Callahan, Siskiyou Co., CA, by CET, SSR and RWP, host heads coll. 7-VII-82; 1 ♀ emerged by 1-X-83. Hwy. 3 S. of Scott Mt. Pass, Trinity Co., CA, by CET and RWP, 43 host heads coll. 5-VIII-83; 1 ♂ emerged by 1-X-83.

**Cirsium hydrophilum vaseyi.* West Point Inn trail, Mt. Tamalpais, Marin Co., CA, by RWP and CET, 100 host heads coll. 6-VII-83; 1 ♀ emerged by 24-V-84.

**Cirsium pastoris.* Cecilville Rd., 8 km S.W. of Callahan, Siskiyou Co., CA, by CET, SSR and RWP, host heads coll. 17-VIII-82; 5 ♀, 11 ♂ emerged by 22-X-82. Slough Rd., S. of Louie Rd. exit I-5, Siskiyou Co., CA, by CET and RWP, 100 host heads coll. 29-VI-83; 55 ♀, 56 ♂ emerged by 1-X-83, 1 ♀ emerged by 5-VI-84. Frontage Rd., Edgewood exit I-5, 5.6 km N. of Weed, Siskiyou Co., CA, by RWP and CET, 100 host heads coll. 3-VIII-83; 1 ♀, 1 ♂ emerged by 1-X-83. Callahan, Siskiyou Co., CA, by CET and RWP, 100 host heads coll. 5-VIII-83; 5 ♀, 10 ♂ emerged by 1-X-83, 1 ♂ emerged by 6-VI-84.

**Cirsium proteanum.* Blackbird Valley off Mines Rd. N.E. of Mt. Hamilton, Santa Clara Co., CA, by SSR, RWP and CET, host heads coll. 19-VII-82; 3 ♀, 5 ♂ emerged by 31-VII-82 and 1 ♀, 3 ♂ emerged by 16-VIII-82. Host heads coll. 10-VIII-82; 3 ♀, 1 ♂ emerged by 13-X-82. By RWP and CET, 100 host heads coll. 21-VII-83; 53 ♀, 70 ♂ emerged by 1-X-83, 1 ♂ emerged by 22-XII-83, 1 ♀, 1 ♂ emerged by 29-VI-84. Hwy. 41, 5.9 km W. of the Kern-Kings Co. line, Kern Co., CA. by CET and RWP, 100 host heads coll. 16-VI-83; 2 ♀, 1 ♂ emerged by 1-X-83. Hwy. 198, 8.5 km E. of Hwy. 25, Monterey Co., CA, by CET and RWP, 100 host heads coll. 12-VII-83; 9 ♀, 10 ♂ emerged by 1-X-83.

Tephritis signatipennis **Foote**

Machaeranthera canescens (Pursh) Gray (Asteraceae, Astereae), (Wasbauer, 1972).

**Saussurea americana.* S. slope of White Mt., old Pacific Crest Trail above Horse Creek, Siskiyou Co., CA, by CET and RWP, 100 host heads coll. 10-IX-83; 9 ♀, 19 ♂ emerged by 13-X-83.

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LITERATURE CITED

Cole, F. R. 1969. The flies of western North America. Univ. California Press, Berkeley. 693 pp.

Federal Register. 15 Dec. 1980. Endangered and threatened wildlife and plants; review of plant taxa for listing as endangered or threatened species. Federal Register 45: 82480–82569.

———. 28 Nov. 1983. Endangered and threatened wildlife and plants; supplement to review of plant taxa for listing; proposed rule. Federal Register 48: 53640–53670.

Foote, R. H. and F. L. Blanc. 1963. The fruit flies or Tephritidae of California. Bull. Calif. Insect Survey, vol. 7. 117 pp.

Goeden, R. D. 1983. Initial host-plant records for five species of fruit flies from southern California (Diptera: Tephritidae). Proc. Entomol. Soc. Wash. 85: 399–400.

Julien, M. H. 1982. Biological control of weeds. A world catalogue of agents and their target weeds. Commonwealth Agricultural Bureaux, Commonwealth Institute of Biological Control, Slough, U.K. 108 pp.

Lamp, W. O. and M. K. McCarty. 1982. Biology of predispersal seed predators of the Platte thistle, *Cirsium canescens*. J. Kans. Entomol. Soc. 55: 305–316.

Moore, R. J. and C. Frankton. 1974. The thistles of Canada. Research Branch, Canada Dept. Agriculture, Monograph No. 10. 111 pp.

Ownbey, G. B., P. H. Raven, and D. W. Kyhos. 1975. Chromosome numbers of some North American species of the genus *Cirsium*. III. Western United States, Mexico, and Guatemala. Brittonia 27: 297–304.

Steck, G. J. 1984. *Chaetostomella undosa* (Diptera: Tephritidae): biology, ecology, and larval description. Ann. Entomol. Soc. Am. 77: 669–678.

Steyskal, G. C. and R. H. Foote. 1977. Revisionary notes on North American Tephritidae (Diptera), with keys and descriptions of new species. Proc. Entomol. Soc. Wash. 79: 146–155.

U.S. Dept. Agriculture, Soil Conservation Service. 1982. National list of scientific plant names. Vol. 1. List of plant names. 416 pp.

Wasbauer, M. S. 1972. An annotated host catalog of the fruit flies of America north of Mexico (Diptera: Tephritidae). California Dept. Agriculture, Sacramento. 172 pp.

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THE PUPA OF *EPACMUS LITUS* (COQUILLETT), ANOTHER TAXON OF BEE FLIES LACKING CEPHALIC SPINES (DIPTERA: BOMBYLIIDAE)

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Abstract.—The pupa of *Epacmus litus* (Coquillett) (Diptera: Bombyliidae) is described for the first time. The significance of the lack of cephalic spines in this genus and others in the Bombyliidae is discussed.

In September of 1984, Saul I. Frommer, Senior Museum Scientist in the Department of Entomology, University of California, Riverside, presented me with the parasitized remains of an unidentified ethmiid (Lepidoptera) cocoon along with the pupa of its parasite, a brachycerous dipteran. The pupal case of the parasite contained an adult close to emergence, the head features, legs, and abdominal segments all clearly visible through the nearly translucent sclerotized pupal case. The adult keyed to *Epacmus litus* (Coquillett), a representative of the bombyliid subfamily Aphoebantinae, and a common species in southern California and Arizona during the months of September and October.

Since the immature stages of most Bombyliidae are unknown, this record is an important contribution to the knowledge of the biologies of these flies. The only previous records of Aphoebantinae immatures are those of *Aphoebantus hirsutus* Coquillett and *A. mus* (Osten Sacken) on the warrior grasshopper, *Camnula pellucida* (Scudder) (Riley, 1880, 1881a, 1881b; Wilson, 1936), *Petrorossia* on various Hymenoptera (Aldrich, 1928; Dutt, 1912; Evenhuis and Arakaki, 1980), and *P. feti* Zaitsev & Charykuliev on the egg cocoon of the spider *Uroctea limbata* (Zaitsev & Charykuliev, 1981). This marks the first host record and pupal illustration for the genus *Epacmus* Osten Sacken, and the first lepidopterous host record for this subfamily.

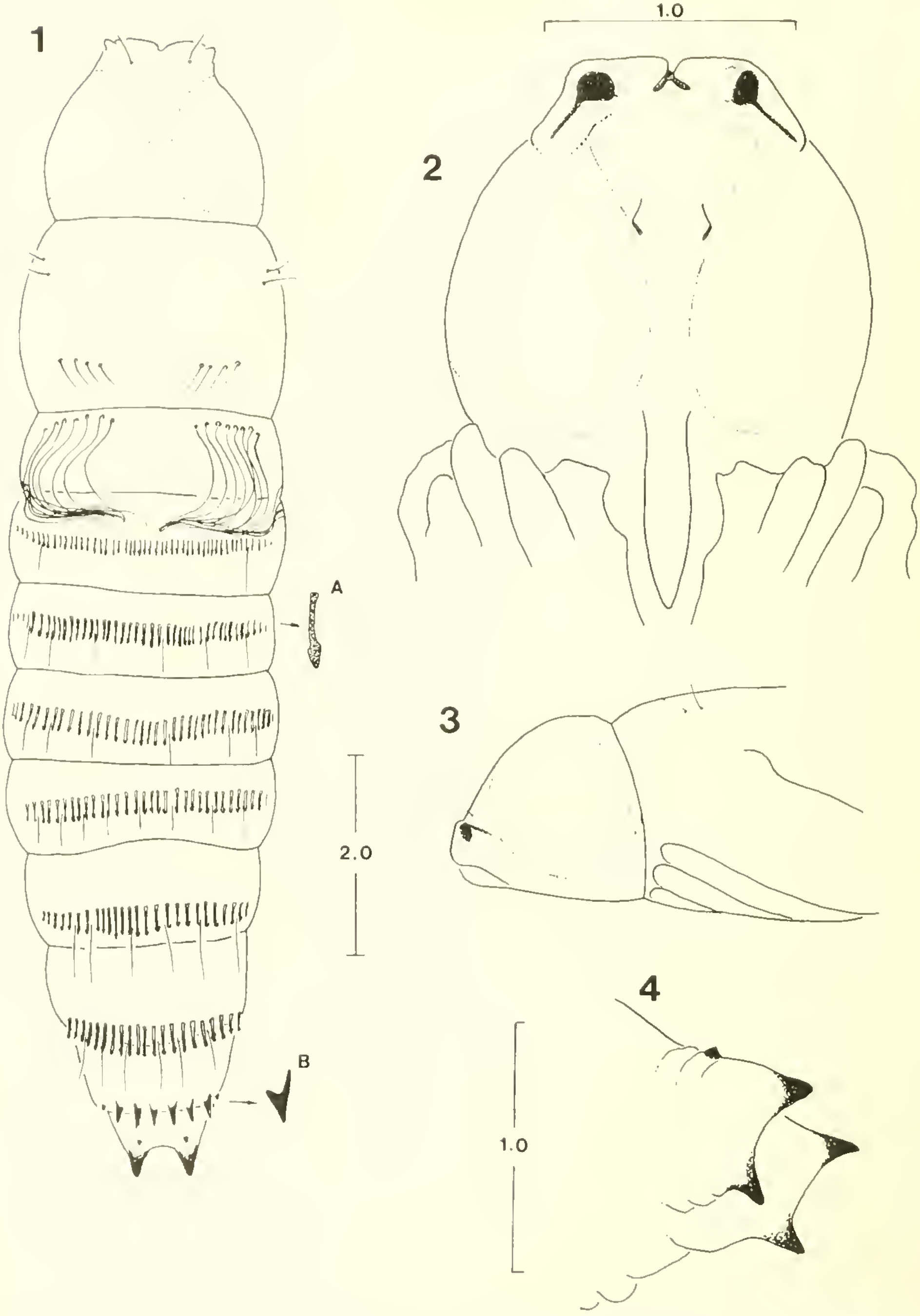
Epacmus litus (Coquillett)

Figs. 1–4

Aphoebantus litus Coquillett, 1886: 84.
Epacmus litus (Coquillett). Melander, 1950: 11.

Pupa. *Length:* 8.5 mm. *Head width:* 1.65 mm. *Thorax width:* 1.90 mm. *Abdominal width:* 2.15 mm, tapering to 1.25 mm at width of anal segment. *Pigmentation:* generally light brown overall; dorsal abdominal chitinous rods and caudal spines brown; setae amber dorsally, yellow to pale yellow laterally and ventrally.

Head: In lateral view with front produced, not heavily chitinized, without



Figs. 1–4. *Epacmus litus* (Coquillett), pupa. 1, Dorsal view; a, detail of chitinous rods on abdominal tergites II–VII; b, detail of spines on abdominal tergite VIII. 2, Head, ventral view. 3, Head, lateral view. 4, Segment IX (anal segment), ventrolateral angle.

cephalic armature; antennal sheaths prominent, extending ventrolaterally, sheaths separate basally. In ventral view with proboscis sheath extending caudally to thorax, tip of proboscis located between fore coxal sheaths; anterior tentorial pits evident, located approximtely ⅜ distance from antennae to proboscis. In dorsal view with one pair of setae located just posterior to antennal sheaths.

Thorax: Dorsally, with 2 pairs of anterodorsal setae, 4 pairs of admedial posterior setae. Prothoracic spiracle small, inconspicuous, slightly darker sclerotized than surrounding area, flush with surface, located directly posterior to head and above fore coxal sheath. Dorsum of thorax smooth, without evident texture; base of halter sheath evident laterally above wing pad.

Abdomen: Segment I with 8 pairs of long, curved setae dorsally, extending onto anterior portion of segment II, 4 pairs of long, lateral setae, also extending onto anterior portion of segment II, intertwining with dorsal setae; segment II with 48 dark, arrow-shaped, chitinous rods, oriented longitudinally, extending transversely across dorsum of segment onto upper lateral portions, 1 pair of short dorsal and 4 pairs of long lateral setae; segment III with 42 dorsal rods, 3 pairs of short dorsal and 3 pairs of longer lateral setae; segment IV with 36 dorsal rods, 3 pairs of short dorsal and 3 pairs of longer lateral setae; segment V with 32 dorsal rods, 4 pairs of dorsal and 3 pairs of lateral setae; segment VI with 26 dorsal rods, 3 pairs of dorsal and 3 pairs of lateral setae; segment VII with 22 dorsal rods, rods longer than on preceding segments, 3 pairs of dorsal and 3 pairs of lateral setae; segment VIII with 6 short, black, spine-like chitinous protuberances plus 1 rudimentary spine each side of dorsal spines, no setae present dorsally or laterally; segment IX (anal segment) with 2 lobes, each lobe possessing a single large darkly sclerotized dorsal and ventral-oriented spine, a single large darkly sclerotized dorsal and ventral-oriented spine, a single small rudimentary sclerotized tubercle anterior to each dorsal spine. Ventrally, segments II–VI with one pair of sublateral setae; segment VII with 4 setae sublaterally; abdominal spiracles small, slightly raised above surface, brown, present laterally on segments I–VII.

Certain features of the pre-emergent adult are apparent through the translucent chitin of the pupal case: Antennae black, segment III onion-shaped basally, with long terminal style apically; eyes red, smoothly indented along posterior margin; eyes separated at vertex by ca. 2× width of ocellar tubercle; wing pads with vague indications of venation anterobasally; legs fully formed, tibiae and tarsi with typical spicules and spines; claws black; pulvilli not evident; abdominal segments with heavy fat deposits; apex of abdomen retracted away from anal segment leaving pupal segments VIII–IX clear; apical abdominal segment of pre-emergent adult valvulate and spread showing thickened cerci of female genitalia; hooked spines evident on acanthophorites.

Material examined: 1 female pupal specimen in alcohol, California: Riverside County: Sec. 33, T.75, R.1E, Site I, 116°52′30″W; 33°32′30″N, ca. 5 mi [8.0 km] N of Aguanga, 13.X.1978, E. M. Fisher, ex sifted soil below *Simmondsia*, collection 302326, Jojoba project.

DISCUSSION

Most bombyliid pupae possess heavily sclerotized cephalic processes called spines. These spines are used during the pre-emergent adult phase when the pupa must dig its way out of earthen cells in which it has spent its parasitic or predaceous immature life (e.g., on grasshopper egg pods, solitary bees and wasps, tiger beetles, armyworms and cutworms, etc.). The pupa of *E. litus* represents the first bombyliid outside of *Toxophora* Meigen, *Geron* Meigen, *Systropus* Wiedemann, and taxa within the Mythicomyiinae (viz., *Glabellula* Loew and *Psiloderoides* Hesse) to lack these spines. The fact that this species of *Epacmus* lacks the cephalic spines is most likely indicative of an independently derived character. Other genera in this subfamily have pupae that possess distinct sclerotized cephalic spines [*Aphoebantus* Loew (Hull, 1973) and *Petrorossia* Bezzi (Evenhuis and Arakaki, 1980; Zaitsev and Charykuliev, 1981)]. The implications of the findings in this study may have a bearing on using the lack of cephalic spines as a character in grouping together so-called "primitive" genera or subfamilies, and separating them from typical bombyliid taxa. Pupal head capsules of the latter possess two and often three pairs of cephalic spines anteriorly and anteroventrally. Rather than representing a phylogenetic character defining a monophyletic grouping of primitive taxa, the lack of such ornamentation on the pupal head capsule in bombylioid Diptera is instead homoplasious and apparently closely associated with specialized parasitic habits. Supporting evidence for this theory includes the fact that those other genera that lack cephalic spines do indeed have rather specialized parasitic habits: *Systropus* is found almost exclusively on Limacodidae (Lepidoptera), *Toxophora* is found primarily on twig-nesting species of Eumenidae and Sphecidae (Hymenoptera), *Geron* is found primarily on Psychidae (Lepidoptera), *Glabellula* is found as an inquiline in nests of *Formica* (Hymenoptera), and *Psiloderoides* is found as a superparasite of Acridoidea [see DuMerle (1975) for complete host records of these taxa and others in the Bombyliidae]. Whether *Epacmus* is also specialized in its parasitic habit will have to await further host records for the genus; however, the lepidopterous host recorded here is the first such record for any aphoebantine representative; all others in this subfamily are parasitic or predaceous on either Acridoidea, Hymenoptera or spiders.

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LITERATURE CITED

Aldrich, J. M. 1928. Three new species of two-winged flies of the family Bombyliidae from India. Proc. U.S. Natl. Mus. 74: 1–3.

Coquillett, D. W. 1886. Monographs of the Lomatina of North America. Can. Entomol. 18: 81–87.

DuMerle, P. 1975. Les hôtes et les stades pre-imaginaux des Diptères Bombyliidae: Revue bibliographique annotée. S.R.O.P., Avignon, France. 289 p.

Dutt, G. R. 1912. Life-histories of Indian insects. IV (Hymenoptera). Mem. Dep. Agric. India, Entomol. Ser. 4: 183–267.

Evenhuis, N. L. and K. T. Arakaki. 1980. Studies in Pacific Bombyliidae (Diptera). IV. On some Philippine Bombyliidae in the collection of the Bishop Museum, with descriptions of new species. Pac. Insects 21: 308–20.

Hull, F. M. 1973. Bee flies of the world. The genera of the family Bombyliidae. Bull. U.S. Natl. Mus. 286: 1–687.

Melander, A. L. 1950. *Aphoebantus* and its relatives *Epacmus* and *Eucessia* (Diptera: Bombyliidae). Ann. Entomol. Soc. Am. 43: 1–45.

Riley, C. V. 1880. On the natural history of certain bee flies (Bombyliidae). Am. Entomol. 3: 279–83.

———. 1881a. Further facts about the natural enemies of the locusts, pp. 259–71. *In* Riley, C. V., A. S. Packard, and C. Thomas, ed., Second report of the United States Entomological Commission for the years 1878 and 1879 relating to the Rocky Mountain locust and the western cricket. Dep. Interior, Washington, D.C. xviii + 322 p.

———. 1881b. Larval habits of bee flies (Bombyliidae). Am. Nat. 15: 438–47.

Wilson, C. C. 1936. Notes on the warrior grasshopper, *Camnula pellucida* (Scudder), and its egg parasite, *Aphoebantus hirsutus* Coquillett in northern California, 1928–29. J. Econ. Entomol. 29: 413–16.

Zaitsev, V. F. and D. Charykuliev. 1981. [On the biology of bee-flies of the genus *Petrorossia* Bezzi (Diptera, Bombyliidae) with description of a new species from Turkmenia.] Entomol. Obozr. 60: 914–16. [English translation published in Entomol. Rev. 60: 158–60.]

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REDESCRIPTION AND NEW LECTOTYPE DESIGNATION FOR THE TYPE SPECIES OF *PSEUDOCLOEON, P. KRAEPELINI* KLAPÁLEK (EPHEMEROPTERA: BAETIDAE)[1]

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Abstract.—The type species of *Pseudocloeon* Klapálek is the Javanese species *P. kraepelini* Klapálek, 1905. That species is known only from the adult stage, and knowledge of the actual generic limits of the genus are thus severely limited. Specimens taken subsequent to the type series and reported as *P. kraepelini* were misidentified. The formerly designated lectotype of *P. kraepelini* is invalid since it was from misidentified material taken some 20 years after Klapálek's syntypes were collected. A new lectotype is designated from the syntype series; *P. kraepelini* is redescribed; and *P. kraepelini* is compared with the previously misidentified material.

The enigmatic genus *Pseudocloeon* Klapálek was described without the use of illustrations and was only broadly characterized by comparison with the genus *Cloeon* Leach. Klapálek (1905) recognized that both *Cloeon* and *Pseudocloeon* were two-winged baetids and that the two genera differed in that *Cloeon* possessed single marginal intercalaries in the fore wing and *Pseudocloeon* possessed paired marginal intercalaries. This has remained the primary basis for separating these two genera. Unfortunately, this adult-based generic characterization has led to the assignment of many unrelated species to the genus *Pseudocloeon*.

Recent systematic studies of Baetidae (Day, 1955; Müller-Liebenau, 1970, 1973, 1974; Morihara and McCafferty, 1979a, b; Provonsha and McCafferty, 1982; Edmunds et al., 1976) incorporate considerable larval characterization for defining generic classifications and have led, in part, to a realization of the systematic problems surrounding *Pseudocloeon* (Day, 1955; Edmunds et al., 1976; Morihara and McCafferty, 1979a; and Müller-Liebenau, 1981, 1982c). Larval character states are especially important because related but phyletically distinct genera can include species with morphologically distinct larvae and symmorphic adults (Morihara and McCafferty, 1979a). This has led modern workers to designate larvae as the type material even when adults are available (e.g., Provonsha and McCafferty, 1982).

The type species of *Pseudocloeon* was originally designated to be the Javanese species *P. kraepelini* Klapálek, 1905. One of the more interesting problems sur-

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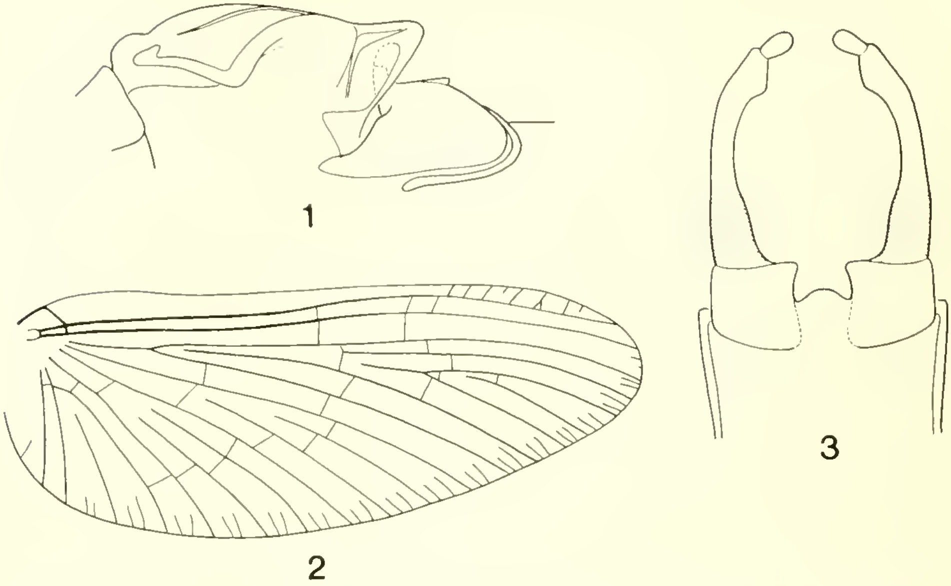
[1] Purdue University Agricultural Experiment Station Journal No. 10,244.

rounding this species, and consequently the strictest and possibly only applicable concept of the genus *Pseudocloeon*, is that the species is presently known only in the adult stage. At least three other species of baetids, including *Baetis feminalis* Eaton, are also characterized only as adults and share the characteristics of two wings and paired marginal intercalaries (Müller-Liebenau, 1981; Waltz and McCafferty, 1985). Since knowledge of the larval stage is essential to understanding and defining generic limits within Baetidae, the genus *Pseudocloeon* is now of dubious taxonomic application and must remain such until a larval-adult association of the type species is provided. Distinctive larvae known from the Orient have been only provisionally placed in *Pseudocloeon* by Müller-Liebenau (1981, 1982a, c, 1984). In addition, several two-winged baetid larvae from the Orient have been assigned to other genera, including *Baetis* (Müller-Liebenau, 1981), *Centroptella* (Müller-Liebenau, 1983), *Indobaetis* (Müller-Liebenau and Morihara, 1982), *Indocloeon* (Müller-Liebenau, 1982b), and *Symbiocloeon* (Müller-Liebenau and Heard, 1979). Obviously, any one of the above may ultimately prove to be the as yet unreared larva of *P. kraepelini*.

The inevitable future revision of *Pseudocloeon* and thus the importance of understanding the type concept led us to examine the syntype material of *P. kraepelini* along with specimens that were used by Ulmer (1939) for his redescription of the species and that were also used by Müller-Liebenau (1981) for her review of *Pseudocloeon*. Our study shows that an invalid lectotype designation (Müller-Liebenau, 1981) for *P. kraepelini* was based on a specimen from Ulmer's comparative material rather than Klapálek's original syntypes. Article 74a of the International Code of Zoological Nomenclature renders any designation of a lectotype from non-type material invalid. Even more important, Ulmer's and Müller-Liebenau's comparative material is not conspecific with the syntype material. Müller-Liebenau's invalid lectotype cannot definitely be placed to any genus at this time. A new lectotype for *P. kraepelini* is thus designated below.

***Pseudocloeon kraepelini* Klapálek**

Syntypes.—The three male adults and one male subimago syntypes (specimens #'s 1–4) are all pinned material and deposited in the Zoological Institut and Zoological Museum, University Hamburg. Lectotype male adult (#1): Buitenzorg, Java, K. Kraepelini leg. 24.II-12.III. 1904., ded. 8.VI.1904 (white label); *kraepelini* Klapálek (white label); syntype (pink label); Z.I.M. Hamburg (white label); Lectotype (#1) (white label); *Pseudocloeon kraepelini* Klapálek, 1905, Lectotype, Des. Waltz and McCafferty, 1985 (red label). Condition: adult male with wings tattered but intact, fore legs absent, remainder of body structures intact. Paralectotypes: Paralectotype (#2): same collection label as for lectotype (white label); *Pseudocloeon kraepelini* (handwritten, white label); *kraepelini* Klapálek (white label); syntype (pink label); Z.I.M. Hamburg (white label); Paratype (#2) (white label); wing on slide (white label); *Pseudocloeon kraepelini* Klapálek, 1905, Paralectotype, Des. Waltz and McCafferty, 1985 (yellow label). Condition: adult male with one wing slide mounted (RDW), the remaining wing, legs, and genitalia missing. Paralectotype (#3): same collection label as for lectotype (white label); *kraepelini* Klapálek (white label); Z.I.M. Hamburg (white label); Paratype (#3) (white label); genitalia in vial (white label); *Pseudocloeon kraepelini* Klapálek, 1905, Paralectotype, Des. Waltz and McCafferty, 1985 (yellow label). Condition: adult male



Figs. 1–3. *Pseudocloeon kraepelini* Klapálek. Paralectotype adult male. 1, Lateral view of thorax. 2, Fore wing. 3, Male genitalia (ventral).

with one wing, head, and legs missing, genitalia reconditioned and stored in vial. Paralectotype (#4): same collection label as for lectotype (white label); *kraepelini* Klapálek (white label); Z.I.M. Hamburg (white label); Paratype (#4) (white label); *Pseudocloeon kraepelini* Klapálek, 1905, Paralectotype, Des. Waltz and McCafferty, 1985 (yellow label). Condition: subimago male with head, one wing, and several legs missing.

Description.—Adult Male: Body ca. 5 mm; wing length 5.5 mm. Turbinate eyes dark brown with lighter margins, apically very broad. Thorax (Fig. 1) dorsally and laterally tan; mesonotum very slightly darkened near wing base; metanotum deeply emarginate posteriorly with metanotal process flattened before apex and projecting posteriorly; thorax ventrally pale amber. Fore wings (Fig. 2) clear, without pigmentation; veins faintly tinted tan; stigmatic area with 5–7 slanting veinlets. Hind wings absent. Fore legs straw colored with distinct brown preapical band on femora; fore tibiae ca. 1.5× length of femora; fore tarsi ca. 0.66× length of tibiae. Other legs straw colored. Abdomen dorsally with segments 2–6 pale smoky to tan; segments 7–8 darker amber; segments 9–10 pale cream; laterally segments 2–7 each with red-purple oblique dash originating from posterolateral corner near spiracle line; segments 2–10 with distinct red-purple continuous line laterally below spiracle line. Genitalia (Fig. 3) with basal segments separated medially one from another and without median process; second segment smoky brown and with fine granulation; third segment pale cream, elongate and slightly expanded apically, not excavate apically; fourth segment small and ovoid.

Remarks.—The syntype material of *P. kraepelini* differs distinctly in the size and form of male genitalia from Ulmer's incorrectly identified material, which consists of adults and subimagos collected from Malaysia in 1925 and from Java in 1928 and 1929. Differences in the genitalia of the two species may be seen by comparison of Fig. 3a (Müller-Liebenau, 1981) with Fig. 3 herein. Minor body and structural size differences are also found in the two species. We are, unfortunately, prevented from making a more specific identification of the previously misidentified material because of its generally bleached condition (preserved in alcohol) and lack of associated larvae.

Our examination of the restored genitalia allows us to correct two previously published errors in Klapálek (1905) and Ulmer (1924) regarding *P. kraepelini.* Klapálek (1905) stated that the basal segments of the forceps touched along the midline; however, in our restored genitalia the bases are well separated (Fig. 3). Also segment 3 of the forceps was reported by Klapálek (1905) and illustrated by Ulmer (1924) as being excavate apically and thus extending around the base of segment 4. Segment 3 of our restored genitalia is slightly expanded apically and segment 4 is juxtaposed to segment 3 as in other baetids (Fig. 3). The slight apical swelling of segment 3 in dried material is subject to collapse and can be easily misinterpreted.

The genitalia of *P. kraepelini* are somewhat similar to the Sumatran species *Baetis fulmeki* (Ulmer) (cf/ Müller-Liebenau, 1981, Fig. 2g), which is a member of the *Baetis atrebatinus* complex [*molawinensis*-group sensu Müller-Liebenau (1984)]. This similarity may indicate some derivation with the *Baetis atrebatinus* complex or alternatively a convergence. This particular *Baetis* complex (Müller-Liebenau, 1981, 1984), however, interestingly includes both species with reduced hind wings and species completely lacking hind wings. The possible relationship and hence possibly necessary generic reassignment of *P. kraepelini* with *Baetis* further indicates the importance of discovering the larvae of the true *P. kraepelini* Klapálek as described herein.

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LITERATURE CITED

Day, W. C. 1955. New genera of mayflies from California. Pan-Pac. Entomol. 31: 121–137.

Edmunds, G. F., Jr., S. L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. Univ. Minnesota Press, Minneapolis. 330 pp.

Klapálek, F. 1905. Plecopteren und Ephemeriden aus Java. Mitt. Nat. Mus. Hamburg 22: 103–107.

Morihara, D. K. and W. P. McCafferty. 1979a. The evolution of *Heterocloeon*, with the first larval description of *Heterocloeon frivolus* comb.n. (Ephemeroptera: Baetidae). Aq. Insects 1: 225–231.

———. 1979b. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). Trans. Am. Entomol. Soc. 105: 139–221.

Müller-Liebenau, I. 1970. Revision der europäischen Arten der Gattung *Baetis* Leach, 1818 (Insecta: Ephemeroptera). Gewässer und Abwässer 48/49 (1969): 1–214.

———. 1973. Systematisch-ökologische Beziehungen zwischen europäischen und aussereuropäischen Baetidae (Insecta: Ephemeroptera). Verh. Int. Ver. Limnol. 18: 1505–1511.

———. 1974. *Rheobaetis*: a new genus from Georgia (Ephemeroptera: Baetidae). Ann. Entomol. Soc. Am. 67: 555–567.

———. 1981. Review of the original material of the baetid genera *Baetis* and *Pseudocloeon* from the Sunda Islands and the Philippines described by G. Ulmer, with some general remarks (Insecta: Ephemeroptera). Mitt. Hamb. Zool. Mus. Inst. 78: 197–208.

———. 1982a. New species of the family Baetidae from the Philippines (Insecta: Ephemeroptera). Arch. Hydrobiol. 94: 70–82.

———. 1982b. A new genus and species of Baetidae from Sri Lanka (Ceylon): *Indocloeon primum* gen. n., sp. n. (Insecta: Ephemeroptera). Aq. Insects 4: 125–129.

———. 1982c. Five new species of *Pseudocloeon* Klapálek, 1905, from the oriental region with some general remarks on *Pseudocloeon*. Arch. Hydrobiol. 95: 283–298.

———. 1983. Three new species of *Centroptella* Braasch and Soldán, 1980, from Sri Lanka (Insecta: Ephemeroptera). Arch. Hydrobiol. 97: 486–500.

———. 1984. New species of Baetidae from Sabah (East Malaysia) (Insecta: Ephemeroptera). Proc. Fourth Int. Conf. Ephemeroptera. 1983: 85–99.

Müller-Liebenau, I. and H. W. Heard. 1979. *Symbiocloeon*: a new genus of Baetidae from Thailand (Insecta: Ephemeroptera). Proc. Second Int. Conf. Ephemeroptera 1975: 57–66.

Müller-Liebenau, I. and D. K. Morihara. 1982. *Indobaetis*: a new genus of Baetidae from Sri Lanka (Insecta: Ephemeroptera) with two new species. Gewässer und Abwässer 63/69: 26–34.

Provonsha, A. V. and W. P. McCafferty. 1982. New species and previously undescribed larvae of North American Ephemeroptera. J. Kans. Entomol. Soc. 55: 23–33.

Ulmer, G. 1924. Ephemeropteren von den Sunda-Inseln und den Philippinen. Treubia 6: 28–91.

———. 1939. Eintagsfliegen (Ephemeroptera) von dem Sunda Inseln. Arch. Hydrobiol. Suppl. 16: 443–692.

Waltz, R. D. and W. P. McCafferty. 1985. Lectotype designation and illustrations of *Baetis feminalis* Eaton. Orient. Insects 18: 335–337.

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87(4), 1985, pp. 805–820

LIFE HISTORY AND IMMATURE STAGES OF *PARYDRA BREVICEPS* (DIPTERA: EPHYDRIDAE)

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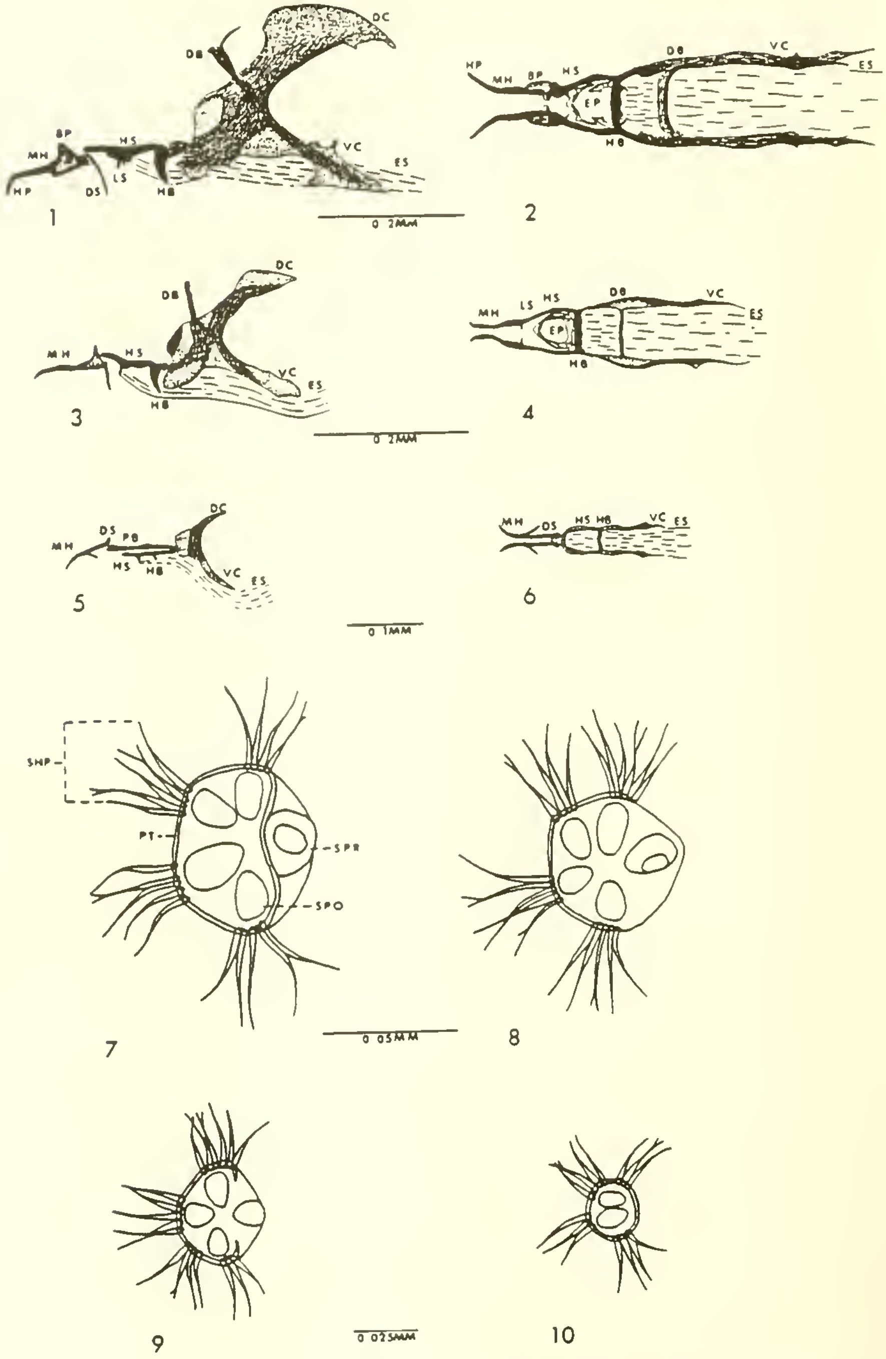
Abstract.—Adults of *Parydra breviceps* Loew occur most abundantly on mud shores, where they feed mainly on benthic diatoms. Eggs are laid on emergent objects on the mud shores in masses of mostly 1–2 eggs. Eggs are covered by a thin, uniform, light-green fecal layer, which turns white in old egg masses. Development from egg to adult requires between 14–17 days at temperatures of 20–26°C. The eggs start to hatch after 3–4 days. Each of the three larval instars lasts 3 days in most cases and 4 days in some others. The puparial phase lasts 2–3 days. Pupariation occurs on or above the mud surface, in thin layers of mud covering rocks, or in mud at the base of plants. Collecting shows the adult overwinters at moderate latitudes (puparia probably also over-winter). Some gravid females were collected in winter. Adults collected in late October, November, and December had guts packed with diatoms. Dissections of field-collected specimens showed that diatoms outnumber any other algae found in the guts of *Parydra breviceps.* The egg, three larval instars, and puparium are described and illustrated. Comparisons are made with *Parydra aquila* and *P. quadrituberculata.*

Shore flies, or Ephydridae, now numbering over 1200 species, constitute important and ubiquitous components of inland littoral and wetlands communities as well as many marine coastal communities. In all of these situations, the adults live above the water while the larvae live in water, wet mud or sand, and algal mats where they feed upon various algae and microbes. Larval habits and microhabitats of many diverse types have been reported (Becker, 1926; Bohart and Gressitt, 1951; Deonier, 1971; Thorpe, 1930; Wirth, 1971).

Information on the life history and immature stages of Ephydridae is restricted to less than 10–15 percent of the nearctic fauna. Deonier and Regensburg (1978) reported on the biology and immature stages of *Parydra quadrituberculata* Loew. Thier and Foote (1980) compared ecological data for 11 species of mud-shore Ephydridae in northeastern Ohio.

Our studies on *Parydra breviceps* Loew were conducted during the period 1979–81 at three main sites: Site 1—Brandywine Co., 0.8 km S. of Bath, Franklin Co., Indiana. Pastureland, springfed brook with average water depth of 30 cm. Site 2—Harkers Run, 1.5 km E. of Oxford, Butler Co., Ohio. Woodland stream with narrow mud shore on 45° shore slope with water depth of 20–50 cm. Site 3—Four-mile Cr., 300 m. SW of site 2. Extensive 5 × 5 m mud flat surrounded by grasses and woodland shrubs.



Figs. 1–10. *Parydra breviceps.* 1, Third-instar larva, cephalopharyngeal skeleton, lateral view. 2, Same, ventral view. 3, Second-instar larva, cephalopharyngeal skeleton, lateral view. 4, Same, ventral view. 5, First-instar larva, cephalopharyngeal skeleton, lateral view. 6, Same, ventral view. 7, Puparium, left posterior spiracle, distal view. 8, Third-instar larva, left posterior spiracle, distal view. 9, Second-instar larva, left posterior spiracle, distal view. 10, First-instar larva, left posterior spiracle, distal view.

Voucher specimens from the study are in the Miami University Insect Collection.

Abbreviations used in illustrations are: AN, anus; ASP, anterior spiracle; BP, basal part of mouthhook; DB, dorsal bridge; DC, dorsal cornu; DCC, dorsocephalic cap; DS, dental sclerite; EP, epistomal plate; ES, esophagus; HB, hypostomal bridge; HP, hook part of mouthhook; HS, hypostomal sclerite; LS, ligulate sclerite; LPT, lateral postanal tubercle; MH, mouthook; PA, papilla, PAE, postanal elongation; PAP, perianal pad; PSP, posterior spiracle; PT, spiracular peritreme; SA, spiracular atrium; SHP, spiracular hydrofuge process; SPO, spiracular orifice; SPR, spiracular remnant (scar); TS, tracheospiracular siphon; VC, ventral cornu; VPT, ventral postanal tubercle.

LIFE HISTORY

Of the 34 nearctic species in the cosmopolitan genus *Parydra* (Clausen and Cook, 1971), *P. breviceps* is considered to be third in abundance in its distribution range (30°–50° latitude in North Ameriaca) after *P. quadrituberculata* and *P. aquila* (Fallen).

Adult.—Adults of *P. breviceps* are semiglossy dark brown flies, with a bulging, light-gray pruinose face (Fig. 11). They lack the paired incurved spines on the probasisternum and the 2 pruinose areas on the mid tibiae found in *P. quadrituberculata* (Deonier and Regensburg, 1978). The males are 2.6–3.0 mm long and the females 2.8–3.6 mm.

The feeding apparatus of *breviceps* consists of highly modified labellar canaliculi (pseudotracheae), which are arranged in 6 or 7 pairs of fanlike processes attached to the paired distal labial palpal sclerites and a medial horseshoe-shaped sclerite. Frey (1921) calls that sclerite the middle part of the furca. The length of rays increases anteroposteriorly up to the second to last fanlike canalicular process. The rays in the last fanlike canalicular process (posterior direction) are slightly smaller than the preceding rays.

As in the study by Deonier and Regensburg (1978), evidence in this research shows that the fanlike canalicular processes in *breviceps* serve for sifting and scooping of diatoms, some unicellular green algae (*Closterium* sp., *Cosmarium* sp.), and detritus. *Navicula* spp. were the most common diatoms in gut dissections in the feeding areas of the mud shore habitats. However, on many occasions segments of *Oscillatoria* sp. and *Melosira* sp. were found in the guts of *breviceps* (Fig. 12) and *quadrituberculata*, which could indicate that they are able to rasp off segments of some algal filaments. During feeding the canalicular processes are spread into the ooze. As in *quadrituberculata*, when feeding (not drinking), the haustellum is flexed rapidly, but incompletely, while the canalicular processes fold in and out. The food particles are carried on the canalicular processes to the central prestomum. When *quadrituberculata* and *breviceps* were taking up fluid for example from a water droplet, no movement of the haustellum or canalicular processes was observed.

Dissections of the gut revealed that the entire gut of *breviceps* is similar anatomically to the gut of *quadrituberculata*. Quantitatively, the filling of the different parts of the gut often depended on the time of the day. Early in the morning some peritrophic envelopes were empty, some showed partial filling in the middle and hindgut or just in the hindgut. Fig. 12 shows the gut contents of a female *breviceps*, containing many diatoms, some detritus, *Closterium* sp., and *Oscillatoria* sp. In most cases when the guts showed some filling, they contained detritus or sand particles, and in many instances the detritus constituted 50–90 percent of the gut contents.

Qualitatively, the composition of the crop and midgut contents appeared similar. In this work, it was found that the membrane was distinctly visible in fresh or in preserved adults especially if it enclosed food particles. The peritrophic envelope was so distinctly visible because of a space between it and the gut wall. Furthermore, the membrane (envelope) became clearly visible because in the fall it turned light red in many of the older *quadrituberculata* and *breviceps* collected in the field. In dissections, the peritrophic envelope could easily be pulled out of sections of the gut (Fig. 12). Dissections showed that *breviceps* has the anterior and posterior spinulose plates of the rectal valve which could account for peritrophic envelope transport and fragmentation.

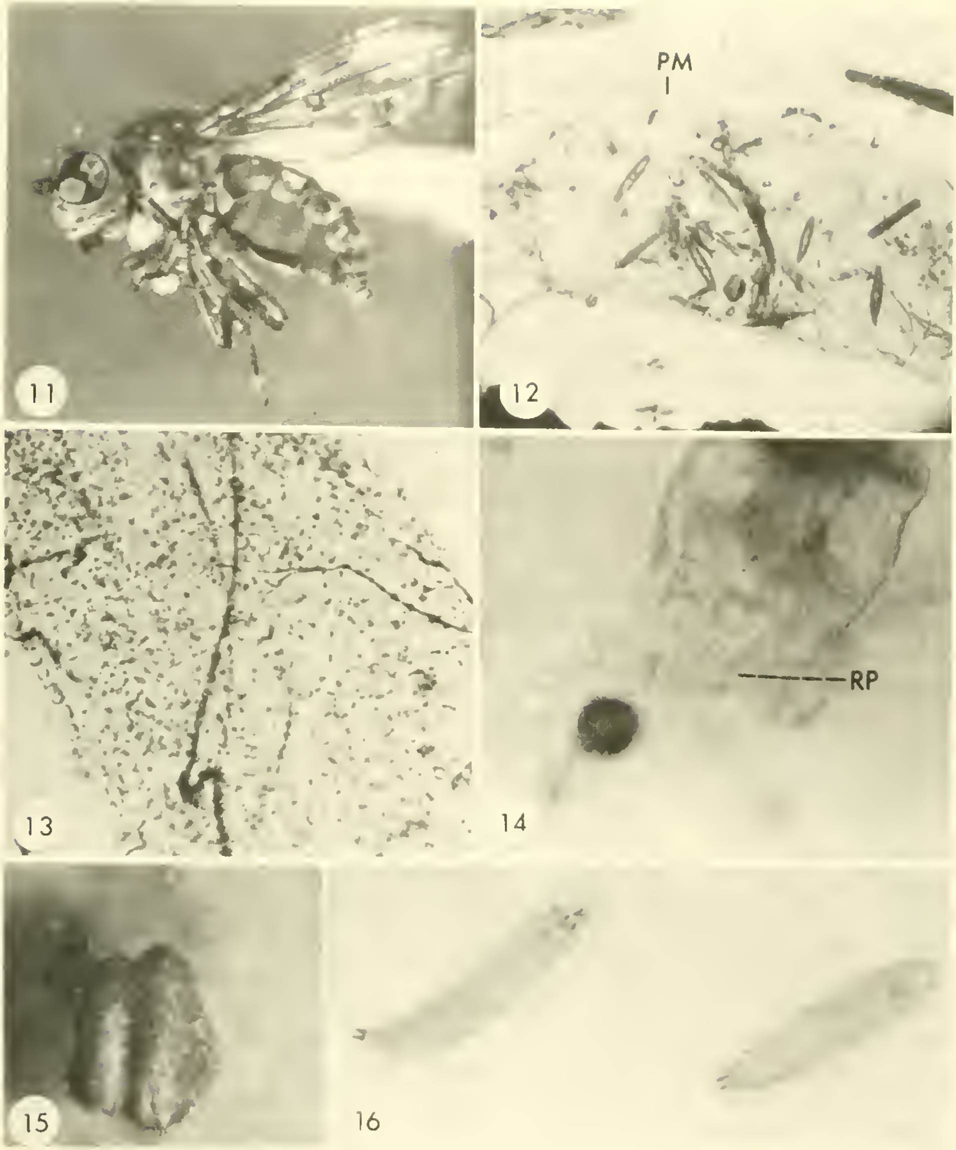
The following daily activity rhythm was observed during 24-hour sampling and observation periods and during the periodic field collecting. The daily activity rhythm on mostly sunny days, with temperatures above 20°C, was different from rainy or cold days.

During darkness adults of *aquila, breviceps,* and *quadrituberculata* were observed roosting almost exclusively on green vegetation immediately next to or on the mud shore where they fed. Adults of these three species were often intermixed and as close as 1 or 2 mm from each other on a grass blade. The arrangement was most often head to tail and headed upward beginning at a few mm to about a meter above the mud.

No feeding was observed during darkness but the onset of light did not seem to be a stimulus or the only stimulus for the *Parydra* to start feeding. Even after sunrise and at temperatures around 12°C, adults were not seen feeding. However, it was observed that in these early morning light hours the roosting adults were much more easily disturbed and stimulated to fly to another roosting site. We noticed that when at or after sunrise the air temperature rose to about 16°C, the number of feeding adults increased even if the sky was overcast. The number of roosting adults decreased during the same period. During the day very few adults of *breviceps* or *quadrituberculata* were seen at the night roosts.

Daytime activities consisted mostly of periods of feeding alternated with periods of cleaning and resting. Between these activities copulation and oviposition were also observed. Copulation attempts were not observed in the night roosting sites, but only during the feeding, cleaning, or resting periods in the feeding area.

During the feeding, or grazing period, which generally started about noon, the flies moved over the substrate tapping it at various spots with one or both fore tarsi, but more often with the proboscis in search for food. In tanks with substrate low in diatoms, the adults of *breviceps* moved around and probed the substrate with their proboscises in various spots much more often and fed less than the same insects on mud rich in diatoms. When small spots of substrate rich in diatoms were placed in tanks with substrate poor in diatoms, *quadrituberculata* and *breviceps* often flew directly to these spots or found them very quickly by probing on the substrate. Analysis of substrate samples from the field showed that most adults fed on a mud shore at the places where the food density was highest. The adult found an adequate feeding spot by moving and probing the substrate with the



Figs. 11–16. *Parydra breviceps.* 11, Female, gravid, 19×. 12, Female, content of peritrophic envelope [membrane] (diatom spp., *Oscillatoria* sp., *Closterium* sp.), 300×. 13, Male, gut containing oil droplets, 300×. 14, Adult, rectal valve with rectal plates, 300×. 15, Two eggs with fecal covering and opened micropyle, 45×. 16, Two first-instar larvae, dorsal view, right larva retracted, 45×.

proboscis. When this spot was found, it started feeding with minute anteroposterior oscillations of the proboscis and larger lateral movements of the whole head, leaving a zig-zag feeding track on the diatom-rich substrate. The feeding activity of *quadrituberculata* and *breviceps* was often accompanied by dipping movements of the abdomen. Defecation occurred during feeding and when the abdomen was characteristically dipped. Fresh feces, which were released on the substrate while feeding, had a very dark brown color, whereas the feces in the roosting sites looked more like the egg covering.

During the feeding period the proboscis was periodically retracted for about 1 sec and then feeding resumed. The anteroposterior oscillations of the proboscis and abdominal dipping movements were observed only when the insects were feeding on substrate. When the same insects were observed taking up fluid from wet filter paper or from a water droplet, no oscillations of the proboscis or dipping movements of the abdomen were observed.

Grooming or cleaning often occurred after *breviceps* moved to a new feeding spot and after a disturbance. Grooming in *breviceps* consisted of rubbing the hindlegs (tibiae and tarsi) along the wings, rubbing mid- and hindlegs together, rubbing hindlegs against each other, rubbing hindlegs over abdomen, thorax, and even the eyes, forelegs rubbing against each other and fore tarsi cleaning eyes, face, and genae. Disturbances in the roosting site at night and at the resting sites during the day often initiated this cleaning activity. Mating, which was observed to take place during feeding activity, was also very often succeeded by grooming.

In *breviceps* no courtship posturing was observed in the field or in the laboratory. Copulation was only observed when the female was feeding. The male either flew towards the female, landing on the substrate about 5 cm away from the female, and then just leaped on the female, most often from behind, or the male approached the female while both were feeding and after some hesitation, stopped feeding and jumped the female from behind from 1 to 3 cm distance. In *breviceps*, in about three out of ten trials in which mounting was not successful, the female shook the male off before copulation could take place. Sometimes the male was successful with its second or third try. It appeared that females did not allow any immediate subsequent mounting after copulation took place. During copulation in *quadrituberculata* the male grasped the female with his fore tarsi at the basal costal area of each wing and separated the wings of the female with its hind tarsi. The male grasped the abdomen of the female with the mid and hind tarsi. The male assumed an angle of approximately 60 degrees with the longitudinal axis of the female. During mounting and copulation the female continued feeding and moving around on the substrate. Copulation lasted from just a few seconds to more than a minute. In the post-insemination phase of *breviceps*, dismounting appeared to be initiated by the female flexing her wings, trying to brush off the male with her hindlegs, and by vigorously moving her abdomen.

Besides feeding and grooming, *breviceps* also showed resting behavior. After feeding for several minutes or after grooming, the flies often moved to a rock, fallen leaf, or another piece of vegetation in the feeding area, or often just stayed on the mud and remained motionless for up to 30 min. Sometimes grooming was also observed during these daytime resting periods. Generally the daytime resting periods of *breviceps* and *quadrituberculata* were within the feeding area. The insects were also much more alert during their resting periods than during the roosting periods.

Data show that *breviceps* is more abundant in narrow mud shores with interspersed or closeby vegetation. No *breviceps* were ever collected in an artificially created mud flat along a narrow mud shore which otherwise had a small, relatively constant population of the species.

Oviposition and fecundity.—In laboratory-reared *breviceps*, mating occurred within 1 to 3 days after emergence. The first eggs were laid 4–5 days after emergence and egg laying continued for 8–14 days. In field-collected *breviceps*, mating and oviposition could be observed in the laboratory the same day the insects were collected.

A maximum of 115 eggs and developing eggs were found in a dissected specimen of *breviceps* which was reared in the laboratory. A female of *breviceps* collected in the teneral stage at East Fork of Four Mile Creek in Hueston Woods State Park, Ohio, laid 226 eggs within 16 days. One hundred and sixty-four eggs were deposited in groups of two and 62 singly. Females reared in the laboratory laid between 33 and 220 eggs. The first eggs laid were mostly deposited singly. Most eggs were usually deposited in groups of two (Fig. 15), rarely in groups of three.

Oviposition was most often observed from midafternoon till roosting time. In the field, eggs of *breviceps* were found side by side with eggs of *aquila* and *quadrituberculata*. Eggs were most often deposited on objects within the feeding area. Fewer eggs were found at the roosting sites. Eggs were mainly deposited on rocks, pieces of glass, pieces of metal, fallen leaves, pieces of wood and on vegetation growing in or adjacent to the feeding area and as high as 2 m above the water level.

In the laboratory, if *aquila, breviceps,* and *quadrituberculata* were reared in the same tank, eggs of the three species were deposited side by side. In the holding tanks the three species laid their eggs on rocks, pieces of wood, dead or growing vegetation, and on the glass walls of the tank. If there was only mud in the tank, all eggs were deposited on the glass walls of the tank. Most eggs on any substrate, whether rock, vegetation or glass, were deposited only millimeters above the mud. No eggs were deposited on the mud or on dry sand. When the female of *breviceps* had selected her ovisite, she often remained there motionless for sometimes 1 minute before ovipositing. Prior to and during oviposition, there was a very slight dipping movement of the abdomen. The eggs adhered to the substrate and immediately after ovipositing the female covered the eggs with a green layer of feces consisting of variable proportions of empty and broken diatom frustules, mixed with light-green pigments.

Development.—In the laboratory, development from egg to adult lasted 14–17 days in 13 different holding tanks and 12 Petri dishes at temperatures from 20–26°C. The 25 females of *breviceps* used in this experiment laid a total of 1300 eggs, from which 777 larvae eclosed after an incubation period of 3–4 days. Each of the three larval instars lasted 3–4 days and the puparial phase lasted 2–3 days. A total of 364 puparia were counted. About 210 adults of *breviceps* emerged from these puparia. At the temperature of 30°C, development from egg to adult lasted 21–22 days in five different holding tanks and 9 Petri dishes. The eggs hatched after about 4 days, each larval instar lasted between 3–5 days, and the puparial phase lasted 2–4 days. At 30°C very few eggs developed to puparia or adults. The females of *breviceps* laid an average of 52 eggs in this experiment. In four of the five holding tanks only about 2 out of 52 eggs completed development to the adult stage.

In another experiment, two virgin males and two virgin females of *P. breviceps* and of *quadrituberculata* were placed in one holding tank with diatom-rich substrate. The females of *breviceps* laid an average of 96 eggs, whereas the females of *quadrituberculata* laid an average of 404 eggs. The first *quadrituberculata* emerged

14 days after the first oviposition was observed and the first *breviceps* 16 days after the first oviposition. Emergences in both species continued for 27 days. In the first part of the emergence period the *P. quadrituberculata* were much more numerous until the latter part of the period when emergences of *breviceps* became more numerous. A total of 70 *quadrituberculata* and 18 *breviceps* emerged. Therefore, in *quadrituberculata* 8.6 percent of the eggs developed to the adult instar whereas in *breviceps* 9.5 percent of the eggs developed to adult instar.

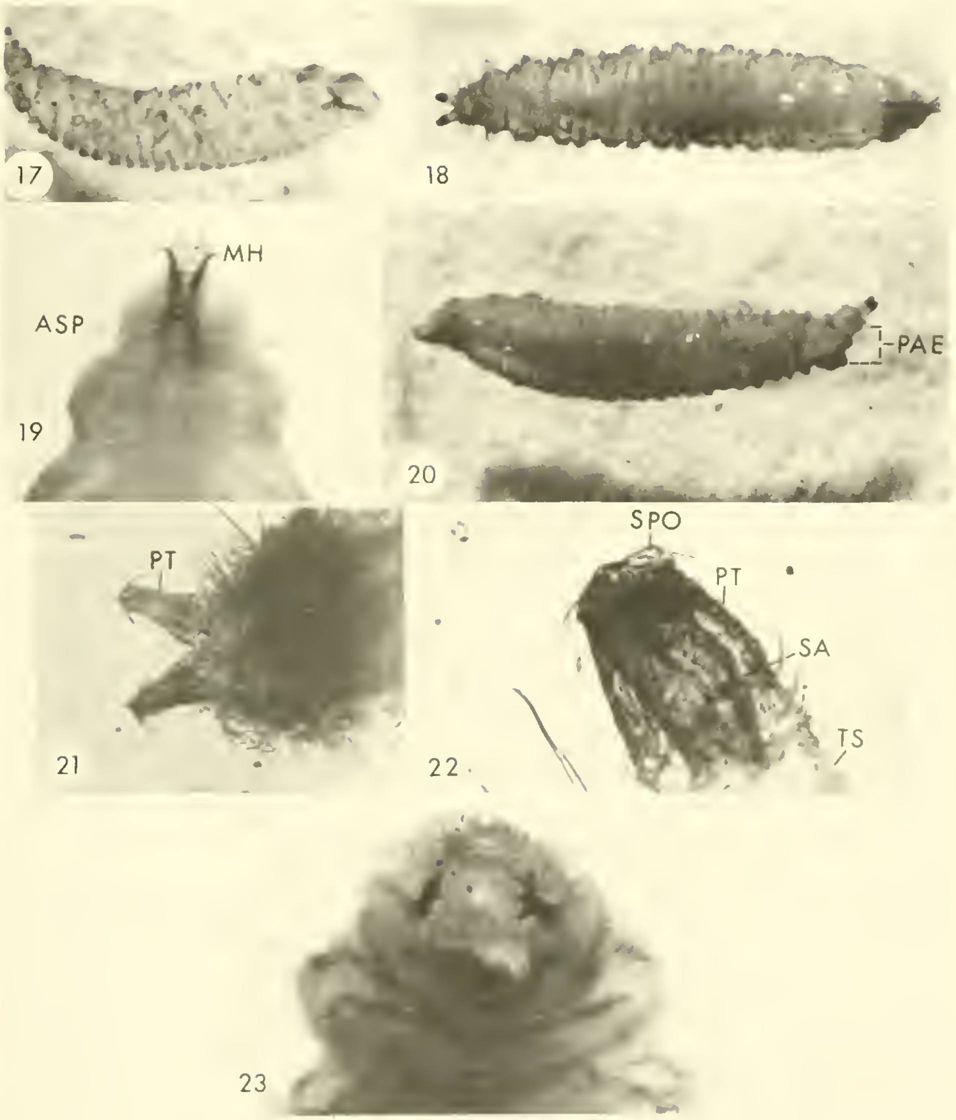
Larva.—Very few larvae of *breviceps* were collected in the field. In an attempt to determine where larvae of *breviceps* occur in their natural habitat, 15 first-, second-, and third-instar larvae were released on mud shores where adults had been seen feeding. The general tendency was to move downward on a slope. When the larvae reached a little depression in the mud they burrowed into the substrate.

In the laboratory, it was found that larvae of *quadrituberculata* and *breviceps* moved toward a good food source without being in direct contact with it. When fresh diatom-rich substrate was added to the diatom-poor substrate present in the tank, within 15 to 30 minutes most larvae were found in the small area of diatom-rich substrate on one end of the tank. When the new substrate was added, some larvae were as far as 30 cm away from the new food source.

Deonier (1972) and Deonier and Regensburg (1978) reported that diatoms constituted the vast bulk of the gut contents in adults of *quadrituberculata* and that the guts of the larvae were packed with diatoms. Thier and Foote (1980) found diatoms and a small quantity of *Oscillatoria* sp. (as the only non-diatom algal genus) in field-collected larvae of *aquila* and *quadrituberculata*. In this study, besides the main constituents of diatoms, frequently *Oscillatora* sp., *Closterium* sp., and *Cosmarium* sp. were found in larval and adult guts.

Thier and Foote (1980) indicated that food particle size could be a mechanism segregating *Parydra* species. Experiments in the present study also showed that food particle size is important. Larvae of *breviceps* that were placed on plates containing diatoms of 0.02 mm length or more died after a few days. Dissection of the guts showed that they were either empty or that they contained only a few of the rare smaller diatoms occurring on those plates. Larvae of *breviceps* could feed and develop only when placed on plates containing mainly diatoms of 0.014 mm maximum length. However, larvae of *quadrituberculata*, even first instar, were found to be able to feed on diatoms of 0.02 mm, 0.03 mm, and larger lengths. This could be a major determinant of overall abundance of the two species. Larvae of *breviceps* could be successfully raised in holding tanks on diatom-rich substrate, because those diatoms were scraped from rocks in flowing water in order to obtain many smaller-sized diatoms.

In dissections of adults and larvae there was generally a striking difference in the amount of sand particles or detritus found in the gut and also in the degree of fragmentation of the diatoms. We believe that these two facts are interrelated. In the adult, quite often when the number of diatoms on the substrate was low a large part of the gut content was detritus. As already mentioned, one of the functions of the detritus could be to pack the gut and ensure diatom fragmentation through gut contractions, mostly in time of low diatom density. In the larvae, very little diatom fragmentation could be found in over 50 dissections of all three larval instars. Therefore, it can be assumed that detritus is not important in the larvae to help pack the gut to ensure diatom fragmentation.



Figs. 17–23. *Parydra breviceps*. 17, Second-instar larva, lateral view, 45×. 18, Second-instar larva, dorsal view, 45×. 19, Anterior end, ventral view of third-instar larva, 50×. 20, Third-instar larva, lateral view, 20×. 21, First-instar larva, posterior spiracles, lateral view, ventral view of larva, 300×. 22, Third-instar larva, posterior spiracle, lateral view, 300×. 23, Third-instar larva, headlobe retracted, anterior spiracles visible, 90×.

Pupariation.—In laboratory observations, larvae restricted their movements to the substrate they were feeding on until shortly before pupariation. One or two days before pupariation the third-instar larvae crawled on the covers of the Petri dishes and as high as 30 cm on the glass walls of holding tanks. To investigate if this larval movement was associated with food searching, control and experimental groups of 10 larvae each were individually placed on diatom-rich substrate in Petri dishes. In the control group, the larvae fed on the same substrate for the duration of the experiment (7 days) but in the experimental group, fresh diatom-rich substrate was added every day to the Petri dish. No difference was observed in the two groups in larval movement from the substrate onto the Petri dish covers. Because this movement happened shortly before pupariation, it seemed obvious that the larvae were searching for a place to pupariate. *Parydra breviceps* were rarely observed pupariating in the flat substrate they fed on. If they pupariated in the mud, it was on elevated places were the mud was drier. When small mounds of fine, dry quartz sand were placed on the mud, no larvae chose those drier areas for pupariation. In the laboratory, most *breviceps* pupariated along the glass walls of holding tanks just a few millimeters above the mud or in thin layers of mud covering rocks, or in mud at the base of plants which was somewhat elevated. Even the puparia on the glass walls had a thin mud covering, carried up with the setulose integument of the third instar. If the mud around the puparium was allowed to dry out, the adult often did not emerge. When the holding tanks were covered with clear plastic to insure high air humidity on the inside, puparia could be found as high as 30 cm upon the glass walls.

This selection of shallow or superficial pupariation sites by larvae of *breviceps* is in contrast to the deeper sites in the mud substrate selected by larvae of *quadrituberculata*. Beginning in the third larval instar of these species, there is a complete reversal in the ratio of postanal to preanal length of the body, with the postanal being 13.5 and 10 percent of the preanal length respectively for *breviceps* and *quadrituberculata* in the second instar in contrast to 8.7 and 16.7 percent respectively in the third instar. This is vastly accentuated in the puparium which in *breviceps* has a short, relatively straight postanal region, or "respiratory tube" (13.7 percent of preanal length), but which in *quadrituberculata* has a postanal elongation 50+ percent of the preanal length and upturned.

Overwintering.—In the fall of 1979 and 1980, when the night temperatures dropped below freezing for several nights, the number of adult *aquila, breviceps,* and *quadrituberculata* observed in the feeding or roosting areas or collected with the aerial net dropped significantly. In October and November of both years when the day temperatures did not reach 10°C, no *Parydra* were collected in the feeding or roosting area with an aerial net. If the day temperatures were above 10°C, all three species were collected in low numbers (between 1 and 10 specimens per species per 100 sweeps) at sites 1 and 2. The relative number of *breviceps* increased, and as many or more *breviceps* than the other two species were collected at sites 1 and 2 in October and November of 1979 and 1980. *Parydra breviceps* collected at the end of October and in November showed increasingly higher numbers of diatoms in their guts. For example, on November 9 and December 8, 1980, when the air temperatures rose close to 20°C a total of 0 *aquila,* 11 *breviceps,* and 0 *quadrituberculata* were collected with an aerial net. The guts of these flies were heavily packed with diatoms, and contained some green pigments and practically no sand. The highest number of diatoms observed in *breviceps* all year was found in these specimens.

On January 17, 1980, with no snow on the ground, one gravid female *breviceps* was caught with the aerial net at site 1. The gravid female was taken to the laboratory and placed alone in a holding tank with diatom-covered mud. No eggs were found in the tank until January 30. The female *breviceps* laid a total of 52 eggs and died 32 days after it was put in the holding tank. Nineteen days after the first eggs were found in the tank, the first emergences of 2 males and 2 females were observed and by March 5, 1980, a total of 12 males and 7 females had developed from the eggs of this overwintering female.

In February 1980, after a light snowfall and at ambient air temperatures of −7 to 0°C, a total of 3 males and 6 females of *breviceps* were collected with the shoreline flushing technique. In February 1980 and January 1981, substrate and vegetation samples brought into the laboratory from site 1 and site 2 and placed in holding tanks yielded 1 male and 3 females of *quadrituberculata* within a few hours. No larval activity, puparia or later emergences were observed in any of the samples. In February 1980, 5, and in February 1981, 2 solar-heated winter emergence traps were set up along Harkers Run and Four Mile Creek. Both years the traps were regularly checked until March 20, and they yielded a total of 1 *breviceps* and 6 *quadrituberculata*. Therefore, we conclude that *breviceps*, like *quadrituberculata*, overwinters as adults and perhaps as puparia in the study sites.

Mortality agents.—On May 23, 1980, a common toad bug, *Gelastocoris oculatus* Fabricus (Hemiptera: Gelastocoridae) was observed leaping on an adult of *quadrituberculata* and carrying it away. The prey and the predator were collected and the prey had a punctured thorax. However, in the laboratory no predation by toad bugs on *Parydra* could be observed. On June 3, 1980, 35 laboratory-reared *quadrituberculata* marked with red fluorescent spray paint on their wings were released in a natural habitat. The next day no marked *quadrituberculata* were seen alive, but 14 marked wings were found on the mud at the place of release.

Ochthera mantis (DeGeer) is a potential predator, but no predation by it on *breviceps* was observed in the field or in the holding tanks. *Ochthera mantis* were often seen side by side with *aquila*, *breviceps*, or *quadrituberculata* on the mud shores and while roosting.

On June 11, 1981, at 0400 hours a spider (*Schizocosa crassipes* Walckenaer) was observed in the light of a flashlight to leap on and kill a *quadrituberculata*. On June 18, 1981, at 0400 hours a spider (*Micrathena gracilis* Walckenaer) whose orb was in the roosting area of the *Parydra* was collected. The orb had a "food package" on it, containing 3 adults of *quadrituberulcata*.

The fact that adults, larvae, and puparia of *Parydra* often aggregate, especially during drought conditions and also, as found in this work, in especially diatom-rich depressions within a mud shore, facilitates predation by shore birds. Deonier and Regensburg (1978) found numerous probing marks of killdeer in the ooze at Brandywine Creek. Reeder (1951) found adults and immatures of various Ephydridae in the stomachs of certain salt-marsh feeding plovers and sandpipers. At site 1, killdeer (*Charadrius vociferus*) and common snipe (*Capella gallinago*) could often be seen feeding. Numerous probing marks in the ooze were found where adult *Parydra* could be seen feeding and where larvae of *Parydra* could be collected from the ooze.

Predation on *aquila*, *breviceps* or *quadrituberculata* eggs has not been observed in the field or in the laboratory. However, potential egg predators were often associated with the *Parydra* populations. Deonier and Regensburg (1978) stated that the fecal covering is an imperfect defense against egg parasitism. Thier et al.

(1976) reported rearing *Anaphes* sp. (Hymenoptera: Mymaridae) from eggs tentatively identified as *quadrituberculata.* Meyers (1981) found *Anaphes* sp. (Hymenoptera: Mymaridae) to be an egg parasite of *aquila* and *quadrituberculata.*

Parasitic mites have been found on *Hydrellia griseola* (Fallén) (Deonier, 1971) and, in the present study, these mites were found on adults of *aquila, breviceps,* and *quadrituberculata* from all three sites. In 1980, mites were found on field-collected *Parydra* from June 19 until September 13, when the number of *Parydra* decreased considerably. In 1981, parasitic mites were found in almost every field collection of *Parydra* from June 12 to July 23 when the number of adults decreased in the field.

Nematodes were found in the abdomen of field-collected adults of *aquila, breviceps* and *quadrituberculata.* In 1980, nematodes were found in field-collected *Parydra* from July 17 to October 10 and in 1981 from June 17 to August 22. Nematodes were often found in tenerals of the three species.

Very few eggs, larvae, or puparia of *breviceps* were collected in the field. In the few specimens no egg, larval or puparial parasites could be detected. Meyers (1981) attempted to study the rates of parasitism for larval populations of *breviceps* and *quadrituberculata.* However, he could not find populations of immatures of *breviceps* in the field. Observations were made on *Kleidotoma* sp. (Hymenoptera: Eucoilidae) in the laboratory where the wasps could be observed to attack larvae of *quadrituberculata,* but not larvae of *breviceps.*

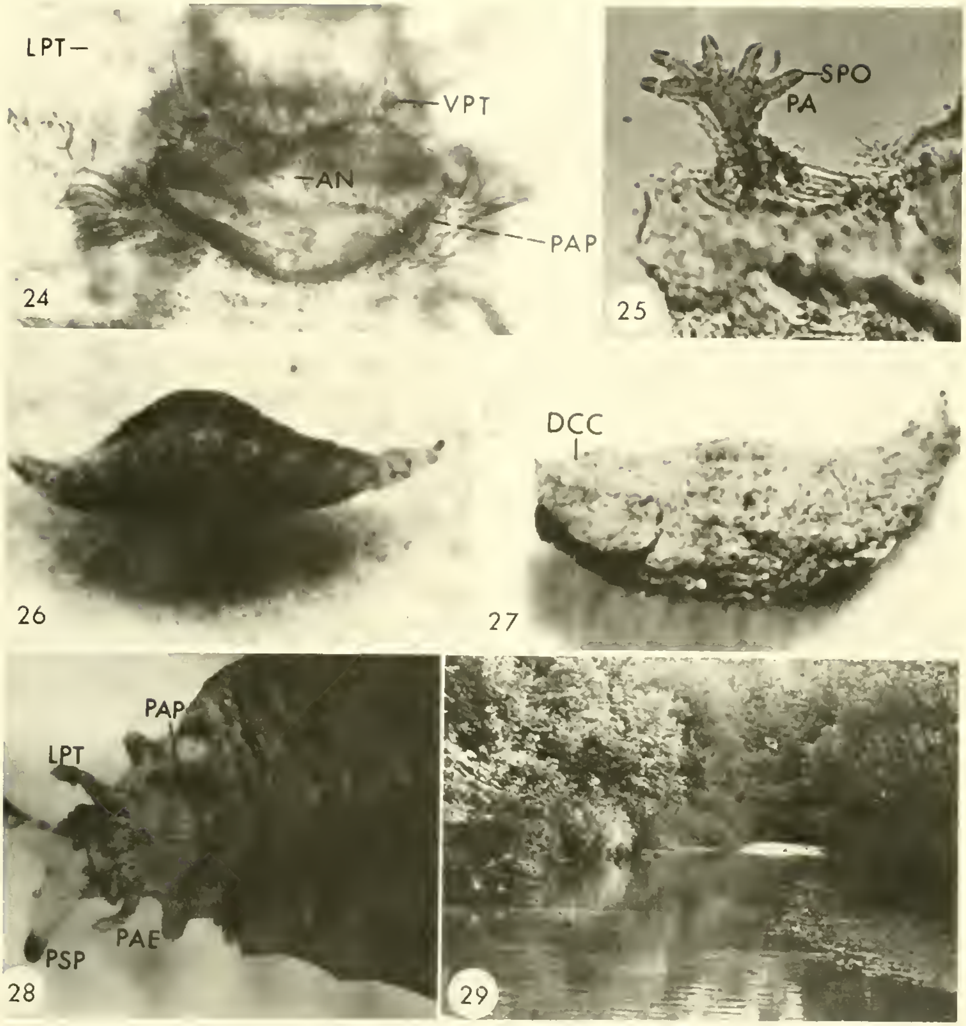
When laboratory colonies of *Parydra* were infested by snails, which feed on the mud, the larvae and the adults of the three fly species died within a few days. Dissections revealed that the guts of these immatures and adults were empty, while immatures and adults in other holding tanks with the same substrate, but without snails, developed and reproduced.

Frequent and heavy precipitation is believed to be a major mortality factor. Heavy precipitation washed the algae off the mud shores and frequent precipitation did not allow the accumulation of an adequate food density on the mud shores. Rising water level due to heavy precipitation diminished the area of exposed mud shores and therefore diminished the feeding areas of the *Parydra.* Possibly most important as a mortality agent of the three species were these effects of heavy precipitation and the resulting large water fluctuations. During heavy rains many eggs and larvae were washed off the mud shores or ended up being covered by shifting substrate when the water level rose drastically.

Descriptions of Immature Stages

Egg (Fig. 15).—Length with fecal covering 0.61–0.73 mm ($\bar{x} = 0.67$); length without fecal covering (length of chorion) 0.51–0.60 mm ($\bar{x} = 0.52$ mm); width 0.16–0.21 mm ($\bar{x} = 0.19$ mm). Chorion microgranulose, hyaline; newly laid eggs nearly white, elliptical, convex dorsally, nearly flat ventrally (based on 55 specimens laid in the laboratory).

First-instar larva.—Length 0.66–1.8 mm; width 0.1–0.23 mm. First instar similar to third instar except in the following characters (Figs. 16, 19). Furcate structures absent; only 1 pair of suprabuccal teeth apparent. Anterior spiracles absent, with only slight protuberance at their future site. Perianal pad proportionately larger in the first instar; in contrast to *P. quadrituberculata,* postanal elongation relatively longer than in third instar; postanal elongation is about 15 percent of



Figs. 24–29. *Parydra breviceps.* 24, Third-instar larva, perianal pad, 60×. 25, Third-instar larva, left anterior spiracle, posterior view, five papillae, 300×. 26, Puparium, lateral view, dorsocephalic cap removed, 15×. 27, Puparium, dorsal view, covered with substrate debris, dorsocephalic cap opened. 28, Puparium, ventral view of posterior end, 50×. 29, Site 2, the mud shore in right side of picture at Harkers Run.

preanal length, whereas in third instar it is 8.7 percent. Posterior spiracles distinctly tapered, proximal end ca. 66 percent wider than distal end, with 2 spiracular orifices (Figs. 10, 21), no spiracular remnant, and 4 spiracular hydrofuge processes. Cephalopharyngeal skeleton (Figs. 5, 6) length (excluding mouthhooks) 0.09–0.13 mm. Pharyngeal sclerite not paler; mouthhooks more pointed and less sharply curved distally and apparently fused basally with ends of dental sclerites; anterior arms of hypostomal sclerite fused, but not in tapering point as in *quadrituberculata*; parastomal bars parallel to hypostomal sclerite, fused anteriorly in a tapering point. Dorsal bridge indistinct; distal parts of dorsal and ventral cornua and anterior part of cornua next to hypostomal sclerite and parastomal bars light brown, central part of the cornua dark brown.

Second-instar larva.—Length 1.2–2.52 mm; width 0.21–0.5 mm. Similar to third instar except in following characters. In contrast to *quadrituberculata*, setulosity not shorter or paler. Posterior pair of suprabuccal teeth in facial mask proportionately longer and farther apart. Anterior spiracles smaller without real papillae, but just 3 or 4 short buds. Perianal pad less distinctly bilobate. Also in contrast to *quadrituberculata*, postanal elongation relatively longer, about 14 percent of preanal length. Posterior spiracle distinctly tapered, proximal end 66 percent wider than distal end, with 3 orifices and less distinct spiracular remnant (Fig. 9). Cephalopharyngeal skeleton (Figs. 3, 4) length (excluding mouthhooks) 0.15–0.21 mm. Mouthhooks proportionately longer and narrower, somewhat longer than hypostomal sclerite. Ligulate sclerite single, projecting slightly farther anteriad, and apparently fused basally to shorter, paler epistomal plate. Pharyngeal sclerite with dorsal bridge straplike and directed anterodorsad. No C-shaped recess on ends of dorsal cornua, in contrast to *quadrituberculata* (Deonier and Regensburg, 1978). Ventral length of pharyngeal sclerite 1.9–2.0 times the hypostomal length.

Third-instar larva.—Length 2.3–4.2 mm; width 0.56–0.9 mm. Light gray or creamy white, except light-brown posterior spiracles, setae and spinules (Figs. 19, 20). Densely setulose and spinulose; integument translucent; body slightly depressed and subfusiform, tapering gradually from middle to head-lobe and to anus. Head-lobe, in ventral view of protracted state with 1 pair of conspicuously black-tipped posteriorly directed toothlike sclerites slightly anterior to mouthhooks, but closer together than mouthhooks (Fig. 20). Deonier and Regensburg (1978) mentioned that these sclerites closely resemble suprabuccal teeth shown by Muirhead-Thomson (1937). Anterior to suprabuccal teeth and farther apart, a pair of 2-segmented antennae; segments distinguished by two ring-shaped light-brown sclerites; proximal ring-shaped sclerites of antennae incomplete anteriorly; antennae slightly longer than posterior suprabuccal teeth with terminal segment cylindrical, round and apically and longer than first segment. Prothoracic dorsum with 2 dorsal transverse, irregular rows of sharp, posteriorly-directed spinules, followed by wide zone of minute sharp spinules; center of dorsum of prothorax between antennae with small elliptical area without spinules. Prothoracic venter only sparsely spinulose. Anterior spiracles protrusile, each with 4–6 vertically aligned, digitiform papillae enlarged apically for spiracular orifices (Figs. 23, 25). Mesothoracic dorsum anteriorly with transverse area of medium-sized spinules followed by 3–5 rows of spinules, preceding a wide patch of minute microspinules and microsetulae. Venter with creeping welt consisting of central area with very minute microspinules, surrounded mainly anterolaterally by microspinules and spinules. Metathoracic dorsum with 2–5 irregular anterior transverse rows of spinules. Venter with lateral triangles or spinules followed by elliptical creeping welt. Dorsum of abdominal segment 1 with 3–5 anterior rows of setulae followed by transverse groove without setulae, preceding 2 rows of setulae. Venter of segments 1–8 each with 3 irregularly bi- or triseriate zones of setulae. Dorsum of abdominal segments 2–7 each with 3 irregularly bi- or triseriate zones of setulae with paired lateral and dorsolateral protuberances; all proturberances more or less papilliform or moundlike. Dorsum of abdominal segment 8, anterior to perianal pad with wide microsetulous zone between paired ventrolateral protuberances.

Perianal pad bilobate, protrusile, and posteriorly expansive with paired ventral postanal tubercles (Fig. 24). Postanal elongation of abdominal segment 8 ca. 8.7 percent of preanal length. Posterior spiracles gradually tapered, ca. 66 percent wider at proximal than at distal end (Fig. 22), in distal view (Fig. 8) with 4 ovoid spiracular orifices, each bordered by hydrofuge process consisting of basal attachment piece bearing 4–6 spiculate, sometimes bifurcated uniseriate setulae having, in contrast to *quadrituberculata,* no membranous web between setulae. Ovoid spiracular remnant distinct in distal view. Cephalopharyngeal skeleton (Figs. 1, 2) length (excluding mouthhooks) 0.23–0.3 mm. Pharyngeal sclerite medium to dark brown towards dorsal bridge, on bifurcation, and proximally on cornua, but light brown with brown fibrous streaks towards hyaline borders; other sclerites, except light-brown epistomal plate and piece of hypostomal sclerite next to pharyngeal sclerite and fenestra of mouthhooks, dark brown or black. Mouthhooks separated basally from hypostomal sclerite; mouthhooks slightly shorter than hypostomal sclerite; hook nonserrate and sickle-shaped; base part of mouthhooks conspicuously fenestrate with dorsal condyloid process; base part articulating posterodorsally with anterior arm of hypostomal sclerite and base of dental sclerite. Hypostomal sclerite, in ventral view, narrowing anteriorly, with hypostomal bridge located ¼ of distance from posterior end and ventral to posterior margin of shield-shaped epistomal plate. Pharyngeal and hypostomal sclerites not fused. Dorsal bridge convex and steeply angled posterodorsally. Dorsal cornua ending in partial C-shaped recess; anteroventral arm of recess with small angulate process; ventral cornua narrowing at midlength and, in contrast to *quadrituberculata,* ending in single arm. Ventral length of pharyngeal sclerite 2.2–2.5 times length of hypostomal sclerite.

Puparium.—Length 3.7–4.55 mm; width 1.1–1.4 mm. Postanal elongation 13.7 percent of preanal length. Empty puparium opaque and medium to dark brown. In contrast to *quadrituberculata,* not steeply upturned, often almost straight (Fig. 26). Venter of preanal portion straight with upturn at anterior end; dorsum strongly arched to anterior end and posteriorly towards postanal elongation. Anterior spiracles light to medium brown, borne anterolaterally on dorsocephalic cap with truncated anterior and undulant posterior margin. Cap with zones of microspinules between the dorsal parts of 2 anterior bands having 2–5 irregular rows of spinules and 2 posterior bands having, respectively, 3–5 and 2–3 irregular rows of setulae. Puparium with only slightly elevated proturberances (Figs. 26, 27) and like *quadrituberculata* with 18 more or less encircling irregularly bi- or triseriate bands of setulae between dorsocephalic cap and anterior edge of the remnant of perianal pad (in *quadrituberculata* perianal pad); with 1 more or less encircling, irregularly triseriate band of setulae and 1 wider encircling zone of serulae posterior to perianal pad. Most empty puparia dark brown to anterior edge of remnant of perianal pad and light brown from there to posterior spiracles. Remnant of perianal pad without ventral postanal tubercles. Postanal elongation very short in comparison to *quadrituberculata.* Spiracular orifices and hydrofuge processes same as in third instar; spiracular remnant much wider than in third instar.

LITERATURE CITED

Becker, T. 1926. Ephydridae (Fam. 56), pp. 1–115. *In* Lindner, E., ed., Die Fliegen der Palaearktischen Region 6, pt. 1. Stuttgart.

Bohart, G. E. and J. L. Gressitt. 1951. Filth-inhabiting flies of Guam. Bull. Bernice P. Bishop Mus. 204: 1–152.

Clausen, P. J. and E. F. Cook. 1971. A revision of the Nearctic species of the tribe Parydrini (Diptera Ephydridae). Mem. Am. Entomol. Soc. 27: 1–150.

Deonier, D. L. 1971. A systematic and ecological study of Nearctic *Hydrellia* (Diptera: Epydridae). Smithson. Contr. Zool. 68: 1–147.

———. 1972. Observations on mating, oviposition, and food habits of certain shore flies (Diptera: Ephydridae). Ohio J. Sci. 72: 22–9.

Deonier, D. L. and J. T. Regensburg. 1978. Biology and immature stages *Parydra quadrituberculata* (Diptera: Ephydridae). Ann. Entomol. Soc. Am. 71: 341–353.

Frey, R. 1921. Studien über den Bau des Mundes der niederen Diptera Schizophora nebst Bermerkungen über die Systematik dieser Dipterengruppe. Acta Soc. Fauna Flora Fenn. 48: 1–245, 10 pls.

Meyers, D. M. 1981. A behavioral-ecological study of *Kleidotoma* sp. (Hymenoptera: Eucoilidae), with notes on *Anaphes* sp. (Hymenoptera: Mymaridae). M. S. Thesis. Miami University, Oxford, Ohio.

Muirhead-Thomson, R. C. 1937. Observations on the biology and larvae of the Anthomyidae. Parasitology. 29: 273–58.

Reeder, W. G. 1951. Stomach analysis of a group of shorebirds. Condor 53: 43–5.

Thier, R. W., R. S. Zack, and B. A. Foote. 1976. *Anaphes* (Hymenoptera: Mymaridae) reared from the eggs of a shore fly (Diptera: Ephydridae). Great Lakes Entomol. 9: 205–6.

Thier, R. W. and B. A. Foote. 1980. Biology of mud-shore Ephydridae (Diptera). Proc. Entomol. Soc. Wash. 82: 517–535.

Thorpe, W. H. 1930. The biology of the petroleum fly (*Psilopa petrolei*, Coq.). Trans. R. Entomol. Soc. Lond. 78: 331–34.

Wirth, W. W. 1971. *Platygymnopa*, a new genus of Ephydridae reared from decaying snails in North America (Diptera). Can. Entomol. 103: 266–70.

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AMBLYOMMA ANTILLORUM KOHLS, 1969 (ACARI: IXODIDAE): DESCRIPTION OF THE IMMATURE STAGES FROM THE ROCK IGUANA, *IGUANA PINGUIS* (SAURIA: IGUANIDAE) IN THE BRITISH VIRGIN ISLANDS

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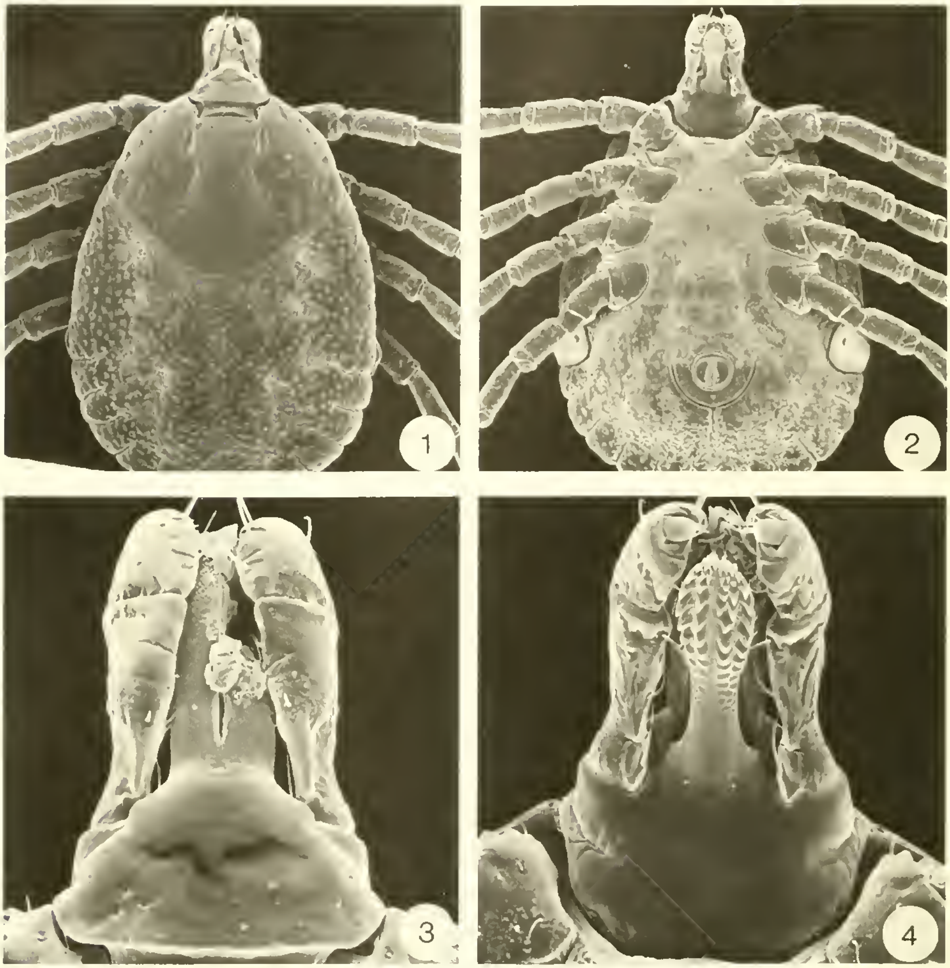
Abstract.—The nymph and larva of *Amblyomma antillorum* are described and illustrated for the first time from specimens collected on the endangered rock- or Anegada iguana, *Iguana pinguis* on Anegada Island, British Virgin Islands.

On Caribbean islands, iguana-feeding ticks of the genus *Amblyomma* comprise a small, relatively compact group of four species: *Amblyomma albopictum* Neumann, *A. antillorum* Kohls, *A. cruciferum* Neumann, and *A. torrei* Vigeuras. *Amblyomma dissimile* Koch is only found occasionally on iguanas. It is primarily a parasite of snakes and also parasitizes Amphibia.

Herein are described the immature stages of *Amblyomma antillorum* Kohls, a parasite of the rock iguana, *Iguana pinguis* (Barbour). The descriptions are based on 2 nymphs and 3 larvae, the only specimens available. Measurements (mm) are given for all specimens. Preparation of immature stages for scanning electron microscopy follows the method of Corwin et al. (1979).

Amblyomma antillorum Kohls

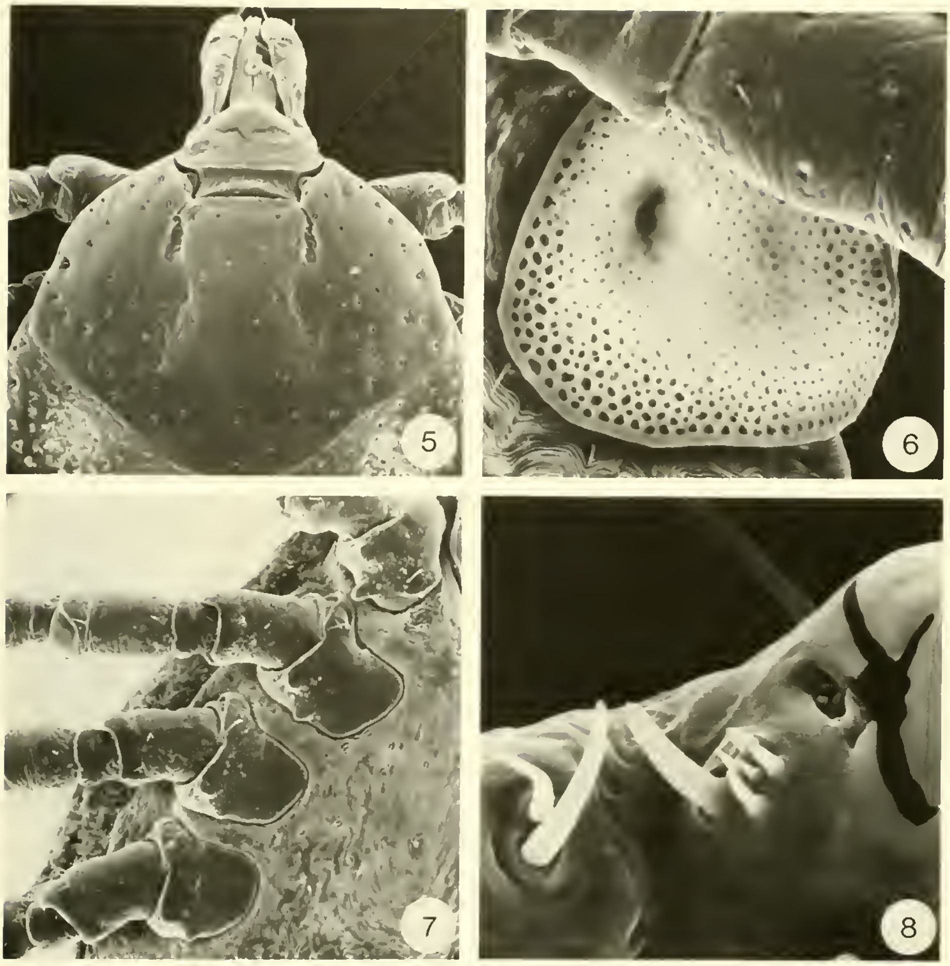
Nymph (Figs. 1–8).—*Body* (Figs. 1, 2). Length from scapular apices to posterior body margin 1.13, 1.64; width 0.86, 1.12, widest at level of spiracular plates. *Capitulum* (Figs. 3, 4). Length from posterior margin of cheliceral sheaths to posterior capitular margin 0.12, 0.11; width at level of scapulae 0.21, 0.20. *Basis capituli* dorsally (Fig. 3) ca. 2× as wide as long, triangular, cornua absent. [The specimen illustrated in Fig. 3 shows the basis capituli with two surface indentations centrally. The other nymphal specimen does not show this artifact.] Basis capituli ventrally (Fig. 4) with posterior margin convex. *Palpi* (Figs. 3, 4) 0.25, 0.23 long, segment 2 ca 2× as long as segment 3; segments decreasing in size in the order 2, 3, 1, 4; setae as illustrated. *Hypostome* bluntly rounded and bulbous anteriorly; dental formula 2/2 throughout with several minute denticles forming an apical corona; ca. 6 teeth in each file diminishing to crenulations basally. *Scutum* (Fig. 1, 5). Length 0.32, 0.33; width 0.41, 0.45; outline as illustrated; evenly distributed; *cervical grooves* short, deep, directed posteriorly; *eyes* at lateral scutal angle, not bulging or encircled by coloration. *Spiracular plate* (Fig. 6) subcircular with slight



Figs. 1–4. *Amblyomma antillorum* nymph (RML117481). 1, Dorsal view (64×). 2, Ventral view (64×). 3, Capitulum, dorsal view (318×). 4, Capitulum, ventral view (212×).

dorsal prolongation. *Legs* (Figs. 7, 8). Coxa I–IV each with two spurs, the externals slightly bulbous, the internals more pointed and decreasing in size from I–IV. Trochanters lack spurs. Tarsus I 0.26, 0.24 long; 0.07, 0.07 wide. Haller's organ (Fig. 8) with roof bifurcate; anterior pit setae number 6.

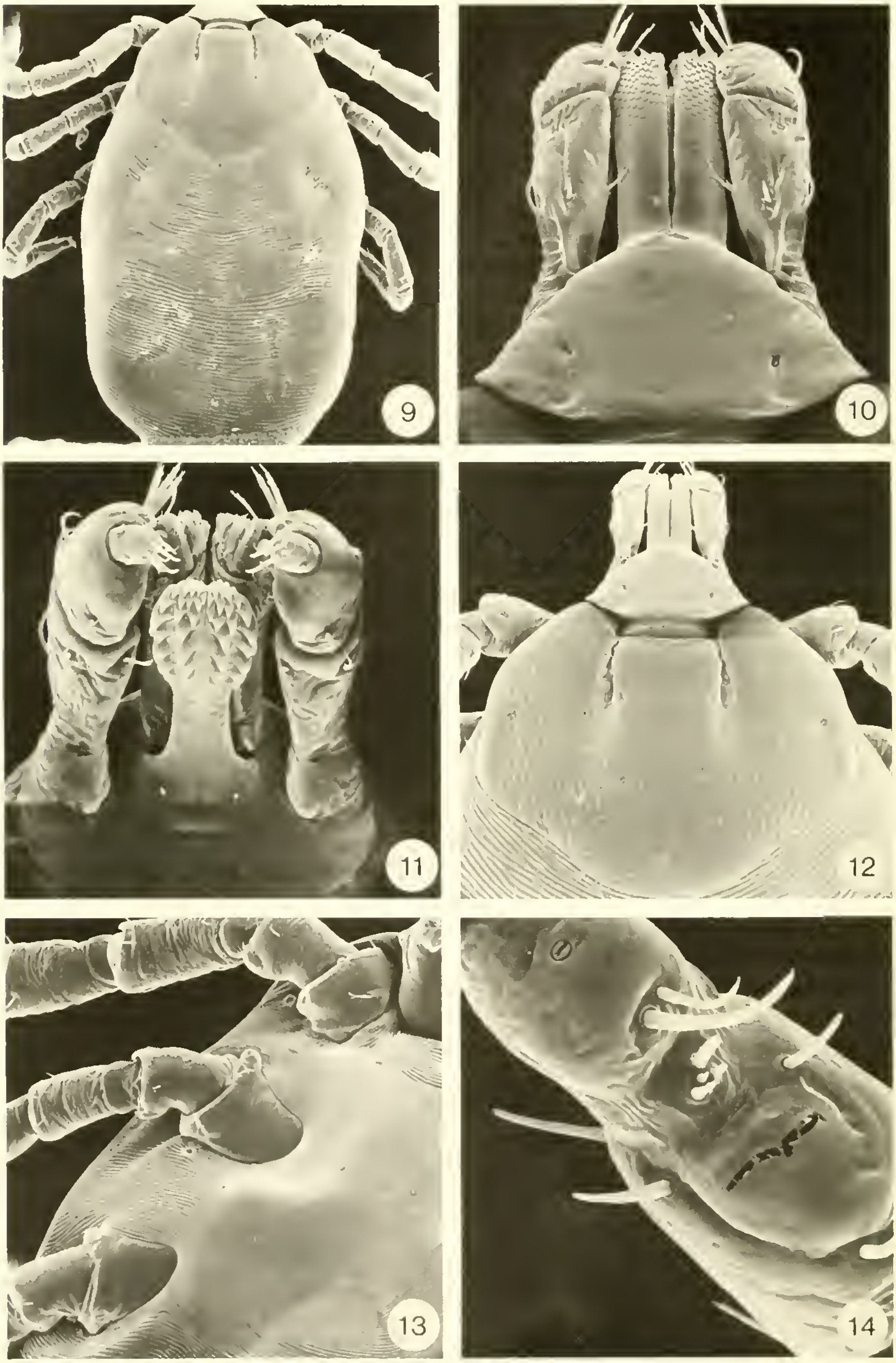
Larva (Figs. 9–14).—*Body* (Fig. 9) partially engorged; length from anterior scutal margin to posterior body margin 0.82, 0.92, 1.05; width 0.55, 0.59, 0.67 widest at level of coxae IV. Dorsal body setae number 10 pairs; 2 pairs central dorsals, 8 pairs marginal dorsals. Ventral setae 12 pairs and 1 pair on anal valves; 3 pairs sternals; 2 pairs preanals; 2 pairs premarginals and 5 pairs marginal ventrals. *Capitulum* (Figs. 10, 11). Length from posterior margin of cheliceral sheaths to posterior margin of basis capituli 0.65, 0.85, 0.81; width 0.12, 0.15, 0.14. *Basis capituli* dorsally (Fig. 10) with posterior margin straight medially then angling anterolaterally, cornua absent. Ventrally (Fig. 11) with posterior margin broadly



Figs. 5–8. *Amblyomma antillorum* nymph (RML117481). 5, Scutum (106×). 6, Spiracular plate (530×). 7, Coxae I–IV (212×). 8, Haller's organ (2120×).

rounded. Posthypostomal setae 1 minute pair. *Palpi* 0.12, 0.15, 0.14 long, suture between segments 2 and 3 distinct; setae 0 on segment 1, 4 dorsally and 2 ventrally on 2, 5 dorsally and 3 ventrally on 3, ca 9 on segment 4. *Hypostome* (Fig. 11) bluntly rounded anteriorly with a corona of fine denticles; dentition 2/2 throughout length with crenulations extending posteriorly. *Scutum* (Figs. 9, 12) 0.30, 0.29, 0.30 long; 0.41, 0.40, 0.41 wide; setae 3 pairs. *Cervical grooves* short deep parallel troughs. *Legs* (Figs. 13, 14) Coxae I–III each with a single, small, truncate spur bearing a small to minute seta posteriorly [the seta is broken off on spur of coxa I in Fig. 13]. Coxal setae, 3 on I, 2 on II and III. Tarsus I 0.15, 0.16, 0.17 long; 0.05, 0.05, 0.06 wide. Haller's organ (Fig. 14) with 5 anterior pit setae.

Material examined.—26 ♂, 1 ♀, 2N, 3L *Amblyomma antillorum* (RML117481) ex *Iguana pinguis* (♀) collected from dewlap, cloaca and hind axillary areas, Anegada Island (18°45′N, 64°20′W), British Virgin Islands, 30 Jul. 1984, James D. Lazell, Jr.



Figs. 9–14. *Amblyomma antillorum* larva (RML117481). 9, Dorsal view (85×). 10, Capitulum, dorsal view (424×). 11, Capitulum, ventral view (530×). 12, Scutum (212×). 13, Coxae I–III (212×). 14, Haller's organ (1272×).

In addition to Anegada Island, *A. antillorum* is also found on *Iguana delicatissima* on the island of Dominica (Kohls, 1969). We have recently found a collection of 11 ♂ *A. antillorum* (RML115734) in the F. C. Bishopp tick collection (Bishopp 15182) from an iguana, East Caicos Island, Bahama Islands, 28 July 1930.

SPECIES RELATIONSHIPS

Little is known about the immatures of Caribbean reptile-feeding *Amblyomma* species. The immature stages of *A. albopictum* are unknown and larvae of both *A. cruciferum* and *A. torrei* are undescribed. Thus, only the larva of *A. antillorum* is known for this group. The nymph of *A. antillorum* is inornate, which separates it from the ornate nymphs of *A. cruciferum* and *A. torrei*.

REMARKS

The host of *Amblyomma antillorum, Iguana pinguis,* is found only on Anegada of the 46 named islands forming the artificial political entity of the British Virgin Islands. This saurian is a highly endangered species, a victim of competition with goats and other feral livestock, predation by dogs and cats, and habitat destruction and hunting by man. Because these iguanas receive no protection, a program was begun in July, 1984, to relocate them from Anegada to Guana Island, a privately owned wildlife sanctuary. *Iguana pinguis* was previously resident on Guana Island but was eradicated by agriculture prior to 1900 (Lazell, pers. comm.).

The host of *Amblyomma antillorum* on East Caicos Island is surely *Iguana carinata carinata.* This iguana was listed in the genus *Cyclura* by Schwartz and Thomas (1975) as occurring on Big Iguana Cay off East Caicos Island.

Iguana pinguis is more commonly known as *Cyclura pinguis,* but I have followed Lazell (1983) who considered both the genera *Cyclura* and *Brachylophus* to be synonyms of *Iguana.*

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LITERATURE CITED

Corwin, D., C. M. Clifford, and J. E. Keirans. 1979. An improved method for cleaning and preparing ticks for examination with the scanning electron microscope. J. Med. Entomol. 16: 352–53.

Kohls, G. M. 1969. A new species of *Amblyomma* from iguanas in the Caribbean (Acarina:Ixodidae). J. Med. Entomol. 6: 439–42.

Lazell, J. D., Jr. 1983. Biogeography of the herpetofauna of the British Virgin Islands, with description of a new *Anole* (Sauria:Iguanidae), pp. 99–117. *In* A. G. J. Rhodin and K. Miyata, eds., Advances in Herpetology and Evolutionary Biology: Essays in Honor of Ernest E. Williams. Museum of Comparative Zoology, Cambridge, xix + 725 pp.

Schwartz, A. and R. Thomas. 1975. Check-list of West Indian amphibians and reptiles. Carnegie Mus. Nat. Hist. Spec. Publ. (1): 216 pp.

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A NEW SPECIES OF *PARASCOTIA* WITH NOTES ON THE GENERA *MYCTEROPHORA* AND *PARASCOTIA* (LEPIDOPTERA: NOCTUIDAE: INCERTAE SEDIS)

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Abstract.—A new species of *Parascotia* Hübner, *mineta*, is described, and the relationship and placement of the genera *Mycterophora* Hulst and *Parascotia* are discussed.

The two genera discussed were not associated as related taxa until the 1983 North American Check List of Lepidoptera (Hodges et al., p. 122) in which Franclemont and Todd placed them next to one another.

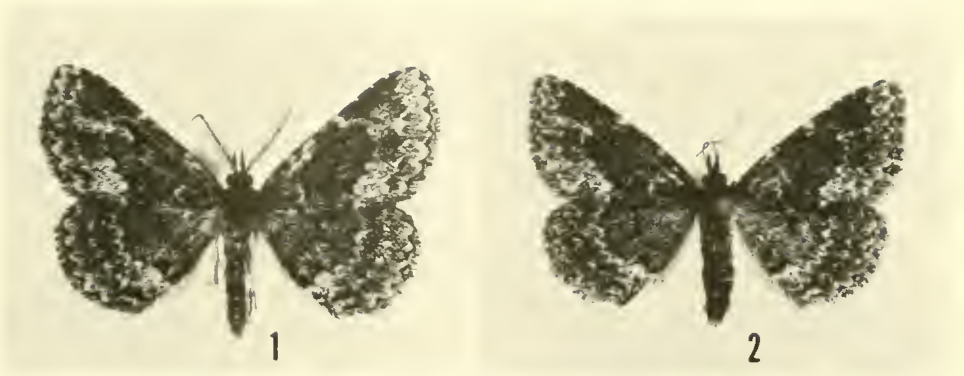
The venation of *Parascotia* Hübner and *Mycterophora* Hulst is essentially the same. In the hind wing M_2 arises well away from M_3, but below the middle of the discocellular veins, the intermediate, not quadrifid, condition and would cause the genera to be associated with either the Herminiinae or the Acontiinae. The affinities of the two genera are very problematical and will remain so until the vast complex of genera in the Catocalinae (including Ophiderinae), Acontiinae, and Herminiinae are carefully studied and the relationships among all the genera are resolved.

Parascotia Hübner

Parascotia Hübner, 1816 [1825]. Verzeichniss bekannter Schmettlinge [sic]: 314.

Type-species.—*Geometra carbonaria* [Denis & Schiffermüller], 1775. Designated by Warren, 1913, as *Phalaena Geometra fuliginaria* Linnaeus, 1761, with *Phalaena Geometra carbonaria* Esper [1799], = *Geometra carbonaria* [Denis & Schiffermüller], shown as a synonym. *Phalaena Geometra fuliginaria* Linnaeus was not one of the originally included species.

[Note: *Geometra carbonaria* [Denis & Schiffermüller] is technically a nomen nudum; if it were so treated, the species name would be attributed to Fabricius, 1787, where the original combination is *Phalaena carbonaria.* The Denis and Schiffermüller names have been discussed by Lempke (1952), and I am in agreement with his conclusions. Through the kindness of I. W. B. Nye of the Department of Entomology, British Museum (Natural History), I have been permitted to study a manuscript of K. Sattler and W. G. Tremewan (now published, 1984) on the "Wiener Verzeichniss" names. Inasmuch as the work is concerned only with European species, I believe that the question of "nomina nuda or not" should be settled to the satisfaction of European lepidopterists.]



Figs. 1, 2. *Parascotia mineta.* 1, Male. 2, Female.

Boletobia Boisduval, 1840. Genera et Index Methodicus Europaeorum Lepidopterorum: 201.

Type-species.—*Geometra carbonaria* [Denis & Schiffermüller], 1775. Monobasic. [*Geometra carbonaria* [D. & S.] is considered a junior subjective synonym of *Phalaena Geometra fuliginaria* Linnaeus, 1761.]

Bolitobia Agassiz, 1846 (1847). Nomenclatoris Zoologicii, Index Universalis: 48. An emendation of *Boletobia* Boisduval.

Type-species.—Ipso facto *Geometra carbonaria* [Denis & Schiffermüller], 1775.

Kara Matsumura, 1925. J. Coll. Agric. Hokkaido Imper. Univ. 15: 160.

Type-species.—*Kara sachalinensis* Matsumura, 1925. Original designation and monobasic. [*Kara sachalinensis* Matsumura is considered a junior subjective synonym of *Phalaena Geometra fuliginaria* Linnaeus, 1761, and ipso facto of *Geometra carbonaria* [Denis & Schiffermüller], 1775.]

Preoccupied by *Kara* Stebel, 1910.

The moths are geometriform with long, porrect palpi; the antennae of the males are pectinate, the rami shortening toward the apex; the antennae of the females are simple. In these characters the moths are very similar to those of *Mycterophora.* The venation is essentially like that of *Mycterophora,* but in the hind wing M$_3$ and CuA$_1$ are short stalked, whereas in *Mycterophora* the two veins arise separately from the discal cell. The tympanal hood, if it can be so considered, appears to be membranous, and the spiracle of the first abdominal segment is of uncertain position. In some specimens it appears to face the tympanum and in other specimens to face laterally. This anomalous condition can probably be attributed to the deformation of the membranous areas brought about when the specimens dry after being caught and killed. In slide mounted preparations it appears lateral, but unlike any of the Herminiinae that I am familiar with, although it is suggestive of the group. *Mycterophora* has the spiracle inside, enclosed by, the small, well sclerotized hood.

The larva of the Eurasian *fuliginaria* is well known in Europe and has been described and figured many times. Two colored figures may be found in Spuler

(1910, vol. 4, pl. 38, fig. 10, and pl. 49, fig. 25). The larva lacks the prolegs on abdominal segments 3 and 4, and is a semi-looper; the hairs are long and curved. Swain (1950, p. 186–200) gives an excellent account of the life-history with figures of all the stages as well as of the very interesting cocoon suspended by a silk thread at each end. The hosts of the larva are given by South (1961, p. 387) as "*Polystitus versicolor, P. abietinus, Polyporus schweinitzii, P. betulinus, Corticum vagum, Stereum hirsutum, Daldinia concentrica,* and *Paxillus panoides.*"

Parascotia mineta Franclemont, NEW SPECIES

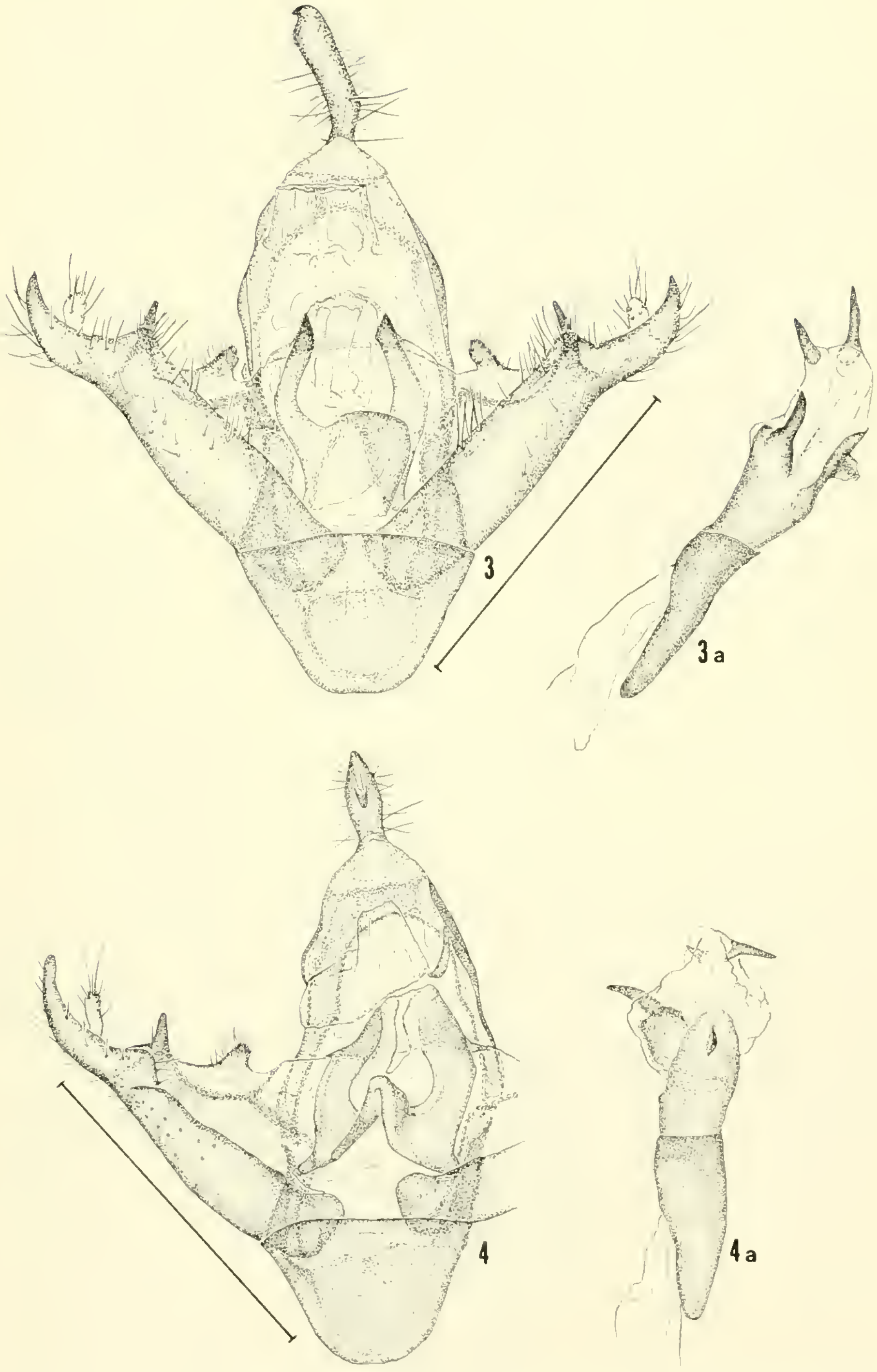
(minetus—patient)

Parascotia fuliginaria; Franclemont & Todd, *in* Hodges et al., 1983: 122; not Linnaeus, 1761. Misidentification.

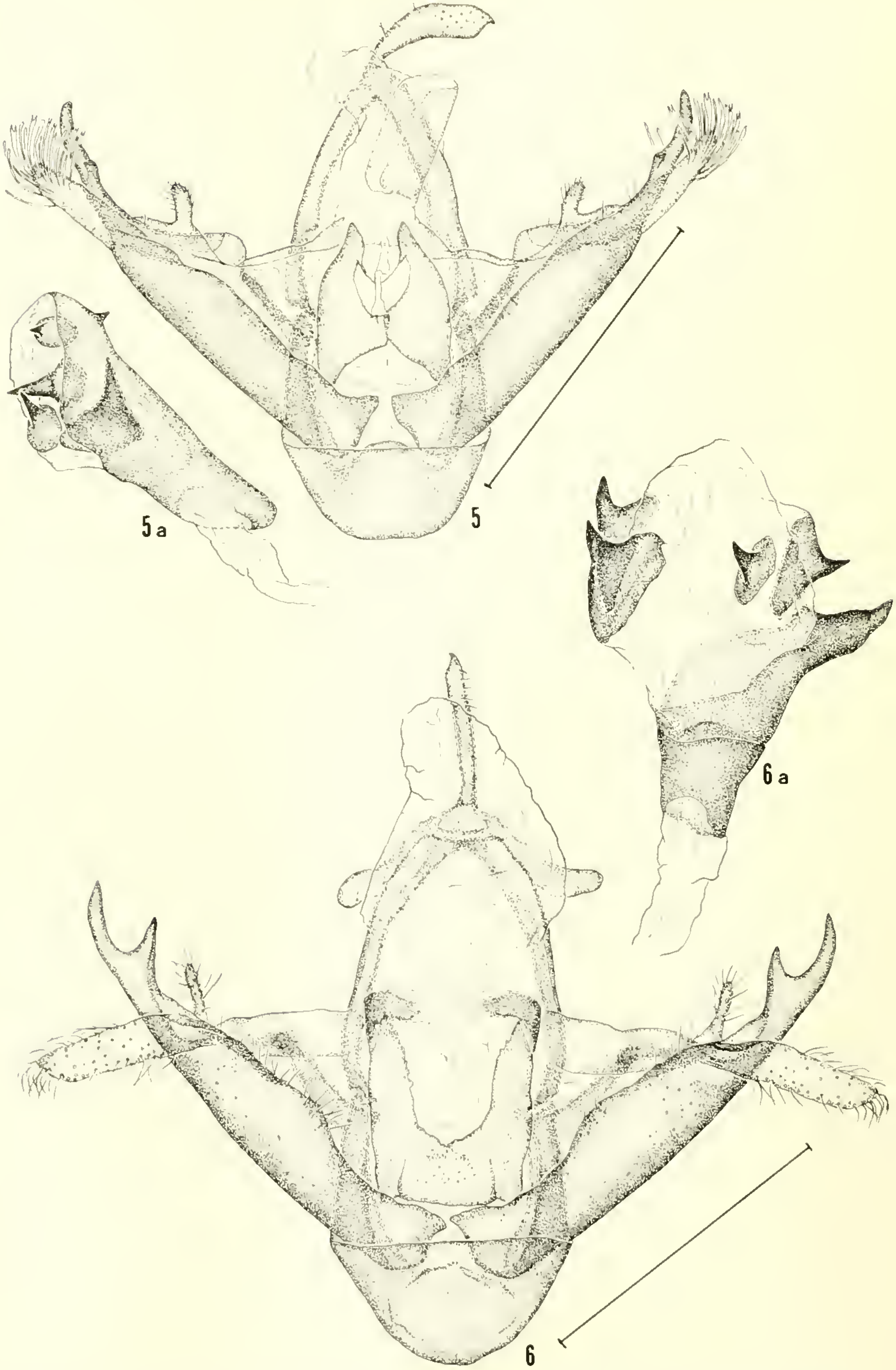
This species was first seen in 1973; intermittently over the past 12 years 15 specimens have been collected at blacklights in an area of gardens, pasture, and woodlands.

Diagnosis.—The species is fragile, very geometriform in appearance; it may be in other collections among undetermined Geometridae, or possibly confused with species of *Mycterophora.* I first decided that it was an undescribed species, but then decided, incorrectly, that it must be the Eurasian *fuliginaria.* Superficially it differs from that species by the more extensive pale areas on the wings, especially the patches on the inner margins near the anal angles, between the postmedial and subterminal lines of fore and hind wings. The male genitalia of *mineta* and *fuliginaria* (Figs. 3, 4) differ in many subtle ways and a few that are obvious; most notable in the latter category is the very different juxta of each species. The female genitalia of the two species are apparently very similar; I know those of *fuliginaria* only from figures. *P. mineta* appears somewhat similar to *nisseni* Turati (1907, p. 34, pl. 1, figs. 18, 19), a Palearctic, Atlanto-Mediterranean species known from Morocco, Algeria, Sicily, Sardinia, Corsica, and the littoral of Provence, France (Dufay, 1962, p. 222). I know the species only from figures, a colored figure in Warren (1913, pl. 71, fig. c [1]), a photograph in Dufay (1962, pl. 5, fig. 31), and the figures accompanying the original description. The photograph in Dufay's paper is the best illustration of the species; those in Turati's paper are somewhat blurred. Although *nisseni* has considerably more yellowish white in its pattern than *fuliginaria,* the pale areas are not distributed like those of *mineta,* and further *nisseni* appears to be a smaller moth.

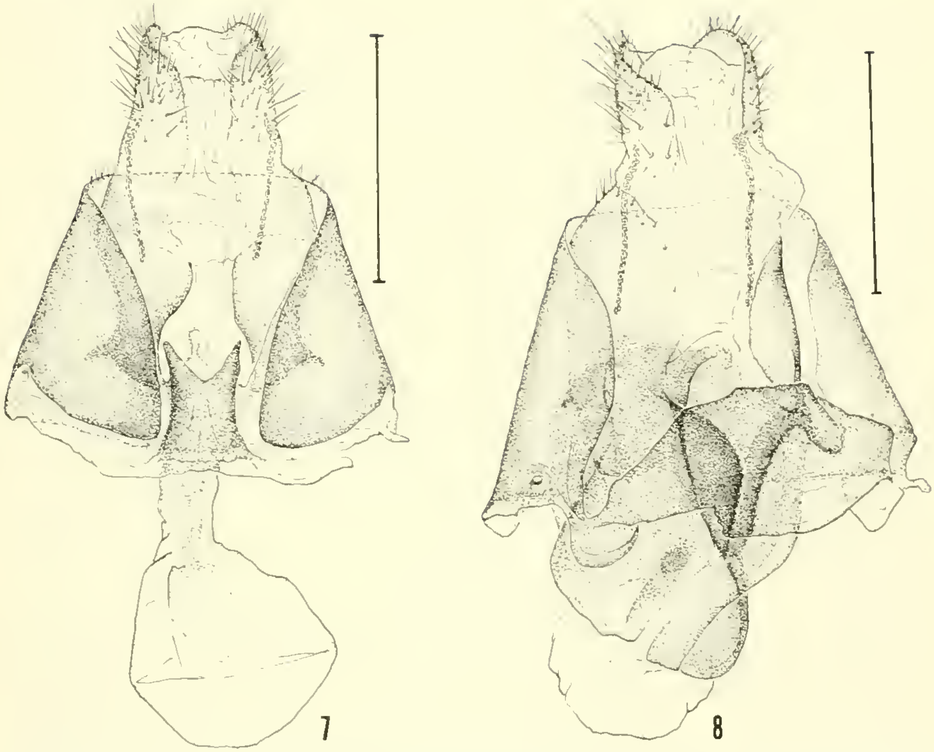
Description: Head, thorax, abdomen, and wings above sooty black; metathoracic tuft an admixture of pale and metallic scales; abdominal tufts present on second and third segments, pale; transverse lines and other markings of wings pale, white, cream-white, or pale fuscous white with a greater or lesser overlay of fuscous scales; fore wing with antemedial line irregular, curved, whitish with some black scales on outer side; median shade or line absent; postmedial line straight immediately below costa, sharply outcurved, then roundly outcurved and incurved to inner margin, whitish with black scales on inner side; subterminal line lunulate, parallel to outer margin, whitish; terminal line undulate, black with white scales on inner side; fringe checkered, sooty black and whitish; reniform a black bar; orbicular not evident; two pale dots on costa between antemedial and postmedial lines, three pale dots on costa between postmedial and subterminal



Figs. 3, 4. Figs. 3, 3a. *Parascotia mineta.* 3, Male genitalia, aedeagus removed. 3a. Aedeagus. Figs. 4, 4a. *Parascotia fuliginaria.* 4, Male genitalia, aedeagus removed. 4a, Aedeagus.



Figs. 5, 6. Figs. 5, 5a. *Mycterophora monticola.* 5, Male genitalia, aedeagus removed. 5a, Aedeagus. Figs. 6, 6a. *Mycterophora inexplicata.* 6, Male genitalia, aedeagus removed. 6a, Aedeagus.



Figs. 7, 8. Fig. 7. *Parascotia mineta*, female genitalia. Fig. 8. *Mycterophora inexplicata*, female genitalia.

lines; conspicuous pale patch between postmedial and subterminal lines near inner margin; hind wing with markings a continuation of those of fore wing, with conspicuous pale patch in same relative position as that on fore wing. Beneath sooty fuscous with much pale scaling toward outer margin, especially on hind wing; postmedial line broad, black, pale on outer side; subterminal line broad, black, pale on outer side; discal spots present on both fore and hind wings.

Fore wing length.—10.5–15 mm, most specimens 12–14 mm. (Illustrated male 14 mm, female 13 mm.)

Male genitalia.—Figs. 3, 3a.

Female genitalia.—Fig. 7.

Holotype.—♂. Snyder Heights 1100 ft., Ithaca, Tompkins County, New York; 22 July 1984; J. G. Franclemont. Franclemont collection.

Paratypes.—10 ♂. 3 ♀. All same locality as holotype; 1 ♂ 18 June 1977, others various dates in July from 10–31, 1973–1984; J. G. Franclemont. Franclemont collection.

In addition to the type series the species has been seen only from the following locations in New York State, "near Ithaca," Tompkins Co., the vicinity of Geneva, Ontario Co., Palmyra, Wayne Co., and Black Creek, 2 miles west of Voorheesville, Albany Co.

T. L. McCabe reared the larva on a pore fungus on a log from eggs laid by a female from the Voorheesville location. The larvae hibernated while still small; they were left on the log over the winter. Only one larva was recovered in the spring; unfortunately, this disappeared before becoming fully grown.

Mycterophora Hulst

Mycterophora Hulst, 1896. Trans. Am. Entomol. Soc. 23: 298.

Type-species.—*Mycterophora monticola* Hulst, 1896. Original designation.

The males of the species of this genus show great similarity to the males of *Parascotia* in the structure of the genitalia, but the membranous, digitiform lobe of the valve is on the ventral or inner side, not on the dorsal or outer side as in *Parascotia*; the costa of the valve has one projection, in *Parascotia* two; the juxta has little or no indication of a median bulla, so conspicuous in *Parascotia*; the cornuti of the vesica are four in number, much larger and stouter than the three found in *Parascotia*. The female genitalia of *Mycterophora* and *Parascotia* (Figs. 7, 8) are strikingly different; the antevaginal plates, the ducti bursae, and the bursae are noticeably dissimilar.

The differences in the female genitalia and the position of the spiracle of the first abdominal segment in relation to the tympanal hood are the essential reasons for maintaining the two genera as discrete taxa.

Mycterophora, insofar as known, is restricted to North America where five species are recognized. Only one of these, *inexplicata* Walker, occurs in eastern North America and might possibly be confused with the new species of *Parascotia*.

The larva of only one species is apparently known. Dyar (1904, p. 877) described the egg and first through third larval instars of *longipalpata* Hulst reared at Kaslo, British Columbia. Like *P. fuliginaria* the larva lacks the prolegs of the third and fourth abdominal segments. Dyar's description of the third instar probably gives a fairly accurate suggestion of the appearance of the fully grown larva. The "soft, pale, long, curved hair" is like that of *fuliginaria*. The food was ". . . green lichens growing on damp wood."

A synopsis of the species follows:

Mycterophora inexplicata (Walker)

Scotosia inexplicata Walker, 1862. List of the Specimens of Lepidopterous Insects in the Collection of the British Museum, part 26: 1722.

Type-locality.—"New York. Presented by E. Doubleday, Esq." [Trenton Falls, Oneida Co.]

Mycterophora slossoniae Hulst, 1898. Can. Entomol. 30: 120.

Type-locality.—"White Mountains, N. H.; from Mrs. Slosson. Winnipeg, Man.; from Mr. Hanham."

Male genitalia.—Figs. 6, 6a.

Female genitalia.—Fig. 8.

Mycterophora geometriformis Hill

Mycterophora geometriformis Hill, 1924. Bull. So. Calif. Acad. Sci. 23: 185, pl. 3, fig. 12.

Type-locality.—"Mt. Lowe, 5000 feet elevation, Los Angeles County, Calif., at light."

Mycterophora monticola Hulst

Mycterophora monticola Hulst, 1896. Trans. Am. Entomol. Soc. 23: 299.

Type-locality.—"Sierra Nevada, California."
Male genitalia: Figs. 5, 5a.

Mycterophora rubricans Barnes & McDunnough

Mycterophora rubricans Barnes & McDunnough, 1918. Contributions to the Natural History of the Lepidoptera of North America 4: 123, pl. 18, figs. 1, 2.

Type-locality.—"Monachee Meadows, Tulare Co., Calif., 5 ♂, 8 ♀. Types, Coll. Barnes."

Mycterophora longipalpata Hulst

Mycterophora longipalpata Hulst, 1896. Trans. Am. Entomol. Soc. 23: 299, pl. 11, fig. 13.

Type-locality.—"Soda Springs, Siskiyou County, California. From Mr. Behrens, July 19."

ACKNOWLEDGMENTS

I express my appreciation to T. L. McCabe for furnishing me with the information about his attempt to rear *P. mineta.* I thank George L. Godfrey and Robert W. Poole for reading the manuscript and for their comments. The specimens from Geneva, New York, were collected in blacklight traps by P. J. Chapman and S. E. Lienk in connection with their work on cutworm moths. The specimen from Palmyra, New York, was taken in a blacklight trap by M. S. Adams. The drawings are by James S. Miller and the photographs by the author.

LITERATURE CITED

Dufay, C. 1962. Les Noctuides de la Faune française ne figurant pas dans le Catalogue L. Lhomme. (Suite). Alexanor 2: 207–224, pl. 5.

Dyar, H. G. 1904. The Lepidoptera of the Kootenai District of British Columbia. Proc. U.S. Natl. Mus. 27: 779–938.

Hodges, R. W., et al., eds. 1983. Check List of the Lepidoptera of America North of Mexico. E. W. Classey and the Wedge Entomological Research Foundation, London and Washington, D.C. 284 pp.

Lempke, B. J. 1952. The Schiffermüller Names. Entomol. Ber. 14: 92–94.

Sattler, K. and W. G. Tremewan. 1984. The Lepidoptera Names of Denis & Schiffermüller—A Case for Stability. Nota Lepidopterologica 7: 282–285.

South, R. 1961. The Moths of the British Isles, edited and revised by H. H. Edelsten and D. S. Fletcher. Series I. Frederick Warne & Co., Ltd. London. 427 pp. 148 pls.

Spuler, A. 1910. Die Schmetterlinge Europas. Vol. 4, Die Raupen. xvii pp. 60 col. pls. E. Schweizerbart'sche Verlagsbuch Handlung, Stuttgart.

Swain, H. D. 1950. The British History, Distribution & Life History of *Parascotia fuliginaria,* the Waved Black Moth. Entomol. Gaz. 1: 186–200, 10 figs., 2 maps.

Turati, E. 1907. Nuove Forme di Lepidotteri. Il Naturalista Siciliano 20: 1–48, pls. 1–6.

Warren, W., *in* A. Seitz, ed. 1913. Die Gross-schmetterlinge der Erde. Vol. 3, 1909–1914. Alfred Kernen, Stuttgart. 511 pp. 75 col. pls.

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, pp. 834–842

A COMPARISON OF GROUND BEETLE (COLEOPTERA: CARABIDAE) FAUNAS OF VALCOUR ISLAND IN LAKE CHAMPLAIN, NEW YORK AND THE ADJACENT MAINLAND

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Abstract.—Fifty-three ground beetle (Coleoptera: Carabidae) species were obtained in this study, with 21 species common to both Valcour Island in Lake Champlain, New York and the adjacent mainland area 1.6 km distant. Twenty-seven species were found only on the mainland whereas five species were found only on the island, including the short-winged *Carabus nemoralis* Muller. *Carabus maeander* Fischer was normal-winged on the island, but short-winged on the mainland. Nearly nineteen percent more normal-winged specimens of the dimorphic *Pterostichus melanarius* Illiger occurred on the island than on the mainland.

Although the vegetation, birds, and mammals of Valcour Island in Lake Champlain have been studied to varying extents (Crissey and Darrow, 1949; Klein, 1972), the island's insect fauna has not been catalogued. Leonard (1928) listed the insects of New York, but localities for ground beetles (Coleoptera: Carabidae) did not include Valcour Island. Lindroth's (1961, 1963a, 1966, 1968, 1969a, b) work on the ground beetles of Canada and Alaska covered New York, as well.

Variability in carabid dispersal sometimes can be attributed to wing polymorphism (Darlington, 1936, 1943). For example, the wings of many species are always rudimentary, consequently, their activities are restricted to the soil and their distribution range is narrow. Other species possess long wings and, provided wing musculature has not atrophied, are capable of flight. Finally, in the case of wing dimorphic species, both normal- and short-winged individuals occur. Wing state is strongly correlated with locality and habitat (Darlington, 1943); arboreal and hydrophilous species are nearly always normal-winged, whereas geophilous species are usually dimorphic or short-winged.

Faunal studies are important for local records on insect diversity and population structure as well as taxonomically for evolutionary and faunal histories between countries and continents, such as those reported by Lindroth (1957, 1963b, 1971). This study was undertaken to categorize ground beetle species collected in various ecological habitats of an island and adjacent mainland area, and to compare faunas of the two areas.

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MATERIALS AND METHODS

Ground beetles were collected from 26 May through 24 October 1976 on Valcour Island and the adjacent mainland. Six different types of collecting sites on Valcour Island were identified on the basis of habitat differences. Mainland sites were selected which corresponded to the different island sites with respect to vegetation, soil, and drainage. These sites were named and abbreviated accordingly: mainland shore (M-SH); island shore (I-SH); mainland open field (M-OF); island open field (I-OF); mainland semi-open field (M-SF); island semi-open field (I-SF); mainland swamp (M-SW); island swamp (I-SW); mainland deciduous woods (M-DW); island deciduous woods (I-DW); mainland cedar woods (M-CW); and island cedar woods (I-CW). A description of each mainland and island site is given in Table 1. The flora was identified, and relative abundance was noted.

Descriptions of collecting sites.—Both the mainland and island study areas were approximately 10 km south of the city of Plattsburgh in Clinton County, New York. Valcour Island is located in Lake Champlain along a north-south axis approximately 1.6 km from the New York mainland. Crissey and Darrow (1949) described the island as having: a length of 3200 m and a width of 1600 m, with an area of 425 ha; an irregular shoreline about 16,000 m long; a gently rolling topography with elevations varying from 31 to 55 m above the lake; shores mostly sloping to rock shingle or sand beach, although the southern shore rises 24 m in sheer cliffs; thin topsoil overlying creviced limestone; and good drainage, with only three vernal swamps of which only one is greater than 2 ha.

The topography of the mainland area, like that of the island, was gently rolling with altitudes of 31–61 m. Drainage appeared to be good, in general. This rural countryside was characterized by open fields, old field successional habitats, and sparse woods.

Collection of ground beetles.—Ground beetles were collected with pitfall traps within a 15.2 × 15.2 m area at most sites. Pitfall traps consisted of 0.95 liter glass jars buried upright with the opening flush with the ground surface. One trap was placed in the center of the plot, and six were placed each 3.0 m from the center in a hexagonal arrangement around the center trap at each OF, SF, and DW site. Seven pitfall traps were buried in random locations at the SW and CW sites. Pitfall traps were checked approximately every tenth day for island sites and every fifth day for mainland sites. Specimens were collected by hand at shore sites.

Sweep net samples were taken infrequently at OF, SF, and DW sites; and a soil sample (30.5 × 30.5 × 15.2 cm) was taken at each site. In addition, an ultraviolet (UV) light trap was operated at all mainland sites, and on the island at I-SH, I-OF, I-SF, and I-SW.

All specimens were identified using Barlow et al. (1969), Lindroth (1961, 1963a, 1966, 1968, 1969a, b), Perrault (1973), and Goulet (1974), and the wing state was examined. Species with rudimentary wings will be referred to as "short-winged," while those which possess long wings will be referred to as "normal-winged."

RESULTS AND DISCUSSION

Mainland collections (714 specimens) yielded 48 species in 19 genera, 21 of which also occurred on Valcour Island (Table 2). Island collections (678 specimens) yielded 26 species in 11 genera, including five species found only on the

Table 1. Characteristics of mainland and island collecting sites (I = island, M = mainland, SH = shore, OF = open field, SF = semi-open field, SW = swamp, DW = deciduous woods, CW = cedar woods).

Site	Soil and Drainage	Dominant Vegetation
I-SH	Gravelly, stony beach	Ground cover: *Spartina pectinata* Link.
M-SH	Gravelly, stony boat launching site, large stones and rock piles	No vegetation
I-OF	Clay-loam, well-drained	Ground cover: *Dactylis glomerata* L.
M-OF	Clay, poor drainage	Ground cover: *D. glomerata*
I-SF	Clay-loam, moderate drainage	Ground cover: *D. glomerata, Melilotus alba* Desr., *Solidago* spp., *Aster novae-angliae* L.; Shrub layer: *Cornus stolonifera* Michx.
M-SF	Clay-loam, moderate drainage	Ground cover: *D. glomerata, Solidago* spp., *Aster* spp.; Shrub layer: *C. stolonifera, C. racemosa* Lam.
I-SW	Dark, porous soil, poor drainage	Ground cover: *Osmunda cinnamomea* L., mosses, numerous wildflowers; Understory: *Prunus* sp., *C. racemosa*; Canopy: young mixed forest—*Abies balsamea* (L.) Mill., *Thuja occidentalis* L., *Populus tremuloides* Michx., *Ulmus rubra* Muhl
M-SW	Poor drainage	Ground cover: *O. cinnamomea, Onoclea sensibilis* L., *Dryopteris noveboracensis* (L.) Gray, mosses; Understory: *Hamamelis virginiana* L., *Pyrus coronaria* L., *C. stolonifera*; Canopy: young mixed forest—*Tsuga canadensis* (L.) Carr., *Pinus strobus* L., *T. occidentalis, P. tremuloides, Ostrya virginiana* (Mill.) K. Koch, *Betula* spp., *Fagus grandifolia* Ehrh., *Quercus bicolor* Willd., *U. rubra, Acer* spp., *Tilia americana* L.
I-DW	Loam, good drainage	Ground cover: *D. glomerata, Avena fatua* L., numerous wildflowers; Shrub layer: *Rhamnus cathartica* L.; Canopy: *O. virginiana, Acer saccharum* Marsh.
M-DW	Loam, good drainage	Ground cover: *D. glomerata, Rhus radicans* L.; Shrub layer: *Juniperus virginiana* L., *Amelanchier laevis* Wieg; *R. cathartica, C. stolonifera*; Canopy: *P. tremuloides, F. americana*
I-CW	Sandy-loam, dry	Shrub layer: *Rhus typhina* L., *Cornus rugosa* Lam.; Canopy: *A. balsamea, T. occidentalis*; also, *T. canadensis*
M-CW	Sandy-loam, dry	Shrub layer: *Juniperus communis* L., *J. virginiana, R. cathartica*; Canopy: *T. occidentalis*; also, *P. strobus*

island (Table 2). These numbers are likely to change as the vegetation goes through successional stages or becomes changed by man.

A study of the ground beetles collected on Plummers Island, Maryland between 1901–1978 has shown how a carabid fauna can change over time (Erwin, 1981). According to Erwin (1981), the decrease in number of carabid species from 160 to 101 occurred as the island's flora changed from juniper-grassland to oak-hickory-maple. The carabid species composition changed from open-habitat species to forest dwellers, from wingless to winged species, and from species with large individuals to species with smaller individuals. Ecological and evolutionary considerations are discussed by Erwin (1981).

Pitfall catches accounted for the greater proportion of specimens collected, except SH sites where ground beetles were hand-collected, and M-OF and M-SF where most of the specimens were attracted to a blacklight. Soil sampling was ineffective in this study, contrary to Briggs' (1960) findings; only one beetle was found using this technique. None were attracted to the UV light when it operated at island sites, possibly because the temperature was too low on those particular nights.

The majority of the ground beetles collected had their expected wing structure (Table 2). However, a few species warrant additional discussion because of wing structure or distribution. The rare presence of a single normal-winged *Carabus maeander* (I-SF) may indicate a range extension southward from Canada. The appearance of this species in both major areas may indicate dispersal by normal-winged morphs. See Larochelle (1973) for a discussion of wing dimorphism in *C. maeander*. *C. maeander* was first reported in New York in 1977 (Powell, 1977).

Special attention is warranted for *C. nemoralis* in this discussion since it was present only at island sites. Yet, it is a short-winged species. Lindroth (1961) reported that this species, first found in North America 115 years ago, was restricted to cultivated ground. According to Barlow (1973), *C. nemoralis* has only recently been collected in forests. In this study, 87.9% of the *C. nemoralis* collected on Valcour Island were found in a deciduous woods. Mainland-based supplies, equipment, and animals were transported to the island when farming took place on the island at the turn of the century. This may explain the spread of this short-winged species on the island.

The dimorphic *Clivina fossor* apparently is new to the state; a single normal-winged specimen was collected in this study. This European introduction was first found in eastern Canada 70 years ago (Lindroth, 1961). The occurrence of normal-winged *Patrobus longicornis* is rare (Lindroth, 1961). Thus, collection of 13.3% in island sites was interesting because it may indicate dispersal by normal-winged morphs.

Although *Nebria lacustris, Pterostichus lucublandus, Agonum gratiosum, A. mannerheimi* and *A. decentis* had full wings, they probably were non-functional (Lindroth, 1961, 1966). *P. melanarius* is reported to occupy a wide variety of habitats ranging from open cultivated or non-cultivated areas to deciduous or coniferous forests. According to Lindroth (1966), the normal-winged form is rare in Europe, but not in North America. This is a sign that the species arrived late and is spreading. Of those specimens collected on the island, 56.5% were normal-winged, whereas only 37.9% of the mainland specimens were. *P. coracinus* was reported to be found both in the forest and in open fields and meadows (Lindroth, 1966). Barlow (1970) showed that for *P. melanarius* and *P. coracinus* populations, the greatest number of each species was found where the other was scarce or absent. This negative association may be the result of competition between the species or responses to different environmental requisites. This differential dis-

Table 2. Species, wing state, and abundance of ground beetles collected at island and mainland sites.[1,2]

Taxon (Wing State)	SH		OF		SF		SW		DW		CW		Total No.[3]
	I	M	I	M	I	M	I	M	I	M	I	M	
Cychrini													
Sphaeroderus lecontei Dejean (S)								R			R		3
Carabini													
Carabus maeander Fischer (D)					R	R							3
C. nemoralis Muller (S)[4]			R		C				A		R		190
Nebriini													
Nebria lacustris Casey (D)[5]		R											1
Elaphrini													
Elaphrus clairvillei Kirby (N)[5]								R					1
Scaritini													
Dyschirius integer Leconte (N)[5]				R						R			2
Clivina fossor Linne (D)[5]						R							1
Patrobini													
Patrobus longicornis Say (D)	R				R		C	R		R			19
Bembidiini													
Bembidion chalceum Dejean (N)[5]		R											2
B. planum Haldeman (N)[4]	R												1
B. salebratum Leconte (N)	C	C											38
B. scopulinum Kirby (D)[5]		C											12
B. castor Lindroth (N)[5]		R											1
B. patruele Dejean (N)[5]		R		R		R		R		R			6
B. versicolor Leconte (N)[5]						R							2
B. frontale Leconte (N)[5]										R			9
Tachys tripunctatus Say (N)	R	R											6

Table 2. Continued.

Taxon (Wing State)	SH		OF		SF		SW		DW		CW		Total No.[3]
	I	M	I	M	I	M	I	M	I	M	I	M	
Pterostichini													
Pterostichus tristis Dejean (S)								R			R		6
P. lucublandus Say (N)	R		R	R	R	R				C			64
P. adstrictus Eschscholtz (N)							R		R		R	R	21
P. melanarius Illiger (D)		R	A	R	C		R	R	C	A	R	R	570
P. coracinus Newman (S)					R		R	C	C		C	C	154
P. corvinus Dejean (N)[5]								R					2
P. caudicalis Say (N)[5]								R					9
P. luctuosus Dejean (N)	R						R	R		R			16
P. leconteianus Lutshnik (N)[4]					R								1
P. femoralis Kirby (D)[4]									R				1
Synuchus impunctatus Say (D)							R	R		R	C		29
Agonum gratiosum Mannerheim (N)							R	R					4
A. thoreyi Dejean (N)							R			R			2
A. lutulentum Leconte (N)[5]				R									1
A. anchomenoides Randall (N)[5]				R									2
A. melanarium Dejean (N)							R	C		C			54
A. trigeminum Lindroth (N)						R	R			R			9
A. harrisi Leconte (N)[5]				R									1
A. tenue Leconte (N)[5]				R									1
A. extensicolle Say (D)	C	C									R		49
A. mannerheimi Dejean (N)[5]								R					1
A. decentis Say (N)							R	R					4
A. tenuicolle Leconte (N)[5]		R											2
Harpalini													
Harpalus erythropus Dejean (N)[5]						R							1
H. fallax Leconte (N)[5]				R									3
Stenolophus ochropezus Say (N)[5]				R		R							2
S. comma Fabricius (N)	R			R									10
Acupalpus pumilus Lindroth (N)[5]						R							1
A. pauperculus Dejean (N)[5]				R									3

Table 2. Continued.

Taxon (Wing State)	SH		OF		SF		SW		DW		CW		Total No.[3]
	I	M	I	M	I	M	I	M	I	M	I	M	
Licini													
Diplocheila assimilis Leconte (N)[5]								R					2
Badister neopulchellus Lindroth (N)[5]				R									2
Chlaeniini													
Chlaenius cordicollis Kirby (N)	C	C											33
C. sericeus Forster (N)	R	R											2
C. impunctifrons Say (N)[5]								C		R			26
Lebiini													
Lebia viridis Say (N)[5]				R		R				R			6
Brachinini													
Brachinus cordicollis Dejean (N)[4]	R												1

[1] Abundance of carabids is expressed using a logarithmic scale: R = rare, 1–10 specimens; C = common, 11–100 specimens; and A = abundant, >100 specimens.

[2] The letters following species names refer to the wing states (Lindroth, 1961, 1963a, 1966, 1968, 1969a): S = short-winged, D = dimorphic, and N = normal-winged.

[3] Total number of carabids collected using all methods.

[4] Found on island only.

[5] Found on mainland only.

tribution also seemed to apply, in general, to the data obtained in this study (Table 2).

The single *Pterostichus femoralis* collected had normal wings, although this dimorphic species usually is short-winged. Another dimorphic species, *Synuchus impunctatus* had unusually high numbers of specimens with long wings, 11.8% of the island and 25.0% of the mainland specimens (Lindroth,1966).

This study was the initial step in cataloging the insects of Valcour Island and the adjacent mainland area in Clinton County, New York. The results would be important in future studies designed to show how flora and fauna change with time, such as the study by Erwin (1981). More species will be added to faunal lists as collections are made as part of an ongoing effort at Plattsburgh State University College.

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LITERATURE CITED

Barlow, C. A. 1970. Phenology and distribution of some *Pterostichus* (Coleoptera: Carabidae) of eastern Canada. J. N.Y. Entomol. Soc. 78: 215–236.

———. 1973. Phenology and distribution of *Carabus nemoralis* (Muller) (Coleoptera: Carabidae) in eastern Canada. Nat. Can. (Que.) 100: 361–369.

Barlow, C. A., J. E. Graham, and S. Adisoemarto. 1969. A numerical factor for the taxonomic separation of *Pterostichus pensylvanicus* and *P. adstrictus* (Coleoptera: Carabidae). Can. Entomol. 101: 1315–1319.

Briggs, J. B. 1960. A comparison of pitfall trapping and soil sampling in assessing populations of two species of ground beetles (Col.: Carabidae). East Mall. Res. Sta. (Annual Report), pp. 103–112.

Crissey, W. F. and R. W. Darrow. 1949. A study of predator control on Valcour Island. New York State Conservation Department. Division of Fish and Game, Research Series No. 1. Albany.

Darlington, P. J., Jr. 1936. Variation and atrophy of flying wings of some carabid beetles. Ann. Entomol. Soc. Am. 29: 136–179.

———. 1943. Carabidae of mountains and islands: Data on the evolution of isolated faunas, and on atrophy of wings. Ecol. Mono. 13: 39–61.

Erwin, T. L. 1981. Natural history of Plummers Island, Maryland. XXVI. The ground beetles of a temperate forest site (Coleoptera: Carabidae): An analysis of fauna in relation to size, habitat selection, vagility, seasonality, and extinction. Bull. Biol. Soc. Wash. 5: 104–224.

Goulet, H. 1974. Biology and relationships of *Pterostichus adstrictus* Eschscholtz and *Pterostichus pensylvanicus* Leconte (Coleoptera: Carabidae). Quaest. Entomol. 10: 3–33.

Klein, S. D. 1972. A comparison of the woodland small mammal populations of Valcour Island, Lake Champlain and a comparable mainland site. M.S. report. Plattsburgh State College, Plattsburgh, New York. 55 pp.

Larochelle, A. 1973. Wing dimorphism in *Carabus maeander* (Coleoptera: Carabidae). Pan-Pac. Entomol. 49: 126.

Leonard, M. D. 1928. A list of the insects of New York. Mem. Cornell Agric. Exp. Sta., No. 111. Ithaca, New York. 1121 pp.

Lindroth, C. H. 1957. The faunal connections between Europe and North America. Wiley, New York. 344 pp.

———. 1961. The ground beetles of Canada and Alaska. Part 2. Opus. Entomol. Suppl. 20: 1–200.

———. 1963a. The ground beetles of Canada and Alaska. Part 3. Opus. Entomol. Suppl. 24: 201–408.

———. 1963b. The fauna history of Newfoundland, illustrated by carabid beetles. Opus. Entomol. Suppl. 23 (Lund): 112 pp.

———. 1966. The ground beetles of Canada and Alaska. Part 4. Opus. Entomol. Suppl. 29: 409–648.

———. 1968. The ground beetles of Canada and Alaska. Part 5. Opus. Entomol. Suppl. 33: 649–944.

———. 1969a. The ground beetles of Canada and Alaska. Part 6. Opus. Entomol. Suppl. 34: 945–1192.

———. 1969b. The ground beetles of Canada and Alaska. Part 1. Opus. Entomol. Suppl. 35: I–XLVIII.

———. 1971. On the occurrence of a continental element in the groundbeetle fauna of eastern Canada. Can. Entomol. 103: 1455–1462.

Perrault, G. G. 1973. A taxonomic review of the eastern nearctic species complex *Pterostichus* (*Haplocoelus*) *adoxus* (Coleoptera: Carabidae). Quaest. Entomol. 9: 35–40.

Powell, J. E. 1977. First New York record for *Carabus maeander* Fischer (Coleoptera, Carabidae). Coleopt. Bull. 31: 148.

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, pp. 843–858

TAXONOMIC STUDY OF THE NEARCTIC SPECIES OF *ELACHERTUS* SPINOLA (HYMENOPTERA: EULOPHIDAE)

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Abstract.—The nearctic species of *Elachertus* (Hymenoptera: Eulophidae) are revised and an illustrated key is presented. A review of the known hosts and distributions of the species is also given along with a diagnosis and notes on types. Lectotypes are designated for *proteoteratis* Howard, *cacoeciae* Howard, *glacialis* Ashmead, *hyphantriae* Crawford, *marylandicus* Girault, *cidariae* Ashmead, and *louisiana* Girault. The following new synonymies are proposed: *coxalis* (Howard, 1885); *proteoteratis* (Howard, 1885); and *pini* Gahan, 1927 = *argissa* (Walker, 1839); *glacialis* (Ashmead, 1902) and *aeneoniger* (Girault, 1917) = *cacoeciae* (Howard, 1885); *hyphantriae* Crawford, 1911 and *marylandicus* (Girault, 1916) = *cidariae* (Ashmead, 1898). Two new taxa (*loh* and *atus*) are described and illustrated. All the species are primary parasites of the larvae of Lepidoptera including the pine tip moth (*Rhyacionia frustrana*), redbanded leafroller (*Argyrotaenia velutinana*), and spruce budworm (*Choristoneura fumiferana*).

Species of *Elachertus* are primary parasites of a variety of lepidopterous larvae. Some species are polyphagous, parasitizing hosts belonging to several different families. The larvae of these wasps are often gregarious and their pupae are frequently seen clustered on the surface of leaves or on the body of their host. They seem to prefer host larvae that occupy sheltered situations such as leafrolls or that bore inside twigs or growing tips. Several of these host species are of economic importance, being pests of various forest trees and ornamental plants. Nevertheless, the North American species of *Elachertus* have never been revised and no keys are available to aid in their identification. In addition, since the publication of the North American Hymenoptera catalog (Burks, 1979) several new host and locality records for a number of the species have been established and undescribed species have been reared. Finally, it has become apparent that taxonomic problems exist in this genus, e.g. undetected synonymy of some of the species and types not selected. This paper is an effort to address these problems and needs.

All types (except *atus* n. sp.) are deposited in the U.S. National Museum of Natural History. Names of hosts follow Hodges et al. (1983) and common names of hosts are from Werner (1982). Terminology for morphological structures follows Graham (1959) and for sculpturing Harris (1979). New host and locality records established during the course of this study are marked by an asterisk. Measurements and ratios were made with an eyepiece reticle. Widths and lengths of antennal segments, metasoma, and so on were measured at the widest or longest point.

Acronyms for museums are as follows: Biosystematics Research Institute, Ottawa, Ontario, Canada (CNC); Illinois Natural History Survey, Champaign, Illinois (INHS); British Museum, London (BM); Museum of Zoology and Entomology, Lund University, Lund, Sweden (SWE); Oregon State University, Corvallis, Oregon (OSU).

Elachertus Spinola

Elachertus Spinola, 1811: 151.

Type-species.—*Diplolepis lateralis* Spinola. Desig. by Gahan and Fagan, 1923.

Microterus Spinola, 1811: 151.

Type-species.—*Diplolepis petiolata* Spinola. Desig. by Gahan and Fagan, 1923.

Elachestus Nees, 1834: 135. Emend.
Elachistus Foerster, 1856: 73. Emend.
Epardalus Girault, 1917: 5.

Type-species.—*Elachistus cidariae* Ashmead. Orig. Desig.

Peteenus Erdos, 1961: 471.

Type-species.—*Peteenus pulcher* Erdos. Orig. Desig.

Diagnosis.—This genus can be differentiated from other genera of Eulophidae by the following combination of characters: antennal funicle with four articles (Figs. 16, 17); toruli at or above ventral margin of eye; notauli complete (Fig. 2); scutellum with lateral grooves, curving inwards posteriorly, delimiting a narrow band of scutellum at the posterior margin (Fig. 2), with two pairs of setae; midlobe of mesoscutum with 3 or more pairs of setae; postmarginal vein longer than stigmal. Males with sensory pores of scape limited to upper third, separated by less than their own diameter (Fig. 18).

Discussion.—Species of *Elachertus* are most similar to the genus *Hyssopus* Girault. Females can be differentiated by the following: 3 or more pairs of setae on the midlobe of the mesoscutum (2 pairs only in *Hyssopus*); toruli inserted at or above ventral margin of eye (below ventral margin in *Hyssopus*). Males can also be separated by the pattern of pores on the scape (Fig. 18 versus 19), although this requires clearing and mounting of the antennae.

Other related genera (e.g. *Miotropis* and *Stenomesius*) either do not have scutellar grooves or the grooves, when present, do not extend the full length of the scutellum and do not meet medially and set off a narrow band of scutellum at the posterior margin. In addition, related genera often have the median propodeal carina split into two parallel carinae for most of its length or otherwise elaborated as in *Stenomesius* (median carina single and complete in *Elachertus* and only rarely with a small dorsal v-shaped opening); the head and thorax are often extensively marked with yellow as in some species of *Miotropis, Stenomesius,* and *Cirrospiloideus* (head and thorax generally wholly black or dark metallic in *Elachertus*); and the occiput may possess a distinct semicircular carina as in *Ardalus* and at least some *Stenomesius* (no occipital carina in *Elachertus*).

This genus is one of a complex of closely related taxa which have been placed by various authors either in the subfamily Elachertinae (e.g. Askew, 1968; Peck,

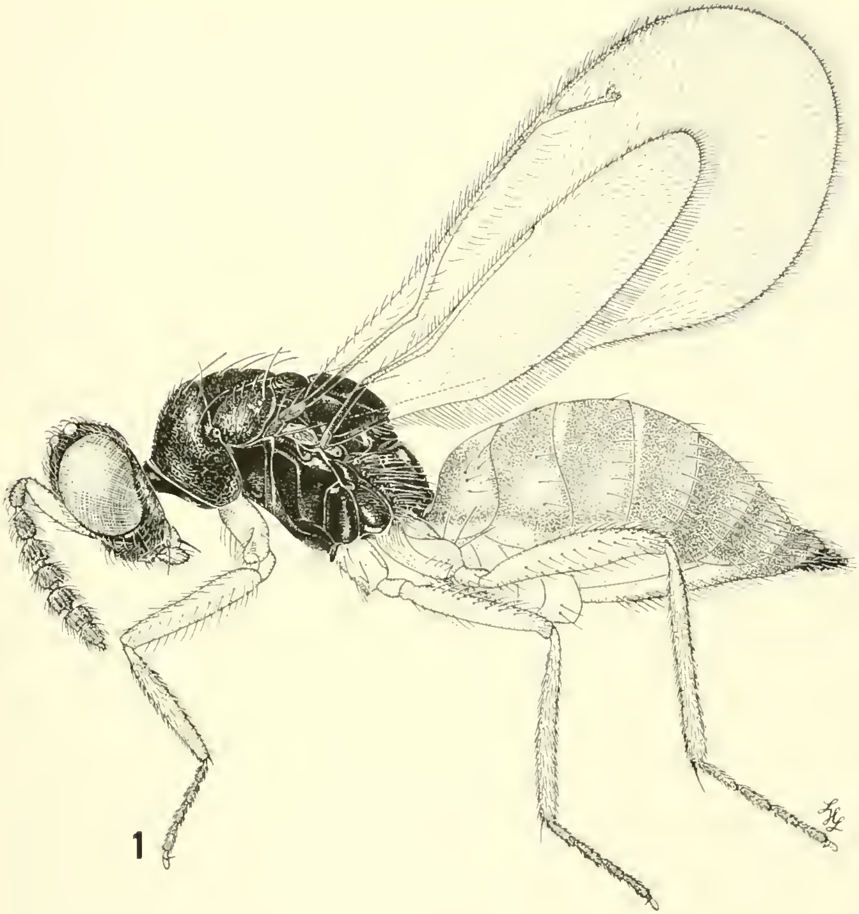


Fig. 1. Habitus of *Elachertus loh* Schauff, new species.

1963) or in the tribe Elachertini (e.g. Burks, 1979). The monophyly of these groups has not been established and I am reluctant to follow any tribal or subfamily classification until such time as a comprehensive analysis of the genera of this group can be carried out. The monophyly of *Elachertus* itself has been questioned and various groups of species have been assigned and later removed from it (e.g. the species included in *Hyssopus* Girault). I have found that most of the characters that have been used to set apart these species either vary among the taxa or can not be interpreted as being uniquely shared among the species. For example, the longitudinal grooves of the scutellum occur in a number of different genera and are expressed in a variety of ways. In species of *Hyssopus*, they are identical to *Elachertus* (grooves curving inward posteriorly and meeting, leaving a narrow band of scutellum at the posterior and lateral margins). The same is true of the number of antennal segments, denticles of the mandibles, wing venation, and so on. The male genitalia also provide no unique structural differences for *Elachertus*. The same basic male genitalic structure is present in males of *Hyssopus*, *Miotropis*, *Ardalus*, *Cirrospiloideus*, and others. Since no comprehensive revision of most of these genera has been undertaken, the limits and monophyly of most of these related groups also remains in doubt. However, another character unique to males does indicate that the species of *Elachertus* are a monophyletic group. The inner lateral surface of the scape of males of *Elachertus* and related genera possess an array of small sensory pores. In all of the species of *Elachertus* in which I have been able to examine the male antennae, the area of the pores is restricted to the distal one third of the scape and the pores form a small tight group (Figs. 18, 19) in which the individual pores are contiguous or separated by less than their own diameter. I believe this state to be synapomorphic for *Elachertus*. In some species, this area is clearly marked and can be seen in point mounted specimens, although the pores themselves cannot generally be seen with a dissecting microscope. In others, this area can only be discerned in cleared and slidemounted antennae. In *Hyssopus* (Fig. 20) these pores are scattered over nearly the entire surface of the scape and are set off from one another by one or two diameters. In other genera, the size of the area may be reduced, but again, the pores are seldom in contact with one another and the lower pores usually reach at least half way down the scape.

Many of the North American species placed in *Elachertus* were described one or two at a time by various authors from single specimens or short series. Most of the differences between these species cited by the original authors were small differences in coloration. After studying larger series and specimens from wider geographic areas, I attribute most of these color differences to intraspecific variation.

Key to the Nearctic Species of *Elachertus*

This key includes males and females. The species *multidentatus* (Girault) is known only from the holotype which is missing several critical parts and I have not included it in the key. It can be identified by the following characters: axillae ending on line with anterior margin of scutellum as in Fig. 2; mandibles with row of about 9 minute teeth along the upper edge (Fig. 21); mesoscutum rugose; scutellum coriaceous; dorsellum a transverse narrow band, propodeum laterad of carina sunken and minutely sculptured (similar to Fig. 13); all funicular articles longer than wide.

1). Anterior margin of scutellum and axillae forming a straight line (Fig. 2); petiole at least as long as wide; dorsellum with lateral lobes, excavated ventrally (Fig. 3) 2

– Axillae protruding cephalad of the anterior margin of the scutellum (Figs. 4, 6, 12); petiole reduced to a narrow transverse band; dorsellum without lateral lobes, not excavated ventrally (Figs. 5, 7, 13) 3

2). Malar suture in females straight (Fig. 14); POL 2× OOL; male head with vertex and occiput lightly sculptured as in Fig. 8; male antennae densely setose (Fig. 16) . . . . *argissa* (Walker)

– Malar suture in females curved (Fig. 15); POL 1.5× OOL; male head rugose except for scrobes (Fig. 11); male antennae with only a few sparse setae (Fig. 17) . . . . *atus* Schauff n.sp.

3). Scutellum smooth (Fig. 4); mandibles with 2 large and 3–4 smaller teeth (Fig. 8) 4

– Scutellum alutaceous or coriaceous (Fig. 6); mandible blunted, without obvious teeth (Fig. 10) 5

4). Face below toruli evenly rugose (Fig. 9); midlobe of mesoscutum with 3 pairs of setae; male antennae with sparse white hairs, pores on scape as in Fig. 19 . . . . *loh* Schauff n.sp.

– Face below toruli lightly sculptured medially, smooth laterally (Fig. 8); midlobe of mesoscutum with more than 3 pairs of setae; male antennae with numerous white hairs, pores on scape as in Fig. 18 . . . . *cacoeciae* (Howard)

5). Propodeum laterad of carina sunken and with some sculpture (Fig. 13); cubital and basal vein absent, submarginal with 3 or 4 setae (Fig. 22) . . . . *louisiana* (Girault)

– Propodeum laterad of carina not sunken, smooth (Fig. 7) forewing with cubital and balsal vein present, submarginal vein with 7 setae (Fig. 23) . . . . *cidariae* (Ashmead)

Elachertus argissa (Walker)

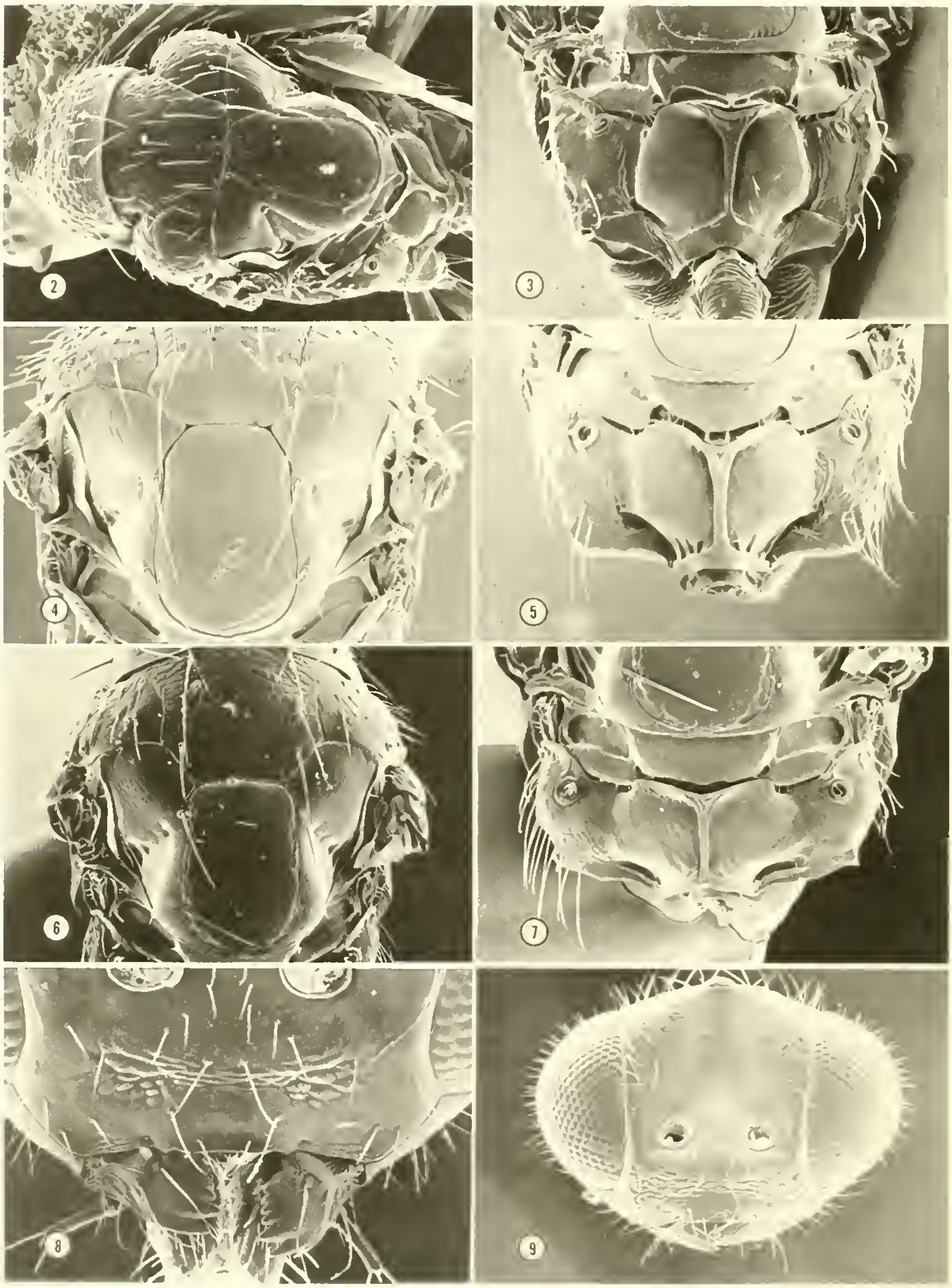
Eulophus argissa Walker, 1839: 172.
Eulophus saon Walker, 1839: 175. Synonymy by Bouček and Askew, 1968.
Eulophus eurybates Walker, 1839: 178. Synonymy by Bouček and Askew, 1968.
Elachistus opaculus Thomson, 1878: 193. Synonymy by Bouček and Askew, 1968.
Elachistus proteoteratis Howard, 1885: 27. New Synonymy.
Elachistus coxalis Howard, 1885: 28. New Synonymy.
Elachertus pini Gahan, 1927: 547. New Synonymy.

Diagnosis.—Anterior margin of axillae on a straight line with the anterior edge of the scutellum (Fig. 2); midlobe of mesoscutum with more than 3 pairs of setae; scutellum coriaceous; malar suture straight (Fig. 14); dorsellum generally smooth; males with eye height ½ to ⅔ of head height; face smooth, occiput and genae alutaceous or coriaceous.

This species is most closely related to *atus* n.sp., which shares the distinct petiole and straight anterior border of the scutellum and axillae. Females can be separated by the straight malar suture (Fig. 14), which is curved in *atus* (Fig. 15); the dorsellum which is generally smooth as in Fig. 3 (generally sculptured in *atus*); and the posterior ocellar length 2× the ocell-ocular length (1.5× in *atus*). Males have the head (except the scrobes) alutaceous or coriaceous, whereas males of *atus* have the head (except for the scrobes) uniformly rugose (Fig. 11).

Types.—According to the original description, *proteoteratis* was described from a series of 3 females (USNM type no. 2658). However, the point on which the specimens were mounted shows evidence of having held 4 specimens. Only 2 specimens remain, the others being indicated only by pieces of wings and legs. The lectotype (present designation) is indicated by a black arrow. The head and antennae are slidemounted. Both point and slide bear the data: Missouri, Kirkwood. June, 1873. ex. larvae of *Proteoteras aesculana* Riley, C.V.R. coll.

The holotype of *coxalis* (USNM type no. 2660) is point mounted with the data: "on window, D.C., June 14, 1881." In his description Howard added that the specimen was collected by C. V. Riley. Howard mounted the antennae on a slide and subsequently Girault mounted the head (which he smashed), parts of the legs, and a forewing on a second slide.



Figs. 2–9. Scanning electron micrographs of *Elachertus*. 2, Thorax of *E. argissa*. 3, Propodeum of *E. argissa*. 4, Dorsal thorax of *E. cacoeciae*. 5, Propodeum of *E. cacoeciae*. 6, Dorsal thorax of *E. cidariae*. 7, Popodeum of *E. cidariae*. 8, Face and mandibles of *E. cacoeciae*. 9, Face of *E. loh*.

The holotype of *pini* Gahan is point mounted (USNM type no. 40180) with the data: Virginia, Falls church. July, 1924. ex. *Rhyacionia frustrana.* R. A. Cushman collector. There are 6 male and 4 female paratypes with the same data as the holotype.

I have not seen the Walker type of *E. argissa.* However, Dr. Z. Bouček has been kind enough to send me specimens from the British Museum that he has compared with the types.

Other specimens examined.—21 ♂ and ♀ (SWE), 16 ♂ and ♀ (OSU), 183 ♂ and ♀ (CNC), 9 ♀ (INHS), 185 ♂ and ♀ (USNM), 4 ♂ and ♀ (BM).

Variation.—Length varies from 1.1 to 2.3 mm. Color varies from flat black with little evidence of any metallic sheen to distinctly metallic green. The metasoma is rarely metallic and is usually lighter in color basally than apically, but in a few specimens the color is uniformly dark throughout. The coxae and legs may be almost entirely yellow in the metallic colored specimens, but in blacker specimens, the coxae become increasingly darker and the hindfemur is occasionally brown medially. In a few specimens, the legs are entirely light brown. The scape and mandibles vary from yellow to brown and the funicular articles from light brown to black. The sculpturing of the scutellum varies from lightly alutaceous to distinctly coriaceous. The dorsellum in a few specimens shows slight evidence of alutaceous sculpture. In one series the anterior end of the median propodeal carina forks, forming a small raised triangular opening.

Nearctic hosts.—Tortricidae: *Amorbia cuneana* (Wlms.)*; *Archips argyrospilus* (Wlk.) (fruittree leafroller)*; *Barbara colfaxiana* (Kearf.) (Douglas-fir cone moth)*; *Epinotia laracana* (Kft.); *Endopizia viteana* Clem. (grape berry moth)*; *Platynota stultana* Wlms.*; *P. idaeusalis* (Wlk.)*; *Proteoteras aesculana* Riley; *Sparganothis sulferana* (Clem.)*; *Spilonota ocellana* (D. & S.) (eyespotted bud moth).* Gracilariidae: *Caloptilia packardella* (Cham.)*; *Parornix geminatella* (Pack.). Gelechiidae: *Pthorimaea operculella* (Zell.) (potato tuberworm)*. Pyralidae: *Omiodes indicata* (F.)*; *Dioryctria zimmermani* (Grote) (Zimmerman pine moth)*; *Acrobasis caryivorella* Rag.*. Oecophoridae: *Psilocorsis reflexella* Clem.*; *Stenoma algidella* (Walk.)*; *Depressaria* sp.*. Olethreutidae: *Rhyacionia frustrana* (Comst.) (pine tip moth); *Rhyacionia buoliana* (D. & S.) (European pine shoot moth).* Coleophoridae: *Coleophora laricella* (Hbn.) (larch casebearer).

Palearctic hosts.—Tortricidae: *Archips xylosteanus* L., *Epinotia fraternana* Haworth, *Exotelia dodecella* L., *Zeiraphera diniana* Guénée. Coleophoridae: *Coleophora limosipennella* Duponchel.

Distribution.—Holarctic. Occurs throughout United States and Canada. Also known from Mexico, South America, and most of Europe.

Notes.—Howard described *coxalis* on the page immediately following his description of *proteoteratis* and noted that the hindcoxae of *coxalis* possessed a slightly darker spot than those of *proteoteratis.* This color difference, and leg color in general, varies considerably and I can find no structural differences that might indicate that two species are present. Likewise, Gahan described *pini* based on a difference in body color (green in *proteoteratis* and black in *pini*), but my material makes it clear that this character also varies. Specimens of *argissa* from Austria and Northern Italy were imported on several occasions and released in North America against the imported European larch casebearer (Ryan et al., 1975, 1977).

These wasps were reared from the related host *Coleophora limosipennella.* It was unknown at that time that this same species already occured in North America under the name of *proteoteratis.* At present, this is still the only species in the genus that is known to have a holarctic distribution.

This is the most common and widespread species of *Elachertus* in North America and it also has the broadest host range. It would appear that this species will attack almost any small lepidopterous larva in a suitable microhabitat and I would expect the host range to continue to broaden as additional rearings are made.

Elachertus cacoeciae (Howard)

Elachistus cacoeciae Howard, 1885: 28.
Elachistus glacialis Ashmead, 1902: 147. New Synonymy.
Elachistus aeneoniger Girault, 1917: 2. New Synonymy.

Diagnosis.—Axillae protruding cephalad of scutellum (Fig. 4); scutellum smooth; petiole reduced, not as long as wide; mandible with obvious teeth (Fig. 8); midlobe of mesoscutum with more than 3 pairs of setae; face below toruli with sculpture only medially.

This species is most similar to *loh* n.sp. which shares the protruding axillae and the distinctly toothed mandible. *E. cacoeciae* can be identified by the setae of the midlobe of the mesoscutum (only 3 pairs in *loh*), and the sculpturing below the toruli (face evenly rugose in *loh*, Fig. 9). Males have the pores on the scape as in Fig. 18 (*loh* as in Fig. 19).

Types.—The original syntype series of *cacoeciae* (USNM type no. 2659) was mounted on a single multipointed card. Three of the six specimens mentioned by Howard have been lost. The lectotype (present designation) is the middle of the three remaining specimens and is indicated by a black arrow. The one intact antenna and a forewing have been slidemounted. The point contains the data: "on rose, Kirkwood near Godfrey, Aug. 1877." Howard, in the original description added: "from the leaf curl of *Cacoecia rosaceana* (Harr.), at Kirkwood, Mo. C. V. R. Coll."

The holotype female of *aeneoniger* Girault (USNM type no. 20024) is point mounted with the data: Ithaca, N.Y. 20 April, 1915. The head and forewing are slidemounted. Girault did not mention how many specimens he had of this species in his original description. There is only a single female labelled as type in the USNM and I hereby designate it lectotype.

The lectotype (present designation) female of *glacialis* is mounted on a minuten pin with the data: Muir inlet [Alaska]. 6/12/1899. Harriman expedition, T. Kincaid collector. USNM type no. 5530. The paralectotype male was collected at Yakutat on June 21. Girault slidemounted the head, abdomen, forewings, and part of the legs of the female as well as the head and antennae of the male. The majority of these pieces are badly crushed or disarticulated.

Other specimens examined.—147 ♂ and ♀ (USNM), 158 ♂ and ♀ (CNC), 4 ♀ (INHS), 22 ♂ and ♀ (OSU), and 7 ♀ (SWE).

Variation.—Length varies from 1.1 to 2.7 mm. Color is generally black or reddish brown with the metasoma dark to light brown. The fore- and midcoxae may be entirely yellow to entirely dark brown or black. The rest of the legs vary from yellow to brown and in a few specimens are almost entirely black. The antennae range from brown to black, with the scape sometimes light brown or yellowish at the base. The metasoma may have extensive yellowish areas anterodorsally and ventrally. The midlobe of the mesoscutum may have as few as 4–5 pairs of setae and as many as 20 pairs; the sculpture of the mesoscutum often fades to smooth as it approaches the anterior edge of the scutellum. The wing veins vary in color from yellow to dark brown.

Hosts.—Tortricidae: *Acleris variana* (Fern.) (eastern blackheaded budworm)*; *Ancylis comptana* (Frölich) (strawberry leafroller); *Archips argyrospilus* (Walk.) (fruittree leafroller); *Argyrotaenia pinitubana* (Kearf.) (pine tube moth); *A. velutinana* (Walk.) (redbanded leafroller); *Argyresthia oreasella* Clem.; *Barbara colfaxiana* (Kearf.) (Douglas-fir cone moth); *Choristoneura fumiferana* (Clem.) (spruce budworm); *C. rosaceana* (Harr.) (oblique banded leafroller); *Cydia caryana* (Fitch)*; *Mellisopus latiferranus* (Wlms.) (Filbertworm). Notodontidae: *Heterocampa guttivitta* (Walk.) (saddled prominent); *Schizura unicornis* (Smith) (unicorn caterpillar). Arctiidae: *Hyphantria cunea* (Drury) (fall webworm).

Burks (1979) lists *Eulophus orgyiae* (Fitch) (Eulophidae) as a host of *cacoeciae*, but I consider this to be highly doubtful since *Elachertus* are not known to be hyperparasitic. In addition, there is a series of specimens in the USNM collection from California that is labelled as "ex. *Bruchus lobatus.*" However, considering the known reliable host associations of these species, I would regard this record as questionable.

Distribution.—Occurs throughout United States and Canada.

Notes.—*E. glacialis* Ashmead and *E. aeneoniger* Girault, synonymized above, were separated by those authors from *cacoeciae* on the basis of color differences. However, as in the case of *proteoteratis*, when a number of specimens from different localities and hosts are examined, it is apparent that intermediate forms are present.

Next to *argissa*, this is the most commonly collected species. Likewise, it is widespread and has a broad host range.

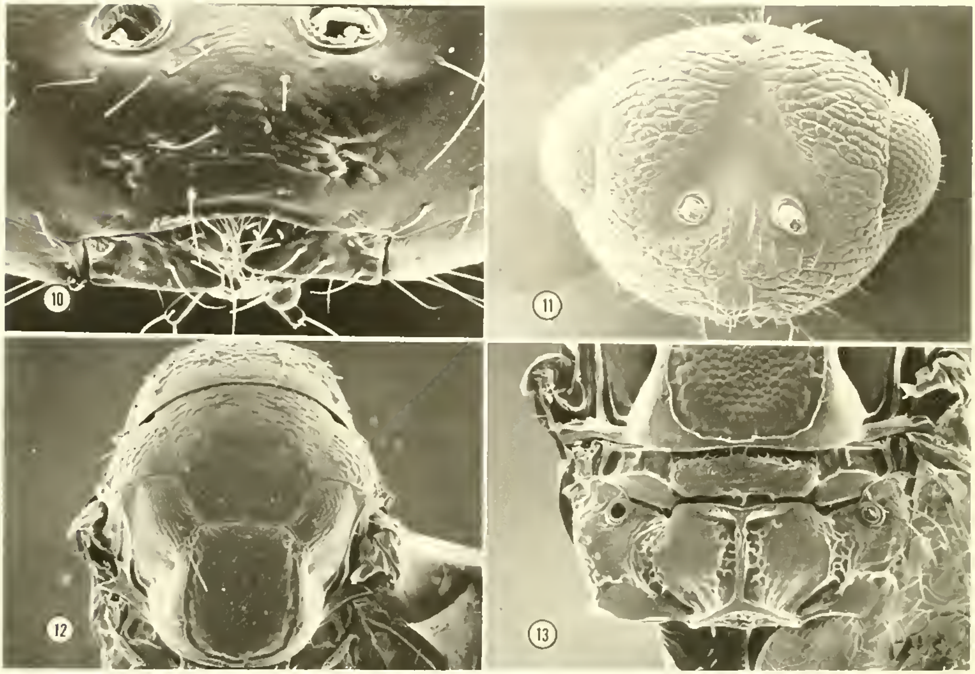
***Elachertus cidariae* (Ashmead)**

Elachistus cidariae Ashmead, 1898: 157.
Elachertus hyphantriae Crawford, 1911: 622. New Synonymy.
Elachistus marylandicus Girault, 1916: 112. New Synonymy.

Diagnosis.—Axillae protruding (Fig. 6); scutellum alutaceous to coriaceous; propodeum laterad of median carina smooth; mandibles reduced (Fig. 10), without obvious teeth; submarginal vein with 7 setae, basal and cubital vein setae present (Fig. 23); midlobe of mesoscutum with 3 pairs of setae (Fig. 6).

This species shares protruding axillae with *cacoeciae*, *loh*, and *louisiana*. However, *cacoeciae* and *loh* have distinctly dentate mandibles and a smooth scutellum. The sunken and sculptured area laterad of the median propodeal carina (Fig. 13), as well as the absence of cubital and basal vein setae under the submarginal (Fig. 22) separate *louisiana* from *cidariae*.

Types.—Ashmead failed to mention how many specimens he had when he described *cidariae*. However, the USNM collection contains 5 specimens labelled as types. Each is mounted on a point with the following data: Cambridge, Mass. Type. Collection Ashmead, no. 2938. USNM type no. 41256. The lectotype (present designation) is mounted on a point with another female and I have indicated it with a black arrow.



Figs. 10–13. Scanning electron micrographs of *Elachertus*. 10, Face and mandibles of *E. cidariae*. 11, Face of male *E. atus*. 12, Dorsal thorax of *E. louisiana*. 13, Propodeum of *E. louisiana*.

Crawford described *hyphantriae* from a series of five females. Four of these specimens have survived and one is missing (the point contains only parts of one leg). The lectotype (present designation) is the only specimen that remains largely intact (Girault mounted and crushed the heads of two of the other syntypes) and I have affixed a lectotype label to it. All of the remaining specimens are labelled as paralectotypes. All of these specimens are point mounted with the following data: Cuero, Texas. Bred from *Hyphantria*. May 10, 1910. USNM type no. 13463.

The two syntypes from which Girault described *marylandicus* are mounted on the same point with no data except a label bearing the species name in Girault's handwriting and the word "type." The lectotype (present designation) is the outermost specimen on the point and is nearly intact. Girault's original description indicated that these specimens were taken in open woodlands in Glendale, Maryland on August 12, 1916.

Variation.—Length varies from 1.3 to 2.0 mm. The thorax and head vary from black to reddish brown. The metasoma varies from entirely yellow to dark brown, often with a lighter area antero-medially. The mandibles and scape vary from yellow to light brown, the funicle from light brown to black. The coxae may be almost entirely yellow, coxae becoming brown to black, the femora dark brown, and tibiae light brown.

Hosts.—Arctiidae: *Hyphantria cunea* (Drury) (fall webworm); *Diacrisia virginica* (F.) (yellow woolybear). Lymantriidae: *Orgyia definita* (Pack.); *O. leucostigma* (J. E. Smith) (whitemarked tussock moth)*; *O. pseudotsugata* (McD.) (Douglas-fir tussock moth). Notodontidae: *Schizura ipomoeae* Doubleday.* Geometridae:

Eulithis diversilineata (Hbn.) (grapevine looper). Coleophoridae: *Coleophora laricella* (Hbn.) (larch casebearer).*

Distribution.—This species has been recorded from most of the states or provinces in eastern United States and Canada and as far west as Texas and Colorado.

Other specimens examined.—76 ♂ and ♀ (CNC); 115 ♂ and ♀ (USNM); 1 ♀ (INHS).

Notes.—In Ryan's key (1979) to the parasites of larch casebearer, he noted an unidentified species of *Elachertus* with protruding axillae. Specimens obtained from Dr. Ryan confirm that the species is *cidariae.*

Elachertus multidentatus (Girault)

Parentedon multidentatus Girault, 1917: 5.

Diagnosis.—Anterior margins of axillae and scutellum forming a straight line (as in Fig. 2); mesoscutum coriaceous; scutellum alutaceous; mandible with row of numerous small denticles along upper edge (Fig. 21); area laterad of propodeal carina sunken and minutely sculptured (similar to Fig. 13); all funicular articles longer than wide.

The relationship of this species to the others remains clouded. Although the axillae are not advanced, the petiole and metasoma are missing from the type and it is not possible to say if *multidentatus* shares these characters with other species like *argissa* and *atus* which have similar axillae. Likewise, the sunken and sculptured area laterad of the propodeal carina of *multidentatus* is similar to *louisiana* Girault, but this last species has blunt mandibles and protruding axillae so that it is doubtful that it is closely related. This is the only species I have seen in which all of the articles of the funicle are longer than broad. In the others, at least the last article is broader than long.

Types.—Lectotype female (present designation) on point with the data: "Jacksonville, Florida, USNM type no. 20759; *Elachistus multidentatus* Girault female type." The head (badly crushed), one forewing, and parts of the legs are slide-mounted. The metasoma and petiole are missing.

Hosts.—Unknown.

Distribution.—Known only from Florida.

Notes.—The only known specimen of this species is the lectotype. As noted above, several critical body parts are missing or have been so badly crushed that definitive statements about the relationship of *multidentatus* to the other species remain problematical.

Elachertus louisiana (Girault)

Epardalus louisiana Girault, 1917: 5.

Diagnosis.—Axillae protruding (Fig. 12); scutellum alutaceous; mandible blunted (as in Fig. 10); propodeum laterad of carina sunken and with foveolate sculpture (Fig. 13); forewing with basal and cubital vein setae absent and submarginal (Fig. 22) with 3 or 4 setae.

This species is most similar to *cidariae,* which shares the protruding axillae, alutaceous scutellum, and blunted mandible. However, *cidariae* has the area laterad of the propodeal carina smooth, and the basal and cubital vein setae are present (Fig. 23) and there are 7 setae on the vein itself.

Types.—Although Girault's original description does not state how many specimens he had, USNM records in Girault's handwriting indicate that there was a series of 3 syntypes. Unfortunately, I have only been able to find a single female in the collection. I hereby designate it as lectotype. The head (badly crushed) and one of the legs is slide mounted. The point mounted thorax bears the data: "La. U. no. 64, sub.1. USNM type no. 20020, *Elachistus louisiana* Gir."

Variation.—No significant variation was observed in the available specimens.

Hosts.—Apaturidae: *Asterocampa clyton* (Bdv. & Leconte).*

Distribution.—Louisiana, Illinois.

Other specimens examined.—2 ♀ and 2 ♂ from Illinois (USNM).

Elachertus loh **Schauff, NEW SPECIES**

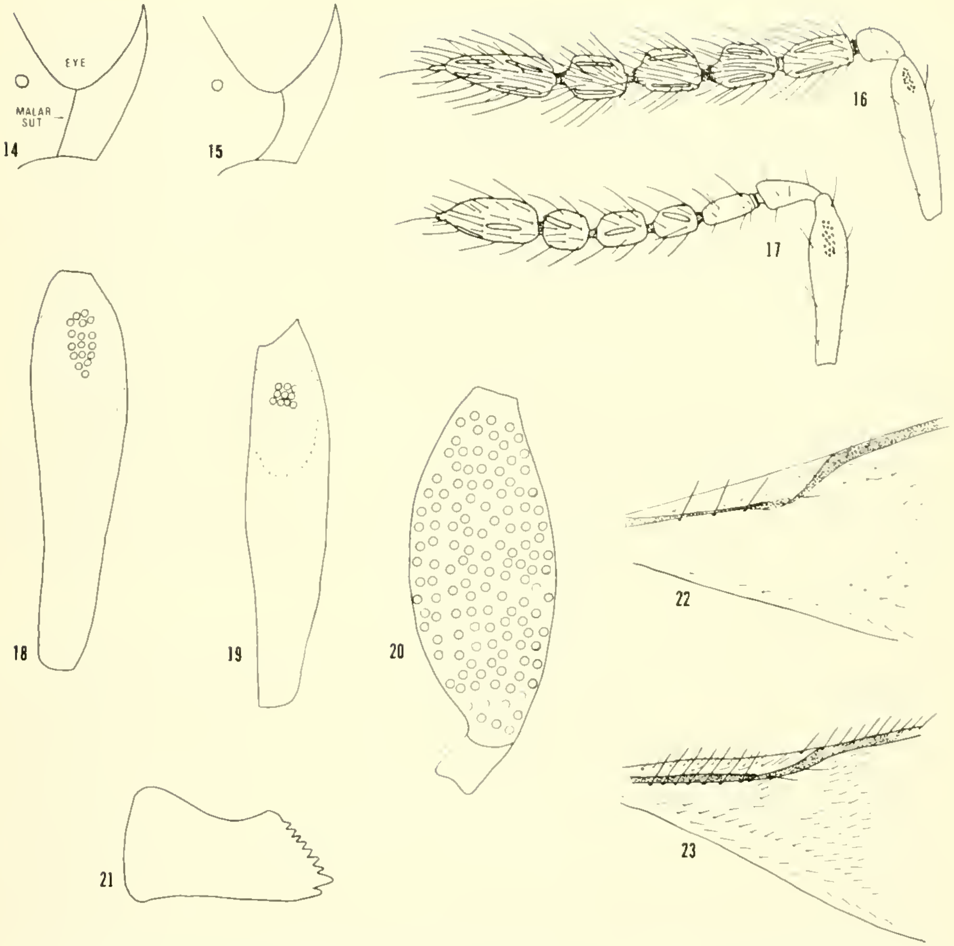
Holotype female.—Length 2.2 mm. Head, thorax, ovipositor sheaths black; dorsal tip of scape, pedicel, funicle, base of forecoxae, metasomal terga except medially on first two brown; scape, mid- and hindcoxae, legs, venter of metasoma and first two terga medially yellow. Head slightly wider than high (66:55); eye height ⅔ head height, with scattered silvery setae; vertex, frons laterally, genae, occiput lightly alutaceous, with numerous small dark setae; scrobes smooth, face under toruli uniformly rugose (Fig. 9); ocelli slightly raised, POL 2× OOL; malar suture straight; mandibles with 6 teeth; antennal ratio (scape : pedicel : funicle : club) 25:9:11:9:9:8:16, funicular articles gradually widening apically, evenly covered by silver setae about equal in length to width of each antennomere; club with apical digit; thorax with pronotum, middle lobe of mesoscutum, side lobes laterally, and axillae laterally alutaceous; lateral lobes of mesoscutum at notauli, axillae medially, scutellum, metanotum, propodeum laterad of carina smooth, rugose near spiracle; midlobe of mesoscutum with 3 pairs of setae; axillae protruding cephalad of anterior margin of scutellum; dorsellum rounded posteriorly, not excavated above, without lateral lobes; median propodeal carinae complete; petiole reduced to a narrow dorsal band; gaster slightly longer than head and thorax combined, in dorsal view about ⅔ as wide as long; ovipositor sheaths slightly exserted past tip of gaster; forewing evenly setose beyond submarginal vein; submarginal vein with 6 setae, and basal and cubital vein setae present.

Male.—Similar to the female except for the following: scape with distinct light yellow oval area surrounded by light brown; funicle and femora light yellowish brown; antero-dorsal ⅓ to ½ of metasoma white medially surrounded by light brown at the edges, ventral ½ white.

Diagnosis.—Axillae protruding (as in Fig. 4); scutellum smooth; face under toruli uniformly rugose (Fig. 9). Males with sensory pores of scape as in Fig. 19.

This species is most similar to *cacoeciae* which also has advanced axillae and a smooth scutellum. The uniform rugose sculpturing under the toruli distinguishes *loh* (face lightly alutacous only medially in *cacoeciae* Fig. 8). Males can be separated by the pattern of sensory pores on the scape (Fig. 18 for *cacoeciae* versus 19 for *loh*).

Types.—Holotype ♀ on point with data: "Nova Scotia, South Maitland, Hants; 27/VI/1984; P. von Aderkas; ex. leafroller on *Matteuccia struthiopterus*." Deposited in the U.S. National Museum. Paratypes deposited in the USNM: 5 ♀, 4 ♂ same data as above. Paratypes deposited in CNC: 4 ♀, Nova Scotia, Aldershot, July 25, 1949, C. Sawyer. Host sawfly (?) on sensitive fern; 1 ♀, Florida, Liberty



Figs. 14–23. 14–15, Malar sutures. 14, *E. argissa.* 15, *E. atus.* 16–20, Male antennae. 16, *E. argissa.* 17, *E. atus.* 18, Scape of *E. cacoeciae.* 19, Scape of *E. loh.* 20, Scape of *Hyssopus* sp. 21, Mandible of *E. multidentatus.* 22–23, Forewings. 22, *E. louisiana.* 23, *E. cidariae.*

Co., Torreya St. Pk., 7-10-1980, Masner and Bowen. Paratypes deposited in INHS: 18 ♀, 5 ♂, Illinois, White Heath, Aug. 5, 1939, Ross and Riegel.

Variation.—Length varies from 1.6 to 2.3 mm. In males, the coxae vary from yellowish brown to entirely black. In females, the coxae change gradually from yellow through light brown.

Hosts.—A series of specimens from Illinois were reared from the larvae of a pyralid in the subfamily Pyraustinae (Det. by D. Weismann). Both series of specimens from Nova Scotia were reared on ferns. Another series of specimens is labelled as ex. Sawfly (?). In view of the known host associations of the other species, this record is suspect.

Distribution.—United States: Ill., Fla. Canada: Nova Scotia.

Etymology.—This species epithet is formed from the initials of L. O. Howard, who named many of the North American species.

Elachertus atus Schauff, New Species

Holotype female.—Length 2.0 mm. Head, thorax, petiole dark metallic greenish black; antennae, mid- and hindcoxae, apical tarsomere of all legs, metasomal dorsum except first tergite brown; forecoxae, femora, tibiae, first 3 tarsomeres, first metasomal tergum, ventral metasoma yellow. Head wider than high (30:26); eye height ½ head height, with scattered silvery setae; vertex, occiput alutaceous; genae strigate; face except scrobes alutaceous, becoming strigate below eyes; scrobes smooth; ocelli slightly raised, POL 1.5× OOL; malar suture (Fig. 15) curved; mandibles with 6 teeth; antennal ratio (scape : pedicel : funicle : club) 25:9:10:8:8:8:15, funicular articles gradually widening apically, evenly covered by silver setae each slightly shorter than width of each article; apical digit of club short; thorax with pronotum, mesoscutum, dorsellum, propodeum laterally alutaceous; scutellum, axillae coriaceous; propodeum laterad of carina smooth; midlobe of mesoscutum with 10 pairs of setae; axillae ending on straight line with anterior margin of scutellum; dorsellum with lateral lobes, excavated ventrally; median propodeal carina complete; petiole about as long as wide; metasoma as long as thorax and head combined, in dorsal view about ½ as wide as long; ovipositor sheaths slightly exserted past tip; forewing evenly setose past submarginal vein, basal and cubital setae present (as in Fig. 28), submarginal with 8 setae.

Male.—Similar to female except the following: head (Fig. 11) except scrobes rugose, dark brown; eye height less than ½ head height; antennae as in Fig. 17.

Diagnosis.—Anterior margins of axillae and scutellum forming a straight line (as in Fig. 2); petiole about as long as wide; malar suture curved (Fig. 15); POL 1.5× OOL; scutellum distinctly coriaceous, dorsellum usually with light sculpturing. Males with head dark brown and uniformly rugose except for scrobes (Fig. 11); scape as in Fig. 17.

This species is most closely related to *argissa* which has a straight malar suture (Fig. 14); POL 2× OOL; scutellum alutaceous (Fig. 2); and the dorsellum usually smooth. Males of *argissa* have the head black or greenish, lightly sculptured, and the eyes at least ½ head height; scape as in Fig. 16.

Types.—Holotype ♀ on point with paratype ♂ with the following data: "Ontario, Niagara; Feb. 18, 1932; W. E. Steenburgh; Crown Gall Goldenrod." Deposited in Canadian National Collection. Paratypes deposited in CNC: 4 ♂ and 6 ♀ with same data as holotype; 4 ♂, 1 ♀ New Brunswick, Kouckibouque N. P., 24-V-1977, G. A. P. Gibson, code 5123A; 1 ♂ Quebec, Great Whale River, 8-VIII-1959, W. R. M. Mason; 1 ♀ Constance Bay, Ontario, VII-1969; 1 ♀ Manitoba, Workworth Cr. near Churchill. 29-VI-1952. J. G. Chillcott; 2 ♀ Ontario, Marmora area. Aug. 25, 1959. L. K. Smith. Paratypes deposited in USNM: 1 ♂, 1 ♀ California, Saticoy. S. E. Flanders collector. ex. *Archips argyrospilus*; 1 ♂, 1 ♀ Indiana, Porter Co., Washington Twp., L. G. Jones, 8-14-1931, from lepidopterous leafroller on goldenrod; 1 ♀, Dixie Co., Fla., May 23, 1972; 2 ♀, New York, Essex Co., Whiteface Mtn., summit 4800′, 30 July, 1979, E. E. Grissell and M. E. Schauff; 1 ♂, Vermont, Rutland Co., 2 mi. E. Danby, 31 July, 1979, E. E. Grissell and M. E. Schauff; 1 ♀, Midland Co. Michigan, 6-24-52, R. R. Dreisbach; 2 ♂ and 2 ♀ same data as holotype.

Variation.—Length varies from 1.2 to 2.0 mm. The coxae vary from light brownish yellow to dark brown, the femora and tibiae from yellow to light brown.

One male specimen has all the legs entirely dark brown to blackish. The dorsellum is generally distinctly alutaceous, but this fades to nearly smooth in a few specimens.

Hosts.—Tortricidae: *Archips argyrospilus* (Wlk.) (fruittree leafroller).*

Distribution.—Eastern and central Canada, Indiana, New York, Vermont, Michigan, Florida, and California. The presence of this species in California indicates that it is probably more widespread than currently known.

Etymology.—The species epithet is an arbitrary combination of letters.

Unplaced Species

***Elachertus spilosomatis* (Howard)**

Elachistus spilosomatis Howard, 1891: 195.

Howard proposed *spilosomatis* by indication to a figure of the pupae attached to their host (*Diacrisia virginica*). No types or other specimens of this species are known to exist. Since there is no way in which to definitely relate the figure of the pupa to any known species, I am reluctant to synonymize it (particularly since it would most likely be the senior synonym).

Acknowledgments

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Literature Cited

Ashmead, W. H. 1898. Descriptions of new parasitic Hymenoptera. Proc. Entomol. Soc. Wash. 4: 155–171.

———. 1902. Papers from the Harriman Alaska Expedition. Proc. Wash. Acad. Sci. 4: 117–274.

Askew, R. R. 1968. Handbooks for the identification of British insects. Hymenoptera: Chalcidoidea (part). R. Entomol. Soc. London 8: 2(b). 39 pp.

Bouček, Z. and R. R. Askew. 1968. Index of Entomophagous Insects. Palearctic Eulophidae (excl. Tetrastichinae). (Hym. Chalcidoidea). Le Francois, Paris. 260 pp.

Burks, B. D. 1979. Family Eulophidae, pp. 967–1022. *In* Krombein, K. V. et al., eds., Catalog of Hymenoptera in America North of Mexico. Vol. 1 Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington, D.C. 1198 pp.

Crawford, J. C. 1911. Descriptions of new Hymenoptera 1. Proc. U.S. Natl. Mus. 39: 617–623.

Erdos, A. 1961. Fauna Eulophidarum Hungariae generibus speciebusque novis aucta (Hymenoptera). Ann. Hist. Nat. Mus. Natl. Hung. 53: 471–489.

Foerster, A. 1856. Hymenopterologische Studien II. Chalcidiae und Proctotrupii. Aachen. 152 pp.

Gahan, A. B. 1927. Four new chalcidoid parasites of the pine tip moth, *Rhyacionia frustrana* (Comstock). J. Agric. Res. 34: 545–548.

Gahan, A. B. and M. M. Fagan. 1923. The type species of the genera of Chalcidoidea or chalcid-flies. Bull. U.S. Natl. Mus. 124: 171 pp.

Girault, A. A. 1916. New species of parasitic Hymenoptera. Bull. Brooklyn Ent. Soc. 11: 111–113.

———. 1917. Descriptiones Hymenopterorum Chalcidoidicarum variorum cum observationibus III. Hillmead Press, Glendale, Md. 10 pp.

Graham, M. W. de V. 1959. Keys to the British genera and species of Elachertinae, Eulophinae, Entedontinae, and Euderinae (Hym., Chalcidoidea). Trans. Soc. British Entomol. 13: 169–204.

Harris, R. A. 1979. A glossary of surface sculpturing. Occasional papers of laboratory services/ Entomology no. 28. California Department of Food and Agriculture, Sacramento, Calif. 31 pp.

Hodges, R. W., T. Dominick, D. Davis, D. Ferguson, F. Franclemont, E. Monroe, and J. Powell. 1983. Check List of the Lepidoptera of America North of Mexico. E. W. Classey Limited and the Wedge Entomological Research Foundation, London. 284 pp.

Howard, L. O. 1885. Descriptions of North American Chalcididae. U.S. Dept. Agric., Bur. Entomol. Bull. No. 5. 47 pp.

———. 1891. The method of pupation among the Chalcididae. U.S. Dept. Agric., Insect Life 4: 193–196.

Nees ab Esenbeck, C. G. 1834. Hymenopterorum Ichneumonibus affinum monographie, genera Europaea et species illustrantes. Stuttgartiae et Tubingae. 448 pp.

Peck, O. 1963. A catalog of the Nearctic Chalcidoidea (Insecta: Hymenoptera). Can. Entomol. Supp. 30. 1092 pp.

Ryan, R. B. 1979. Illustrated key to introduced and native parasites of larch casebearer. USDA For. Serv. Res. Paper PNW-262, Pac. Northwest For. and Range Exp. Sta., Portland, Oreg. 12 pp.

Ryan, R. B., W. E. Bousfield, R. E. Denton, R. L. Johnsey, L. F. Pettinger, and R. F. Schmidtz. 1975. Additional releases of larch casebearer parasites for biological control in the western United States. USDA For. Serv. Res. Note PNW-242, Pac. Northwest For. and Range Exp. Sta., Portland, Oreg. 7 pp.

———. 1977. Releases of recently imported larch casebearer parasites for biological control in the western United States, including relocations of *Agathis pumila*. USDA For. Serv. Res. Note PNW-290, Pac. Northwest For. and Range Exp. Sta., Portland, Oreg. 4 pp.

Spinola, M. M. 1811. Essai d'une classification generale des Diplolepaires. Ann. Mus. Hist. Nat., Paris 17: 138–152.

Thomson, C. G. 1878. Hymenoptera Scandinaviae. Vol. 5. Lund. 307 pp.

Walker, F. 1839. Monographia Chalciditum 1. London, 333 pp.

Werner, F. 1982. Common Names of Insects and Related Organisms (1982 revision). Entomological Society of America, special publication. 132 pp.

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TELOSPHRANTIS AETHIOPICA MEYRICK TRANSFERRED TO CHOREUTIDAE (LEPIDOPTERA)[1]

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Abstract.—The genus and species *Telosphrantis aethiopica* Meyrick, 1932, described from Ethiopia, is transferred to the family Choreutidae, being near to the genus *Anthophila*. Adult maculation and morphology is redescribed and illustrated.

The genus *Telosphrantis*, including only *T. aethiopica* Meyrick from Ethiopia, was described and placed in the family Yponomeutidae by Meyrick (1932). The genus and species was not studied again until Clarke (1965) examined specimens at the British Museum (Natural History) (BMNH) and selected a lectotype. Clarke retained the species in Yponomeutidae. Study of the type and syntypes in the BMNH confirm the transfer to Choreutidae. A modern description of the genus and species is given below.

Telosphrantis Meyrick

Telosphrantis Meyrick, 1932: 116 (Type-species: *T. aethiopica* Meyrick, 1932, by monotypy); Clarke, 1955: 38; 1965: 391.

Diagnosis.—Head small; vertex relatively smooth-scaled; compound eye average; ocellus average; antenna with very long setae in male; labial palpus upcurved, without ventral scale tuft (relatively smooth); maxillary palpus small, 2-segmented (?); pilifers large; haustellum scaled basally; forewing (Fig. 3) relatively elongated, with pointed apex, with long pterostigma, Sc to midwing on costa, R1–R4 to costa, R5 to termen near apex, median veins equally spaced, CuA1 curved and CuA2 near end of cell, CuP present at tornus, A_{1+2} with long basal fork, A_3 vestigial; hindwing (Fig. 3) subtriangular with rounded tornus, Sc to near apex, Rs to apex, median veins nearly equidistant, M1 with thin extension into cell, CuA1 and CuA2 parallel, CuP at tornus, A_{1+2} with long basal fork, A3 long, A4 not evident.

Male genitalia: Simple tegumen-vinculum arrangement; saccus undistinguished; uncus strongly developed, with heavily sclerotized arms as tegumen extensions; gnathos very strong, fused medially into bifurcate apex; valva simple, elongate, with subapical setae and a strong apical point dorsally, plus a small subtended

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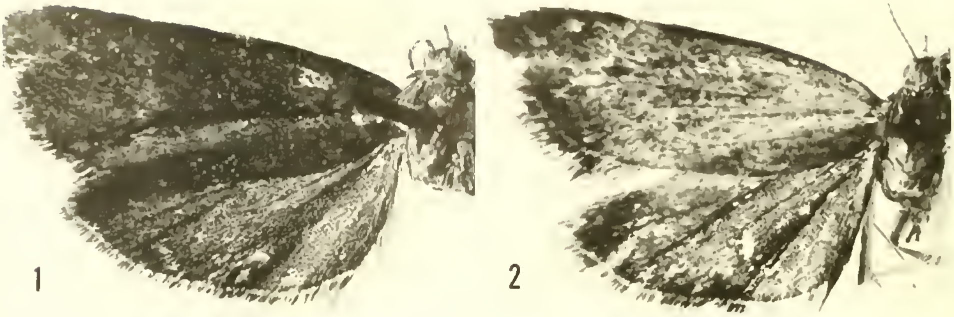
[1] Contribution No. 614, Bureau of Entomology, FDACS.



Figs. 1, 2. *Telosphrantis aethiopica*, adults (paralectotypes), Ethiopia. 1, Male. 2, Female.

spine field; anellus a half-tube; aedeagus simple, cornutus present; ductus ejaculatorius a simple tube.

Female genitalia: Simple, setaceous ovipositor, relatively short; apophyses of average thickness, nearly subequal; ostium on intersegmental membrane between sternites 7 and 8 but partially surrounded by sternite 7 posterior margin; ostium a small opening; ductus bursae a simple membranous tube; ductus seminalis emergent near bursa; corpus bursae a simple oval sac; signum a small spiculate patch.

Remarks.—The genus appears related to *Anthophila* in the subfamily Choreutinae, particularly in regard to the gnathos being present in the male. The scler-

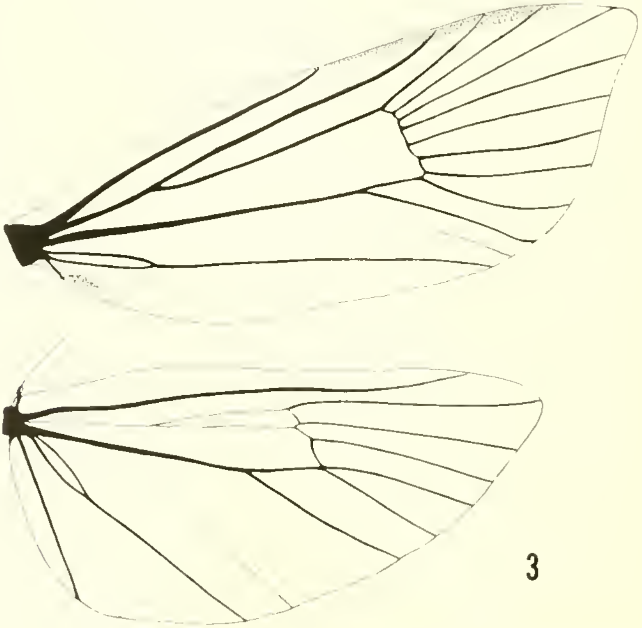
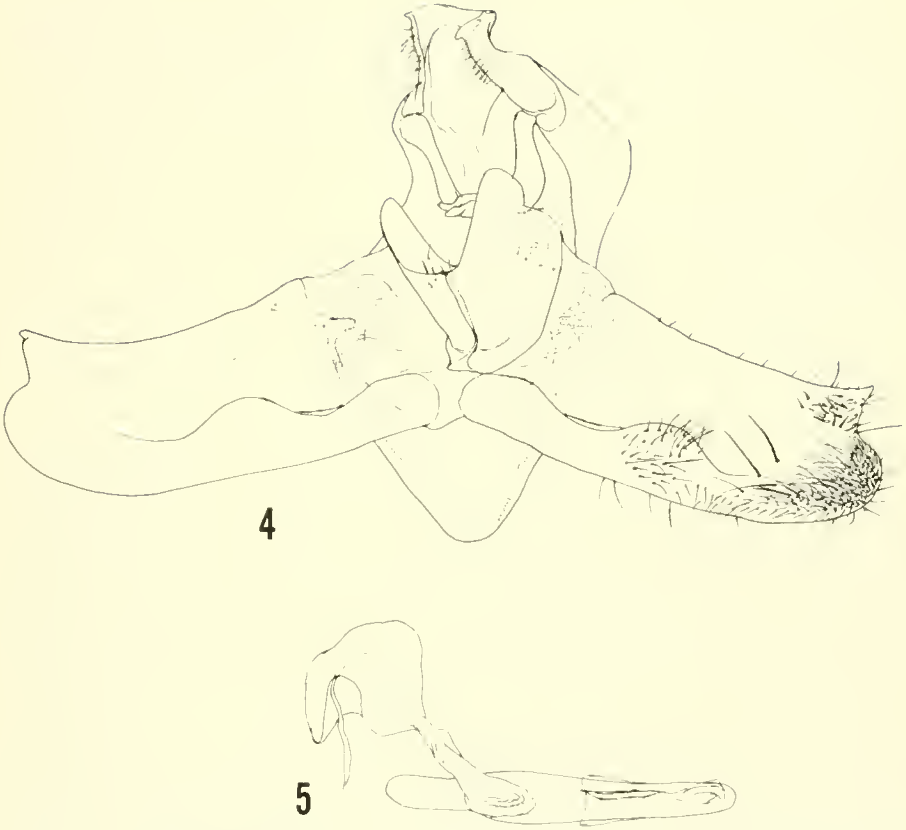


Fig. 3. *Telosphrantis aethiopica*, wing venation (holotype male), Ethiopia (slide JFGC 7512).



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Figs. 4, 5. *Telosphrantis aethiopica*, male genitalia (paralectotype male), Ethiopia. 3, Valvae. 4, Aedeagus (BM slide 20295).

otized uncus is unique in the Choreutidae. The genus was not included in the recent review of Sesioidea taxa (Heppner, 1981).

Telosphrantis aethiopica **Meyrick**

Telosphrantis aethiopica Meyrick, 1932: 116; Clarke, 1955: 38; 1965: 391.

Male.—Forewing 7.0 mm. *Head:* brown with some buff scales mixed in; buff eye margin; venter nearly white; labial palpus nearly white basally, white and fuscous on segment 2 with orange-tan mesally, and apical segment fuscous; antenna alternating fuscous and buff. *Thorax:* brown; venter tan and fuscous; legs fuscous with buff on segmental apices. *Forewing* (Fig. 1): unicolorous dark brown or fuscous, with one narrow buff mark on costal margin at ⅔ from wingbase; venter similar but more shining; fringe fuscous. *Hindwing:* unicolorous fuscous. *Abdomen:* fuscous; venter with buff basally. *Male genitalia* (Fig. 4): tegumen and vinculum subequal in size; uncus sclerotized as a bifurcate tegumen extension around simple anal tube and with a small recurved hook on the apex of each arm; gnathos strongly sclerotized and the arms fused into a bifurcate spined apex; valva

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Fig. 6. *Telosphrantis aethiopica*, female genitalia (paralectotype female), Ethiopia (BM slide 20296).

elongated, somewhat upcurved along dorsal margin, ending at a sharp point subtending several strong spines, with a rounded setose subapical lobe continuing toward the base with decreasing setal numbers; vinculum a simple V-shape; anellus a strongly sclerotized tubular shape, open dorsally; aedeagus (Fig. 5) straight, relatively short, with a small spindle-shaped cornutus and short phallobase; ductus ejaculatorius simple.

Female (Fig. 2).—Same as male; forewing 7.0 mm. *Female genitalia* (Fig. 6): ovipositor setaceous; apophyses of average strength, with anterior pair somewhat shorter than posterior pair; ostium on intersegmental membrane between sclerites 7 and 8, with sternite 7 having a rounded area around ostium but not fused with ostium as a sterigma; ostium a small somewhat elliptical opening, with a membranous ductus bursae; ductus seminalis emergent near bursa; corpus bursae ovate-oblong, with a small round spicule patch as a signum.

Types.—Lectotype ♂: Mt. Chillálo (9000 ft [2743 m]), 14–16-XI-1926, H. Scott, Ethiopia (BMNH) (slide JFGC 7512); designated by Clarke (1965: 391). Paralectotypes (5 ♂, 3 ♀): Ethiopia: (same data as lectotype) (BMNH).

Remarks.—The species has not been collected since the original series was collected in 1926. Nothing is known about its life history or hosts, although the elevation data for Mt. Chillálo provides some ecological information on the habitat of the species and for future reference in searching for it. This is the only species known in the genus *Telosphrantis*.

Acknowledgments

The cooperation and loan of specimens by G. S. Robinson (BMNH) are kindly appreciated, as well as help with label data of syntypes by K. R. Tuck (BMNH). The photographs were completed by the staff photographer, Jane Windsor, Florida Dept. of Agriculture and Consumer Services, Division of Plant Industry; line drawings are by the author.

Literature Cited

Clarke, J. F. G. 1955. Catalogue of the type specimens of microlepidoptera in the British Museum (Natural History) described by Edward Meyrick. Vol. 1. London: British Mus. (Nat. Hist.). 332 pp.

———. 1965. Ibid. Vol. 5. London: British Mus. (Nat. Hist.). 581 pp.
Heppner, J. B. 1981. Choreutidae. *In* J. B. Heppner and W. D. Duckworth, Classification of the Superfamily Sesioidea (Lepidoptera: Ditrysia). Smithsonian Contr. Zool. 314: 1–144.
Meyrick, E. 1932. Entomological expedition to Abyssinia, 1926–27. Microlepidoptera. Trans. Ent. Soc. London 80: 107–120.

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, p. 863

NOTE

New Host Record for the Social Parasite *Pogonomyrmex anergismus* (Hymenoptera: Formicidae)

Pogonomyrmex anergismus Cole was previously known only from the type locality, 15 miles east of Silver City, New Mexico, as a social parasite of *P. rugosus* Emery (Cole, 1968. *Pogonomyrmex* harvester ants, University of Tennessee Press, Knoxsville, 222 pp.). We collected *P. anergismus* on 7 October, 1984, along Pinery Canyon Road, 2 k SE Route 181, 24 k (straight line distance) W of Portal, Chiricahua Mts., Cochise Co., Arizona (1600 m) in a nest of *P. barbatus* (F. Smith). The collection was made in a black-gamma grassland (*Bouteloua eriopoda* (Torr.) Torr.). *P. anergismus* was present in only one of six nests which we partially excavated.

We suggest that *P. anergismus* is widely distributed as both *P. rugosus* and *P. barbatus* have large ranges. This new record is a range extension of over 130 k to the southeast. *Pogonomyrmex anergismus* has a spotty local distribution wherever it occurs, being found only in one nest in an area with large numbers of nests of the host. As all specimens have been collected during excavation of host nests, we suggest this is the best method to collect them. Although this is a new host record, it is not surprising that it occurred in a nest of *P. barbatus* as *P. barbatus* is closely related to *P. rugosus.*

Our specimens differ from paratypes of *P. anergismus* in the following: 1, the males have longer, more flexous hairs on the dorsum of the thorax, and the hairs are also more dense; 2, males and females have longer propodial spines; and 3, females are darker. Until the variability of *P. anergismus* can be evaluated with specimens from other localities, we do not feel that the above differences justify the description of a new species.

Most of the specimens will be deposited in the National Museum of Natural History, Washington, D.C.

We thank Dr. David Smith, Systematic Entomology Laboratory, Agricultural Research Service, Washington, D.C., for the loan of paratypes of *P. anergismus* Cole and *P. colei* Snelling.

William P. MacKay and Steven Van Vactor, *Department of Biology, Box 3AF, New Mexico State University, Las Cruces, New Mexico 88003.*

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, pp. 864–870

REVIEW OF *THRIPS HAWAIIENSIS* AND REVALIDATION OF *T. FLORUM* (THYSANOPTERA: THRIPIDAE)

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Abstract.—*Thrips florum* Schmutz, previously synonymized under *T. hawaiiensis* (Morgan), is revalidated (Rev. Status). Six other names also synonymized previously under *hawaiiensis* are treated here as junior synonyms of *florum*. Characters to differentiate *florum* from *hawaiiensis* are given and variation in both species is discussed. Synonyms and general distribution for both species are presented and a lectotype is designated for *hawaiiensis*.

Thrips hawaiiensis (Morgan) is currently considered a variable species in morphology and color and, consequently, many species were synonymized with it (Jacot-Guillarmod, 1975; Bhatti, 1980). One of the variable morphological characters is the number of antennal segments. According to K. Sakimura (1980, pers. comm.), 62% of 345 specimens of *hawaiiensis* he examined from Hawaii had 8-segmented antennae, 20% had 8 segments on one side and 7 segments on the other, and 18% had only 7-segmented antennae. Most specimens examined by Bhatti (1980) from India had 7-segmented antennae. Specimens examined thus far from southeastern United States have 8-segmented antennae, except for two specimens from Florida with 7-segmented antennae. The number of antennal segments was the major criterion used previously to differentiate *Thrips* (7-segmented) from *Taeniothrips* (8-segmented). Consequently this species was assigned to both genera. To rectify this problem in this and other species, the concepts of both genera were recently revised by Bhatti (1978).

Thrips hawaiiensis is frequently intercepted by agricultural quarantine inspectors in cut flowers at ports of entry. During the past 15 years I have observed that many lots from the Orient and South Pacific islands consisted of females with only 7-segmented antennae, dark brown bodies, and long posteroangular setae on the pronotum. Other lots consisted of females with only 8, 7 and 8, or 7-segmented antennae, paler head and thorax and shorter posteroangular setae. Moreover, the males of these two forms also differed morphologically. Because the first form has not been found in conterminous United States, this study was initiated to find out if *hawaiiensis* as currently recognized consists of more than one species.

Methods and Results

The types of *hawaiiensis* and about half of its synonyms were examined. Only female types were available. Identified lots with females and males, and lots with only females or males were also examined. Based on 12 lots with females and males, I conclude that the current concept of *hawaiiensis* includes two different species, *hawaiiensis* and *florum* Schmutz. The latter species (5 lots, 24 females, 11 males) usually has 7-segmented antennae, rarely with one of the two antennae 8-segmented; females have (1) brown to dark brown bodies with orange subintegumental pigmentation in the thorax and head; (2) pronotum with posteroangular setae relatively long, 66–85 (avg. 76) μm; (3) 8–12 accessory setae on abdominal sternite VII; (4) and antero-angulated area of mesonotum lack striations by the anterior pores (Fig. 1). Males have (5) outer posteroangular setae 54–73 (avg. 62) μm long, inner pair 59–68 (avg. 65) μm long; and (6) 4 posterior setae on abdominal tergite IX with mesal pair longer and often stouter than lateral pair, distance between mesal setae 3.0–5.6 times the distance between the mesal and lateral setae (Fig. 3). Conversely, *hawaiiensis* (7 lots, 27 females, 20 males) has usually 8-segmented antennae, less frequently with one of the two antennae 7-segmented or both antennae 7-segmented. Females (1) with brown abdomen, thorax and head yellow, yellowish orange or brown with orange subintegumental pigmentation; (2) pronotum with shorter posteroangular setae, 33–62 (avg. 45) μm long; (3) abdominal sternite VII with 13–19 accessory setae; (4) and antero-angulated area of mesonotum striated by the anterior pores (Fig. 2). Males have (5) outer posteroangular setae 30–50 (avg. 38) μm long, inner pair 33–62 (avg. 45) μm long; and (6) abdominal tergite IX with 4 similar, bristle-like posterior setae, mesal pair usually longer than lateral pair, distance between mesal setae 1.0–1.8 times the distance between the mesal seta and lateral seta (Fig. 4). In other material, the coloration and the range of variation for characters 1–3 of the two species overlap. However, characters 4 and 6 are different, and character 3 apparently overlaps by one seta. Unfortunately, character 4, the presence or absence of striations on the anterior angulated area of the mesonotum, can be seen distinctly only on cleared specimens that do not have the pronotum lying over the anterior part of the mesonotum.

DISCUSSION

Thrips hawaiiensis is more variable than *florum*. The types of *hawaiiensis* have posteroangular setae that are 42–55 μm long and 13 accessory setae on sternite VII. One specimen from Australia has 76 μm long posteroangular setae, and Sakimura (pers. comm.) has seen a specimen from Hawaii that has 82 μm long posteroangular setae. Some specimens from India resemble *florum* in color and have relatively long posteroangular setae, 54–78 μm long, rarely as long as 86 μm, but have 15–23 accessory setae on abdominal sternite VII.

Thrips florum Schmutz previously treated as a junior synonym of *hawaiiensis* (Jacot-Guillarmod, 1975; Bhatti, 1978) is revalidated (Revised Status). Two paralectotypes of *florum* have outer posteroangular setae 78–87 μm long, and inner pair 71–85 μm long. Some of the types of the following species synonymized here under *florum* are in poor condition; however, I was able to see 11 accessory setae on sternite VII of *magnipes* Schmutz, *pallida* Schmutz and *rhodamniae* Schmutz; *magnipes* Schmutz has outer posteroangular setae 80–85 μm long, inner pair 76–80 μm long; *exilicornis* Hood has posteroangular setae 76–94 μm long and 10–13 accessory setae on sternite VII; and *florum* var. *dunbariae* have outer posteroangular setae 66–86 μm long, inner pair 73 μm long, and 10–11 accessory setae on sternite VII. According to Priesner (1934), *florum* var. *dunbariae* Priesner has

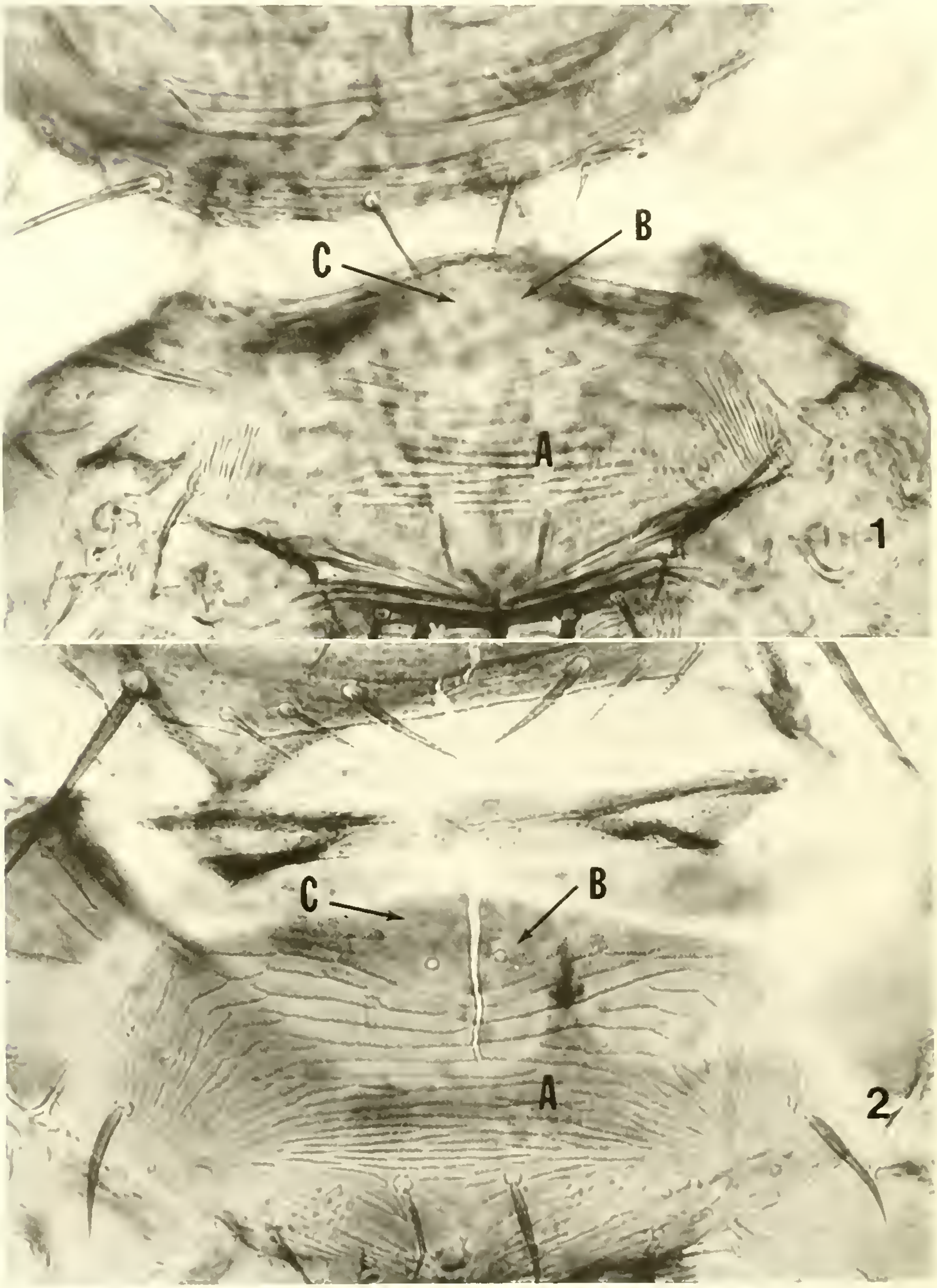
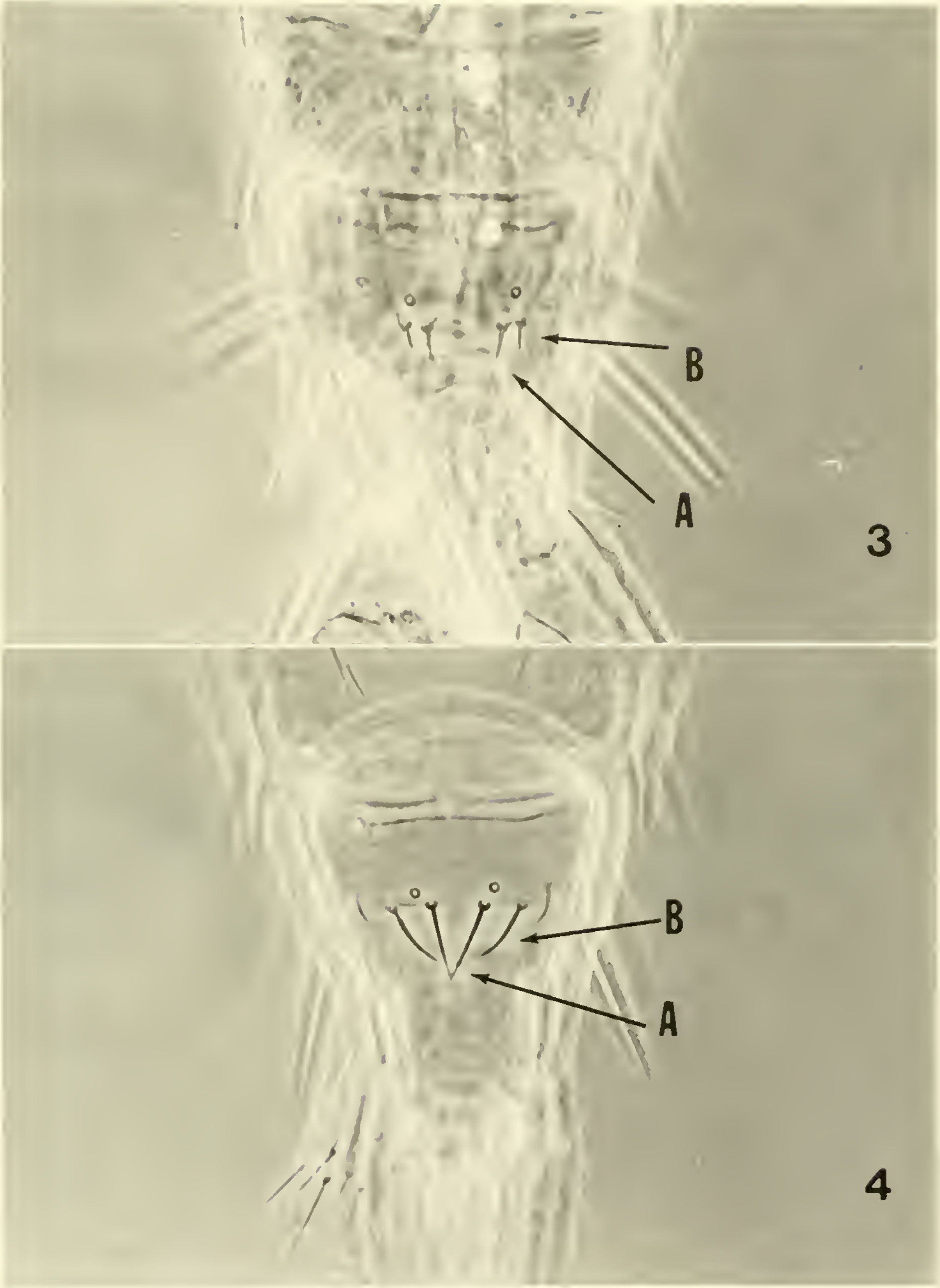


Fig. 1, 2. Female mesonota. 1, *Thrips florum*. 2, *Thrips hawaiiensis*. A, mesonotum; B, anterior pore; C, striations (lacking in Fig. 1).

4–5 pairs of accessory setae on sternite IV and *florum* has 6–10 pairs of accessory setae on the same sternite; however, in the *dunbariae* material, two specimens had 10 and 13 setae on sternite IV.

Three females from Singapore compared with the types of *florum* by Priesner,



Figs. 3, 4. Posterior setae on abdominal tergite IX. 3, *Thrips florum* male. A, mesal seta; B, lateral seta. 4, *Thrips hawaiiensis* male. A, mesal seta; B, lateral seta.

and four females from Peradenya, Ceylon and two females from Kuala Lumpur, Malaysia identified by Priesner as *florum* have posteroangular setae and accessory setae in range of variation for *florum*. Other females from South Pacific Islands, Philippines, and Thailand also agree with the concept of *florum*. In all examined specimens on which the anterior part of the mesonotum was clearly visible, striations were lacking from the anterior angulated area by the anterior pores.

Acronyms for the depositories of the material examined are: CAS = California Academy of Sciences, San Francisco; NHMV = Naturhistorisches Museum, Vienna, Austria; SMF = Naturmuseum und Forschungsinstitut Senckenberg, Frankfurt, West Germany; USNM = United States National Museum of Natural History, Beltsville, MD.

***Thrips hawaiiensis* (Morgan)**

Euthrips hawaiiensis Morgan, 1913.
Thrips longalata Schmutz, 1913.
Thrips sulphurea Schmutz, 1913.
Thrips nigriflava Schmutz, 1913.
Thrips albipes Bagnall, 1914.
Physothrips pallipes Bagnall, 1916.
Thrips versicolor Bagnall, 1926.
Taeniothrips hawaiiensis (Morgan): Moulton, 1928a.
Taeniothrips eriobotryae Moulton, 1928b.
Thrips hawaiiensis form *imitator*, Priesner 1934.
Taeniothrips rhodomytri Priesner, 1938.
Taeniothrips pallipes var. *florinatus* Priesner, 1938.
Thrips hawaiiensis (Morgan): Priesner, 1934; Jacot-Guillarmod, 1975; Bhatti, 1980. *Thrips leucaenae* Moulton, synonymized by Jacot-Guillarmod (1975) with *hawaiiensis*, was recently treated as a junior synonym of *sumatrensis* Priesner by Bhatti (1980). *Thrips florum* Schmutz and other species treated in this study as junior synonyms of *florum* were previously treated as synonyms of *hawaiiensis* by various thysanopterists. *Thrips longalata, sulphurea*, and *nigriflava* are possibly junior synonyms of *florum* but, because the types were not available to me for study, I have followed Jacot-Guillarmod (1975) and Bhatti (1980) in treating these species as synonyms of *hawaiiensis*. *Thrips exilicornis* Hood, recently treated by Bhatti (1980) as a junior synonym of *hawaiiensis*, is here considered a junior synonym of *florum*.

Type material examined.—Lectotype and 1 paralectotype of *T. hawaiiensis* mounted on same slide labeled on left: Thrips sp.?, det. Pergande; see let. D. T. Fullaway, Feb. 6, 09, Honolulu, H. I.; right label: Thrips, cotton, Fullaway, Aug. 08; label on back of slide on right: *Thrips hawaiiensis* (Morgan), LECTOTYPE (larger and darker specimen) designated by S. Nakahara (USNM). *Thrips albipes* Bagnall (co-type) (USNM), *Physothrips pallipes* Bagnall (co-type) (USNM).

Other material examined: 7 lots with ♀ and ♂: Hawaii 4 ♀, 6 ♂; Georgia 6 ♀, 5 ♂; Japan 7 ♀, 2 ♂; New Zealand 3 ♀, 1 ♂; Okinawa 1 ♀, 2 ♂; Philippines 2 ♀, 2 ♂; India 4 ♀, 2 ♂. Many other unassociated ♀ and ♂ from Hawaii, Orient and India (CAS, USNM). The ♀ and ♂ examined from Georgia were from different collections. However, only the 8-segmented antennal form has been examined from Georgia and the specimens represent one species.

This species feeds primarily in the inflorescence of various plants. It is a pest of various agricultural crops in India (Ananthakrishnan, 1984), and a pest of roses in the state of Georgia (Beshear, 1985, pers. comm.). This thrips is widely distributed in the Orient and Pacific Islands; in North America, it is recorded from California, Florida, Georgia, South Carolina, Texas, and District of Columbia.

Thrips florum **Schmutz, Revised Status**

Thrips florum Schmutz, 1913.
Thrips parva Schmutz, 1913.
Thrips magnipes Schmutz, 1913.
Thrips rhodamniae Schmutz, 1913.
Thrips pallida Schmutz, 1913.
Thrips peradenyae Schmutz, 1913 (probably replacement name for *T. pallida* (Bhatti, 1980)).
Thrips florum var. *dunbariae* Priesner, 1924.
Thrips exilicornis Hood, 1932.

Type material examined.—2 paralectotypes of *T. florum*; Ceylon, Peradenya, 19 Dec. 1901, Ciramonum-Bluten, leg. Uzel No. 29 (NHMV). 2 paralectotypes of *Thrips magnipes* Schmutz; Ceylon, Peradenya, 18 Dec. 1901, *Clerodendron fragrans*, leg. Uzel No. 30 (NHMV). Lectotype of *Thrips parva* Schmutz; Ceylon, Peradenya, 19, Dec. 1901, Ciramonum Bluten, leg. Uzel No. 29 (NHMV). 1 paralectotype of *Thrips rhodamniae* Schmutz; Ceylon, Peradenya, 22 Dec. 1901, *Rhodamnia trinervis*, leg. Uzel No. 41 (NHMV). 2 paralectotypes of *Thrips pallida* Schmutz; Ceylon, Peradenya, 31 Dec. 1901, Bluten von!, leg. Uzel No. 37 (NHMV). 8 paralectotypes of *Thrips florum* var. *dunbariae* Priesner, Java, Tjandi b. Semarang, 6-VII-1913, in Bluten *Dunbaria* spec., leg. Docter van Leeuwen (SMF). Holotype and 5 paratypes of *Thrips exilicornis* Hood, Ibadan, S. Nigeria, Jan. 14, 1915, flowers of *Melia azedarach*, A. W. Jobbins-Pomeroy (Hood no. 53) (USNM).

Other material examined: 5 lots with ♀ and ♂: Solomon Arch. 2 ♀, 1 ♂ (SMF); Ceylon (Peradenya) 9 ♀, 1 ♂; India (2 localities) 12 ♀, 8 ♂; origin unknown 1 ♀, 1 ♂. Many ♀ from South Pacific islands, Philippines and Thailand (CAS, USNM).

The primary reason for selecting *florum* over other available Schmutz (1913) names is based on the comparison of a lot (9 females, 1 male) from Peradenya, Ceylon with two female paralectotypes of *florum*, which was described from Peradenya. Moreover, *florum* is the oldest available name of the *Thrips* species described by Schmutz in 1913. Six other species previously treated as junior synonyms of *hawaiiensis* are treated here as synonyms of *florum*.

Because *florum* has been misidentified as *hawaiiensis*, some of the pest problems attributed to *hawaiiensis* may have been caused by *florum*. Although this species is currently known from the Orient, Pacific Islands and Nigeria, the correct distribution can be ascertained only by examining the past determinations of *hawaiiensis*.

ACKNOWLEDGMENTS

I thank A. Kaltenbach, Naturhistorisches Museum Vienna, Austria for the loan of various Schmutz types; R. zur Strassen, Forschungsinstitut Senckenberg, Frankfurt on Main, West Germany, for the loan of *Thrips florum* var. *dunbariae* Priesner types and other material of *florum*; W. J. Pulawski, California Academy of Sciences, San Francisco, for the loan of *florum* and *hawaiiensis* material; K. Sakimura, Honolulu, Hawaii, for information on morphological variation; and R. Beshear, University of Georgia, Experiment, for information on the pest status of *hawaiiensis.* I also thank T. Kono, California Dept. of Food and Agriculture, Sacramento, L. J. Stannard, Golconda, Illinois, and J. M. Kingsolver, Systematic Entomology Laboratory, Washington, D.C., for their reviews of the manuscript, and M. B. Stoetzel, Systematic Entomology Laboratory, Beltsville, Maryland, for the photographs in Figs. 1–4.

LITERATURE CITED

Ananthakrishnan, T. N. 1984. Bioecology of Thrips. Indira Publishing House, Oak Park, MI, 233 pp.

Bagnall, R. S. 1914. Brief description of new Thysanoptera. III. Ann. Mag. Nat. Hist. 13: 287–297.

———. 1916. Brief descriptions of new Thysanoptera. VIII. Ann. Mag. Nat. Hist. 17: 397–412.

Bhatti, J. S. 1978. A preliminary revision of *Taeniothrips* (Thysanoptera: Thripidae). Orient. Insects 12: 157–199, illus.

———. 1980. Species of the genus *Thrips* from India (Thysanoptera). Syst. Entomol. 5: 109–166, illus.

Hood, J. D. 1932. New species of the genus *Thrips* from Central Africa and Egypt. Bull. Soc. R. Entomol. Egypte 16: 115–140, illus.

Jacot-Guillarmod, C. F. 1975. Catalogue of the Thysanoptera of the world. (Part 4). Ann. Cape Prov. Mus. (Nat. Hist.) 7: 977–1255.

Morgan, A. C. 1913. New genera and species of Thysanoptera, with notes on distribution and food plants. Proc. U.S. Nat. Mus. 46: 1–55.

Moulton, D. 1928a. Thysanoptera of the Hawaiian Islands. Proc. Haw. Entomol. Soc. 7: 105–134.

———. 1928b. The Thysanoptera of Japan: New species, notes and a list of all known Japanese species. Annot. Zool. Jap. 11: 287–337.

Priesner, H. 1934. Indomalayische Thysanopteren. VI. Natuurk. Tijdschr. Ned.-Ind. 94: 254–290.

———. 1938. Materialien zu einer Revision der *Taeniothrips*-Arten des Indo-Malayischen Faunengebietes. Treubia 16: 496–526.

Schmutz, K. 1913. Zur Kenntnis der Thysanopterenfauna von Ceylon. Sitz. Ber. Akad. Wiss. Wien Math.-Naturw. KL., Abt. 1, 122: 991–1088.

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A NEW SPECIES OF *MEGANOLA* DYAR FROM EASTERN NORTH AMERICA (LEPIDOPTERA: NOCTUIDAE: NOLINAE)

John G. Franclemont

Department of Entomology, Cornell University, Ithaca, New York 14853.

Abstract.—A new species of *Meganola*, ***spodia***, is described from eastern North America; it had been characterized in 1960 but left without a name.

The new species described at this time was diagnosed as *Meganola* species, and the genitalia of both sexes were illustrated in Franclemont (1960, p. 35, figs. 72, 80). However, it was not given a name in keeping with W. T. M. Forbes's policy that no new names be introduced in the "Lepidoptera of New York and Neighboring States."

Figs. 1, 2. *Meganola spodia*. 1, Male. 2, Female. Figs. 3, 4. *Meganola minuscula*. 3, Male. 4, Female.

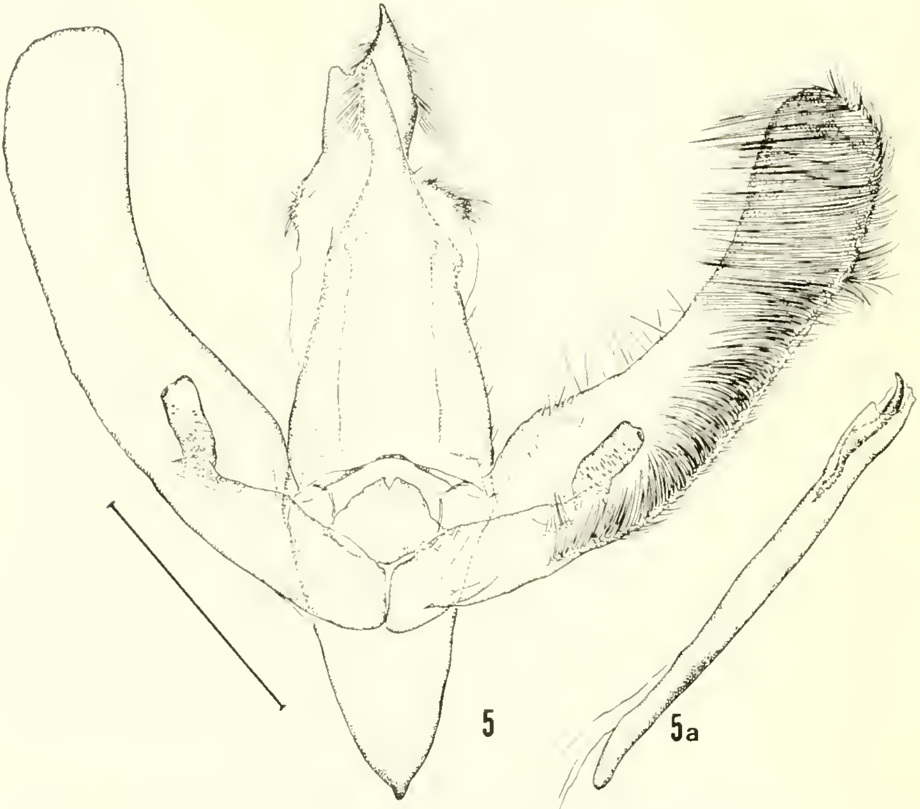

Fig. 5. *Meganola spodia.* 5, Male genitalia with aedeagus removed. 5a. Aedeagus. Scale 1 mm.

Meganola spodia **Franclemont, New Species**

Figs. 1, 2, 5, 6

(spodios—ash colored, from spodos—ashes, et cetera)

Diagnosis.—This moth has been confused with *Meganola minuscula* (Zeller) (Figs. 3, 4); it may be distinguished from that species by the darker, brown tinted gray color of the fore wing; *minuscula* has the fore wing lighter gray with a whitish or silvery tint, and the black spot at the middle of the costa is triangular, whereas that in *spodia* is rectangular. The hind wing is darker with a decided brownish tint in *spodia*, more or less uniform in color, whereas that of *minuscula* is paler gray, somewhat infuscate on the veins and somewhat whitish toward the base. The genitalia of both sexes of *spodia* differ conspicuously from those of *minuscula*. The male of *spodia* has the vesica armed with a long, heavily sclerotized, moderately curved cornutus; that of *minuscula* has a short, moderately sclerotized, strongly curved cornutus. The genitalia of the female of *spodia* have the ductus bursae approximately six times as long as that of *minuscula*; the bursa of *spodia* is without an appendix bursae; *minuscula* has an appendix bursae; *spodia* has two diffuse signa on the bursa, and *minuscula* has one heavily sclerotized signum.

Description.—Head, thorax, and fore wings gray with slight brownish tint. Fore wing with elongate, blackish spot at base of costal margin, a second more or less

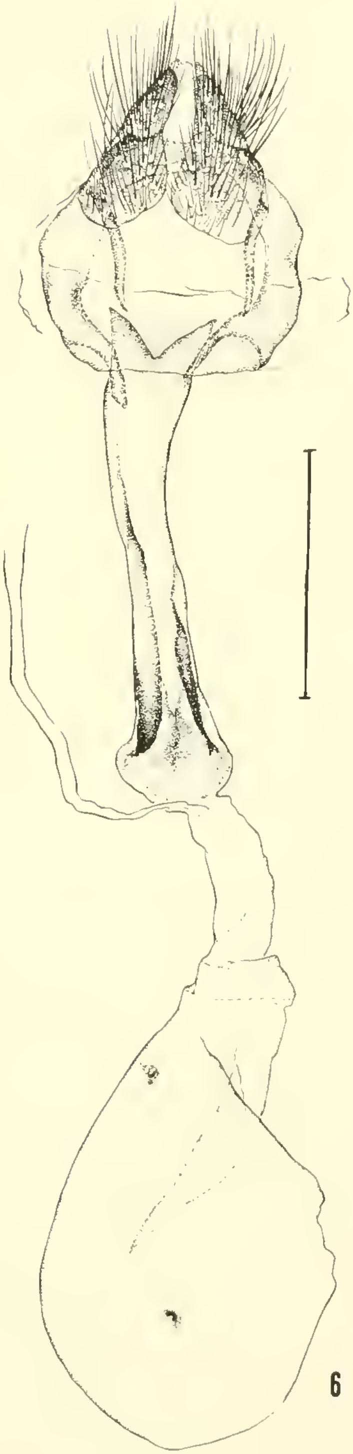

Fig. 6. *Meganola spodia.* Female genitalia. Scale 1 mm.

rectangular, at middle of costal margin; antemedial line black, fine, sharply excurved from costa to R, then straight, then angled inward to inner margin, two small teeth projecting inward on Cu and 2nd A (recte 1st A); postmedial line double, both lines black, inner less well defined, less sharp, appearing as blackish smudges on upper part, inward projecting teeth on Cu and 2nd A (= 1st A), outer line sharp, emphasized on veins by black dots, lines parallel, curved outward from costa, then inward to inner margin; subterminal line blackish gray, irregularly toothed, often interrupted in males, usually complete in females; terminal line a series of black dots on veins; fringe vaguely checkered; reniform and orbicular spots not evident. Hind wing even fuscous gray; fringe concolorous; vague discal dot. Beneath both wings uniform gray, paler than above; fore wing darker than hind; conspicuous discal dot on hind wing, some specimens with indication of discal dot on fore wing.

Fore wing length.—Males: 9–11 mm, females: 12–13 mm.

Male genitalia.—Fig. 5, 5a.

Female genitalia.—Fig. 6.

Holotype.—Male. Wrangle Brook Road, Lakehurst, [Ocean County], New Jersey, 26 June 1954; J. G. Franclemont. Franclemont collection.

Paratypes.—69 males, 5 females. Same locality as holotype, 18 June to 16 July, 1939, 1940, 1952, 1954, 1955 (most specimens collected during last third of June); J. G. Franclemont. Franclemont collection.

In addition to the type series the species has been collected at Millwood, Westchester Co., New York, in late June; at Salem, Roanoke Co., Virginia, in early mid-June; at Kill Devil Hills, Dare Co., North Carolina, at the very end of May; and at Highlands, Macon Co., North Carolina, in late June and early July. It has also been seen from Orient, Suffolk Co., Long Island, New York, and from Crailhope, Green Co., Kentucky.

I thank Ronald W. Hodges for reading the manuscript. The drawings are by James S. Miller and the photographs by the author.

LITERATURE CITED

Franclemont, J. G. 1960. Family 52. Nolidae, pp. 50–53, figs. 69–87, *In* W. T. M. Forbes, Lepidoptera of New York and Neighboring States, Part IV; Cornell University Agricultural Experiment Station, Memoir 371.

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SURVEY FORMAT INFLUENCES EVALUATING PUBLIC ATTITUDES TOWARD ARTHROPODS

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Abstract.—Four hundred visitors to the Arizona Sonora Desert Museum were interviewed to evaluate the effect of survey format, age, sex, and education on respondent answers. The effect of question presentation, an alternate method for arthropod identification, and educational information on attitudes toward arthropods was measured. Using two different ranking systems for respondents to rate their preferences for four arthropod groups produced similar mean responses, but different results dependent on the demographic variables of age and gender. Utilizing visual aids rather than names separated respondents who recognized the arthropod from those who recognized only the name.

Public knowledge and attitudes toward either specific insect pests, such as carpenter bees (Barrows, 1980), wood-infesting insects (Robinson, 1980), mosquitoes (Robinson and Atkins, 1983), and cockroaches (Wood et al., 1981; Zungoli and Robinson, 1985), lawn insects (Ravlin and Robinson, 1985), or arthropods in general (Bennett et al., 1983; Byrne et al., 1984; Levenson and Frankie, 1983) have been evaluated in different areas of the U.S. These surveys provide information on human interactions with arthropods. Some of the survey results have been used to design educational programs and materials (Robinson and Atkins, 1983; Robinson and Zungoli, 1985).

Generally, surveys concerning urban insect pests did not contain questions to test if structure and wording may have biased respondent answers. Surveyors may unconsciously word a question to obtain a desired answer (Sudman and Bradburn, 1982). Respondent attitudes toward arthropods may have been inaccurately represented if the attitude evaluation was based on a single question. In a survey conducted in California, New Jersey, and Texas, respondent attitudes toward insects were considered to be dependent on respondent age or ethnic background based on one question, "Are there any insects that you like?" (Levenson and Frankie, 1983). Questions assessing attitudes toward arthropods should be reworded and repeated within the survey to check bias in question presentation (Sudman and Bradburn, 1982).

Surveys have referred to insects by common name rather than showing respondents specimens or photographs of the insects. Respondents may associate names with specific insects which are different than the accepted common names. Wood et al. (1981) discussed substitutions in survey terminology in an attempt to match local names for cockroaches used by residents in public housing. In his

Table 1. Mean rating of animals from 0 to 100.

Animal	Mean[1]
Bald eagle	81.1 a
Horse	65.3 b
Butterflies	62.1 b
Deer	50.0
Bees	48.7 c
Coyote	41.8 c
Skunk	32.2 d
Spiders	26.5 de
Beetles	23.9 e

[1] Mean ratings followed by the same letter a–e are not significantly different at $F_{0.05}$ using ANOVA with a Scheffé test.

survey of damage caused by *Xylocopa virginica* (L.), Barrows (1980) mentioned some respondents apparently confused this carpenter bee with other hymenopterans.

Entomologists have proposed that public education is the key for acceptance of urban pest management programs (Zungoli and Robinson, 1985) and improvement of attitudes toward arthropods (Byrne et al., 1984). None of the surveys has evaluated changes in respondent attitudes or reactions toward specific arthropods after information was provided on these animals. This survey examines three aspects of attitude surveys about arthropods: 1) the effect of question presentation, 2) an alternate method for arthropod identification, and 3) educational content on respondent attitudes toward arthropods.

MATERIALS AND METHODS

Survey site and method.—From September through December 1981, 400 visitors were interviewed at the Arizona-Sonora Desert Museum (ASDM), Tucson, Arizona. Trained interviewers randomly selected adult visitors entering the museum grounds to survey.

Survey.—Survey questions were written and pretested according to recommendations in the Interviewer's Manual (Anonymous, 1976). The survey format consisted of a person to person interview followed by a written questionnaire. During the interview, respondents were asked seven questions selected to evaluate survey techniques. Question presentation was assessed by using two rating systems for respondents to rate their preference for four kinds of arthropods (butterflies, bees, beetles, and spiders). Respondents numerically rated four kinds of arthropods and four vertebrates from 0 to 100. When a similar question was pretested for a nationwide survey, Carpenter and Blackwood (1979) found that respondents gave a deer a neutral rating of 50 points. Thus, a deer was assigned an arbitrary value of 50 in this survey. Respondents scored each arthropod group more or less than 50 depending on whether they liked it more or less than the deer. Respondents also descriptively rated the four arthropod groups, selecting one out of six phrases which best described how they related to each kind of arthropod. So I could evaluate the use of actual specimens rather than naming arthropods, respondents were asked to select the more dangerous arthropod from two unidentified live specimens, a brown spider *Loxosceles* sp. and a millipede *Orthoporus* sp. The impact of educational information was assessed by recording respondent reactions to a large unfamiliar arthropod, the whip scorpion *Mastigoproctus giganteus* (Lucas), before and after it was identified as harmless. In the questionnaire, respondents answered 12 questions concerning their age, gender, occupation, residency, education, and number of Desert Museum visitations.

Data analysis.—All survey data were coded and analyses were performed using SPSS (Statistical Package for the Social Sciences) programs (Nie et al., 1975). Analysis of variance was used to test for significant differences among mean numerical ratings for the arthropods and vertebrates. Scheffé's test was used to separate the mean ratings. A chi-square test was used to test for association between the respondents' demographic variables and responses to the descriptive rating, dangerous arthropod, and whip scorpion questions.

RESULTS AND DISCUSSION

Respondents were almost equally divided between men (48%) and women (52%) and averaged 44.5 ± 16.5 years in age (range 17–92 yr). Respondents were well educated; 77.5% had some level of college education. About 40% of the respondents were Arizona residents and 28% lived in Tucson. The remaining 60% were from 40 other states and 6 foreign countries. About half (49%) of the respondents lived in suburbs; the remainder were divided between urban (28%) and rural (22%) areas. Fifty percent of the interviewees had previously visited the ASDM at least once.

Each question is quoted from the survey, followed by discussion of the responses. The questions are not presented in the order in which they were asked during the interview, but are grouped to provide easier discussion of the results.

QUESTION PRESENTATION

"We would like to know how much you like different kinds of animals. We are going to assume that a deer is worth 50 points. As I read a list of animals, please tell me how many points from 0 to 100 you would give each animal to show how much you like it compared to a deer. For example, if you like an animal I name less than a deer, then give it less than 50 points. If you like the animal more than a deer, give it more than 50 points. Animals: coyote, butterflies, skunk, bees, horse, beetles, bald eagle, spiders."

Eagle received the highest average rating (81.1) which was significantly greater than the scores for horse (65.3) and butterflies (62.1, Table 1). Bees and coyote had intermediate scores, 48.7 and 41.8 respectively. Beetles received the lowest mean rating (23.9) which was significantly less than the score of the lowest rated vertebrate, skunk (32.2), but not significantly different from the score for spiders (26.5). In a similar question in a survey of Arizona residents, the bald eagle received the highest rating, butterfly and honey bee received median ratings, and garden spider was rated lower than skunk (Byrne et al., 1984).

"I am going to show you four different kinds of insects and related animals. As I show you each kind please select one of the following phrases (respondent was given a list of phrases) which best describes how you relate to each animal: 1) enjoy their presence, 2) tolerate them, 3) indifferent to them, 4) dislike them, 5)

Table 2. Respondent relationships to four arthropod groups.

Arthropod Group	Percentage Response				
	Enjoy	Tolerate	Indifferent	Dislike	Afraid
Butterflies	96.7	1.7	0.7	0.5	0.2
Bees	29.8	41.0	5.9	7.6	15.8
Beetles	10.2	42.7	19.1	24.9	3.1
Spiders	9.1	30.4	13.4	27.1	20.0

afraid of them, 6) other." (Interviewer named each arthropod group as specimens were pointed out in a display of preserved butterflies, beetles, bees, and spiders.)

The overall results of the descriptive (Table 2) and numeric (Table 1) rating systems are compatible. Butterflies were enjoyed by a majority of respondents (96.7%) and also received the highest numeric score for an arthropod (62.1). Bees were the second must enjoyed arthropod and second most feared arthropod. The polarity in response to bees indicates their intermediate numeric rating (48.7) may represent a compromise for respondents who appreciate bees but fear being stung. Spiders and beetles were the most disliked kinds of arthropods and received the lowest numeric scores, 26.5 and 23.9 respectively. Spiders received the highest percentage of negative responses; 27.1% of the respondents disliked them, and 20% were afraid of them. Beetles were the second most disliked type of arthropod, as rated by 24.9% of the respondents. In addition to many colorful beetles such as *Plusiotis gloriosa* LeConte (Scarabaeidae), the display contained several large beetles such as *Alaus oculatus* (Linn.) (Elateridae) and *Dynastes granti* Horn (Scarabaeidae) whose appearance may have disturbed respondents.

Both rating systems generally demonstrated similar attitudes toward arthropods dependent on gender and level of education (Table 3). Over 77% of the respondents had continued their educational studies beyond high school. College educated respondents, compared to respondents with only a high school education, tended to give spiders a significantly higher numeric rating, 28.5 vs. 21.0 respectively (ANOVA, $P = 0.001$; Scheffé test, $P < 0.05$) and enjoyed or tolerated spiders more in the descriptive rating, 43.6% vs. 24.7% respectively. Females, compared to males, demonstrated a greater dislike and fear of venomous arthropods by both rating systems. Women rated bees 7.5 points less and spiders 6.7 points less than men did. Similarly, about 11% more women compared to men were afraid of bees and 22.5% more were afraid of spiders. Men gave butterflies a significantly lower numeric rating than women did, 55.6 vs. 68.2 respectively (t test, $P < 0.0001$). There was no significant difference between the genders in their descriptive rating of butterflies ($\chi^2 = 5.71$, df = 4, $P = 0.22$).

The two rating systems did not demonstrate similar attitudes toward arthropods dependent on respondent age (Table 3). At the termination of the study, respondent ages were divided into three categories; under 36 yr (38.7%), 36 to 55 yr (29.8%), and over 55 yr (31.3%). Respondents under 36 yr rated bees significantly lower in numeric scoring than older respondents did (ANOVA, $P < 0.0001$; Scheffé test, $P < 0.05$). No significant differences between age classes were detected in the descriptive rating of bees ($\chi^2 = 10.07$, df = 8, $P = 0.26$). Similarly, 17.3% of the respondents under 36 yr disliked spiders, compared to 26.1% of the 36 to

Table 3. Respondent demographics and attitudes toward arthropods.

	Numeric Rating[1] (0–100)	Descriptive Rating[2]				
		Enjoy (%)	Tolerate (%)	Indifferent (%)	Dislike (%)	Afraid (%)
Level of Education						
Spiders:						
High School (86)[3]	21.0	4.7	20.0	11.8	36.5	27.1
Some college (116)	26.3	9.6	31.6	14.0	21.9	22.8
College (88)	24.3	9.1	26.1	15.9	26.1	22.7
Graduate (92)	34.9	13.3	41.1	13.3	23.3	8.9
Gender						
Bees:						
Female (206)	45.0	24.1	40.4	5.4	8.0	21.2
Male (193)	52.5	35.4	41.8	6.3	6.3	10.1
Spiders:						
Female	23.2	7.4	26.0	10.3	25.5	30.9
Male	29.9	11.1	34.7	16.8	28.9	8.4
Age						
Bees:						
Under 36 (155)	41.3	25.5	45.6	7.4	6.7	14.8
36 to 55 (119)	51.5	33.1	35.6	8.5	6.8	16.1
Over 55 (126)	58.3	31.7	40.5	1.6	9.5	16.7
Spiders:						
Under 36	27.2	13.3	30.7	14.0	17.3	24.7
36–55	27.8	10.9	32.8	12.6	26.1	17.6
Over 55	24.5	2.4	27.8	13.5	39.7	16.7

[1] Mean ratings not in boxes are significantly different within subsets at $F_{0.05}$ using ANOVA. A subset is the listing of descriptive or numeric ratings of an arthropod group by a demographic category (level of education, gender, age).

[2] Mean ratings not in boxes are significantly different within subsets $\chi^2_{0.05}$.

[3] ( ) = sample size.

55 yr age bracket and 39.7% of the over 55 yr age group. There were no significant differences between age classes in the numeric rating of spiders (ANOVA, $P = 0.52$). Based on one question, Levenson and Frankie (1983) concluded people who liked insects were generally younger. In this study, different perspectives of age class attitudes toward arthropods were obtained dependent on question presentation.

ARTHROPOD IDENTIFICATION

"Which of these two animals would you consider more dangerous and why?" (Respondents were shown a millipede, *Orthoporus* sp., and a brown spider, *Loxosceles* sp.)

The majority (74.9%) of the respondents considered the spider more dangerous. A poisonous bite or sting was cited by most respondents as the reason for their selection. Respondent selection and identification of the arthropods were independent of level of education ($\chi^2 = 3.07$, df = 6, $P = 0.80$). Responses were generally not based on accurate knowledge of these arthropods. Only 9% of the respondents correctly identified the spider as a relative of the brown recluse spider, *Loxosceles reclusa* Gertsch and Mulaik. Respondents apparently confused the millipede with a centipede (14 interviewees actually called it a centipede). Due to lack of knowledge, most respondents appeared to select a dangerous arthropod based on its appearance. The small size and mobility of the spider disturbed some respondents, who expressed opinions that spiders could creep up and bite them without being seen. Conversely, the large size of the millipede frightened other respondents, who thought the millipede looked more dangerous or vicious than the spider.

Respondent decisions were significantly related to residency ($\chi^2 = 15.10$, df = 2, $P = 0.0005$) and number of previous visits to the ASDM ($\chi^2 = 15.04$, df = 2, $P = 0.0005$). A higher percentage of Arizona residents (15.2%) and return visitors (14.7%) correctly identified the brown spider compared to nonresidents (4.5%) and new visitors (3.3%). Venomous arthropods and reptiles receive wide public exposure in Arizona through radio, television, newspapers, and publications of the University of Arizona and the State Poison Control Center. This may explain why more Arizona residents and return visitors recognized the brown spider.

Educational Content

"What would you do if you found this animal in your house?" (Respondent was shown a live whip scorpion, *Mastigoproctus giganteus*.)

A whip scorpion was selected to evaluate how people react when confronted with a large, unfamiliar arthropod. At the termination of the study, respondent answers were coded into four categories: killing, removing, saving, or not knowing what to do. Nearly 32% of the respondents would have killed the whip scorpion. Respondents were generally explicit about who would kill the animal (respondent, relatives, friends, professional exterminators) and how it would be done (physical or chemical methods). About 44% of the interviewees would have removed the whip scorpion, placing it outside the home. Respondents usually described who would remove the animal and how it would be done. All respondents would have avoided physical contact with the whip scorpion while removing it by scooping it into a container or sweeping it out the door. Over 13% of the respondents would have saved the whip scorpion to have it identified, keep as a pet to observe and photograph, or donate to local organizations like zoos, museums, schools, scouts, or 4-H clubs. Over 10% of the respondents did not know what they would do upon encountering the whip scorpion and generally appeared distressed when shown the animal.

"This animal (whip scorpion) is harmless to humans. It doesn't sting or have a dangerous bite. Knowing this information, now what would you do if you found this animal in your house?"

Supplying information on the whip scorpion changed the reaction of the respondents toward this arthropod. Compared to the initial response, 21.5% fewer respondents would have killed the whip scorpion (10.1% total) and 29.4% more of the respondents would have removed the animal (73.7% total). Twelve percent of the respondents would have saved the animal and 4% were still undecided.

Respondent reaction to the whip scorpion was significantly related to level of education, gender, and age (Table 4). Upon encountering the whip scorpion, a

Table 4. Respondent demographics and reaction to whip scorpion before and after information.

	Respondent Reaction to Whip Scorpion[1]			
	Kill (%)	Remove (%)	Save (%)	Other (%)
Level of Education				
Before information:				
High School	37.6	28.2	15.3	18.8
Some college	28.1	40.4	18.4	13.2
College	33.3	49.4	10.3	6.9
Graduate school	29.7	59.3	9.9	1.1
Gender				
Before information:				
Females	28.9	39.3	12.4	19.4
Males	34.7	49.7	14.0	1.6
After information:				
Females	9.4	74.9	8.9	6.9
Males	10.9	72.9	15.1	1.0
Age				
Before information:				
Under 36	25.7	46.7	17.1	10.5
36 to 55	28.2	49.6	13.7	8.5
Over 55	42.1	36.5	8.7	12.7
After information:				
Under 36	12.1	73.2	14.8	[2]
36 to 55	8.8	73.7	17.5	
Over 55	10.3	84.6	5.1	

[1] Mean ratings are significantly different at $\chi^2_{0.05}$ within subsets. A subset is the listing of reactions, before or after information, of a demographic category (level of education, gender, age).

[2] Percentages were less than 5% and were not used in the χ^2 analysis.

higher percentage of college educated respondents would have removed the animal and a lower percent would have killed it, saved it, or been indecisive compared to the reaction of high school level graduates. After information on the whip scorpion was supplied, level of education was no longer correlated with respondent reactions to the animal.

Men reacted more decisively than women when initially confronted with the whip scorpion. Only 1.6% of the men compared to 19.4% of the women did not know what they would do with the whip scorpion. After learning that the whip scorpion is harmless, the majority of both men and women would have removed the animal. However, 6.9% of the women compared to 1.0% of the men reacted indecisively.

Upon the first encounter with the whip scorpion, at least 14% more of the respondents over 55 yr compared to younger individuals would have killed the whip scorpion. Learning that the whip scorpion is harmless reduced and equalized the percentage of individuals in each age group who would have killed the animal. Only about 2% more of the respondents over 55 yr compared to younger respondents would have killed the whip scorpion. A higher percentage of respondents over 55 yr wanted to remove the whip scorpion from their presence. About 10% more of these respondents would have transferred the animal outdoors, and 10% less would have saved it compared to respondents in the younger age brackets.

Conclusion

Results of this survey indicate urban entomologists should consider recommendations when designing and implementing sociological surveys. Key questions assessing attitudes toward specific arthropods should be reworded and repeated within the survey to check bias in question presentation. Desert Museum respondents were asked to rate four arthropod groups numerically in comparison to four vertebrates and descriptively in reference to preserved specimens. The two rating systems yielded similar mean responses, but different results dependent on the demographic variables of age and gender.

Instead of referring to specific arthropods by common name, the interviewer should show respondents photographs or specimens of the animals. The percentage of ASDM interviewees who correctly or incorrectly identified the brown spider and millipede was accurately determined by showing respondents live specimens. In addition, numerous ASDM respondents who did not recognize the brown spider later remarked that they heard of the brown recluse but didn't know how to identify one. Utilizing visual aids rather than names apparently screens out respondents who can recognize the name but not the actual arthropod.

By providing educational information, surveys may determine the receptiveness of respondents to modify their actions and attitudes toward particular arthropods. Results of this survey demonstrate education may improve public attitudes and reactions toward arthropods. Providing information on the whip scorpion significantly altered the reactions of ASDM respondents to this animal because 21% fewer respondents would have killed the whip scorpion after learning about it. In addition, college educated individuals were more tolerant toward arthropods than were high school level graduates. Some entomologists have suggested that individuals receiving more formal education might be more receptive to learning about urban arthropods (Byrne et al., 1984). Results of this survey indicate this assumption may be inaccurate. Level of education was not significantly related to responses requiring knowledge of specific arthropods (brown spider and millipede) or reaction to the whip scorpion after information was supplied. In fact, a higher percentage of high school level graduates compared to college graduates would have saved the whip scorpion, indicating their desire to learn about the animal.

Urban entomologists need to design surveys carefully to avoid biasing respondent answers. Following the suggested recommendations should enhance the accuracy of the survey data and improve the effectiveness of education programs based on survey results.

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LITERATURE CITED

Anonymous. 1976. Interviewer's Manual. Institute for Social Research, University of Michigan. 143 pp.

Barrows, E. M. 1980. Results of a survey of damage caused by the carpenter bee, *Xylocopa virginica* (Hymenoptera: Anthophoridae). Proc. Entomol. Soc. Wash. 82: 44–47.

Bennett, G. W., E. S. Runstrom, and J. A. Wieland. 1983. Pesticide use in homes. Bull. Entomol. Soc. Am. 29: 31–38.

Byrne, D. N., E. H. Carpenter, E. M. Thoms, and S. T. Cotty. 1984. Public attitudes toward urban arthropods. Bull. Entomol. Soc. Amer. 30: 40–44.

Carpenter, E. H. and L. G. Blackwood. 1979. The effect of question position on responses to attitudinal questions. Rural Sociol. 44: 56–72.

Levenson, H. and G. W. Frankie. 1983. A study of homeowner attitudes and practices toward arthropod pests and pesticides in three U.S. metropolitan areas. *In* Frankie, G. W. and C. S. Koehler, eds., Urban Entomology: Interdisciplinary Perspectives. Praeger Press, N.Y. 512 pp.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical packages for the social sciences. McGraw-Hill, New York. 675 pp.

Ravlin, F. W. and W. H Robinson. 1985. The target audience of residential turfgrass pest management programs. Bull. Entomol. Soc. Am. (In press).

Robinson, W. H 1980. Homeowner knowledge of wood-infesting insects. Melsheimer Entomol. Ser. 29: 48–52.

Robinson, W. H and R. L. Atkins. 1983. Attitudes and knowledge of urban homeowners towards mosquitoes. Mosquito News 43: 38–41.

Robinson, W. H and P. A. Zungoli. 1985. An integrated control program for German cockroaches in multi-unit dwellings. J. Econ. Entomol. (In press).

Sudman, S. and N. M. Bradburn. 1982. Asking questions—a practical guide to questionnaire design. Jossey-Bass, Washington. 397 pp.

Wood, F. E., W. H Robinson, S. K. Kraft, and P. A. Zungoli. 1981. Survey of attitudes and knowledge of public housing residents toward cockroaches. Bull. Entomol. Soc. Am. 27: 9–13.

Zungoli, P. A. and W. H Robinson. 1985. Feasibility of establishing an aesthetic injury level for German cockroach pest management programs. Environ. Entomol. 13: 1453–1458.

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THE SAWFLY GENUS *TRICHIOCAMPUS* IN JAPAN (HYMENOPTERA: TENTHREDINIDAE)

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Abstract.—Adults of the three Japanese species of *Trichiocampus* are keyed and recorded: *Trichiocampus populi* Okamoto, *T. pruni* Takeuchi, and *T.* ***flaviventris*** sp. nov.

Trichiocampus Hartig is a small genus containing about six species that occur in the Holarctic Region. Two species, *T. populi* Okamoto, 1912, and *T. pruni* Takeuchi, 1956, were previously known from Japan. Recently, I obtained four specimens reared from larvae feeding on poplar in Hokkaido and have concluded that they represent a new species. In this paper, I describe this new species and give a key to the Japanese species of this genus.

Trichiocampus **Hartig**

Cladius, subgenus *Trichiocampus* Hartig, 1837, Fam. Blatt. Holzwesp., p. 176.

Type-species.—*Nematus grandis* Lepeletier. Desig. by Rohwer, 1911.

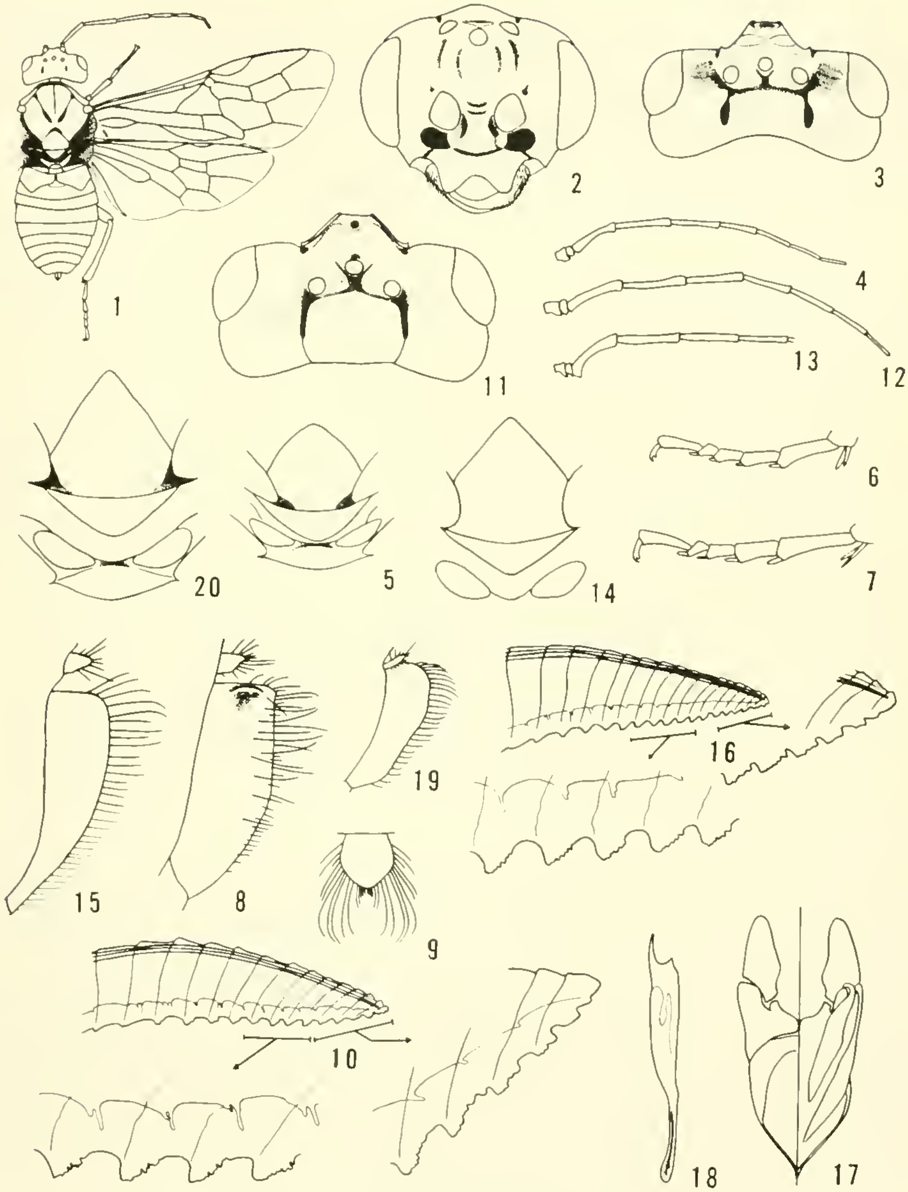
Diagnosis.—Antenna long and slender. Antenna of male simple, not pectinate. Anterior basitarsi shorter than the following segments combined (Fig. 5). Lancet without lateral armature, but with twelve to seventeen segments. Venation similar to that of *Cladius.*

KEY TO THE JAPANESE SPECIES (FEMALES)

1. Body black 2
– Head and thorax black; abdomen yellowish orange; costa of forewing yellow .... *flaviventris* sp. nov.
2. Large species (length 8–9 mm). Wings beyond stigma distinctly hyaline; legs yellowish white, except for black coxae .... *populi* Okamoto
– Small species (length 5 mm). Wings uniformly infuscate; legs black .... *pruni* Takeuchi

Trichiocampus flaviventris **Togashi, NEW SPECIES**
Figs. 1–10, 21–26

Female.—Length 6.5 mm. Head and thorax black; maxillary and labial palpi light brown but basal two segments and basal half of 3rd segment of maxillary palpus black; cenchri yellowish white. Antenna brown except for black two basal segments, but dorsal surface darker. Wings slightly infuscate but beyond the stigma of forewing distinctly hyaline; costa and subcosta of forewing yellow, other veins



Figs. 1–20. Figs. 1–10. *Trichiocampus flaviventris.* 1, Dorsal view. 2, Head, front view. 3, Head, dorsal view. 4, Antenna, lateral view. 5, Mesoscutellum and cenchri, dorsal view. 6, Front tarsus, lateral view. 7, Hind tarsus, lateral view. 8, Sawsheath, lateral view. 9, Do, dorsal view. 10, Lancet. Figs. 11–18. *Trichiocampus populi.* 11, Head, dorsal view. 12, Antenna of female, lateral view, 13, Do of male. 14, Mesoscutellum and cenchri. 15, Sawsheath, lateral view. 16, Lancet. 17, Male genitalia, dorsal aspect on right half, ventral aspect on left half. 18, Penis valve. Fig. 19. *Trichiocampus pruni.* Sawsheath, lateral view. Fig. 20. *Trichiocampus viminalis.* Mesoscutellum and cenchri.

Figs. 21a, b. Larva of *Trichiocampus flaviventris*. Larva: a, lateral view; b, dorsal view.

and stigma dark brown. Abdomen yellowish orange, sawsheath black. Legs pale yellow with following parts black: all coxae, all femora, and hind tarsus; fore and mid tarsi brown.

Head: Postocellar area transverse (length : width = 1.0:1.6); lateral furrows deep and elongate (Fig. 3); postocellar furrow slightly depressed; interocellar furrow depressed; OOL : POL : OCL = 1.0:1.4:1.6; lateral walls slightly raised; frontal area depressed; lateral foveae punctiform (Fig. 2); median fovea large and depressed (Fig. 2); supraclypeal area rather evenly raised; malar space long, as long as a diameter of front ocellus; anterior margin of clypeus emarginate (Fig. 2). Antenna longer than costa plus stigma of forewing, relative lengths of segments about 2.0:1.0:10.0:13.5:12.5:8.5:8.5:5.0:5.0.

Thorax: Mesoscutellum nearly flattened. Wing venation as in Fig. 1. Front tarsus as in Fig. 6; hind tarsus as in Fig. 7.

Abdomen: Sawsheath as in Figs. 8, 9; lancet with 17 serrulae (Fig. 10).

Punctation: Head and thorax covered with fine setigerous punctures, shining; 1st to 6th abdominal tergites nearly impunctate, shining; 7th to last tergites covered with setigerous punctures.

Male.—Unknown.

Habitat.—Japan (Hokkaido).

Holotype: ♀, 3.VIII.1984, Hitsuzigaoka, Sapporo, Hokkaido, N. Yoshida leg. Preserved in the Entomological Laboratory of Hokkaido University, Sapporo, Hokkaido, Japan.

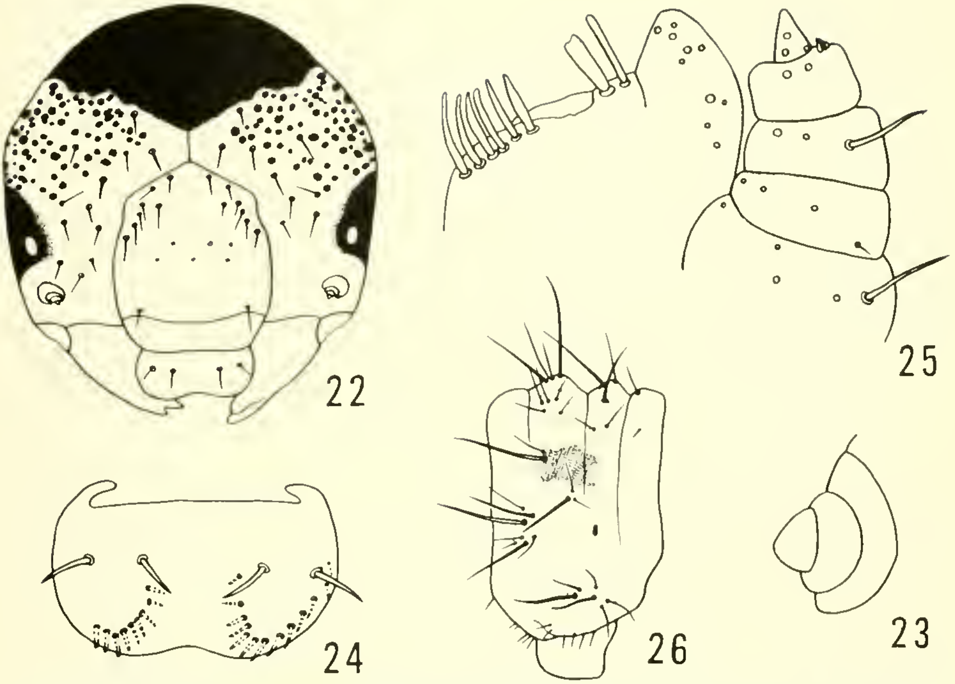
Paratypes: 1 ♀, 5.II.1963, Bibai, Hokkaido, reared from larva feeding on leaves of black poplar, K. Kamijo leg.; 1 ♀, 2.IX.1969, Bibai, Hokkaido, reared from larva feeding on leaves of black poplar, K. Kamijo leg.; 1 ♀, 5.IX.1984, Hitsuzigaoka, Sapporo, Hokkaido, N. Yoshida leg. One paratype is deposited in the National Museum of Natural History, Washington, D.C.; one paratype is deposited in the Entomological Laboratory of Hokkaido Branch, For. & For. Prod. Res. Inst., Sapporo, Hokkaido, and one paratype is preserved in the Laboratory of Biology, Ishikawa Agricultural College, Ishikawa.

Remarks.—The new species closely resembles *T. viminalis* (Fallén) but is easily separable from the latter by the black pronotum, tegulae, mesopleuron, and sawsheath, the form of the lateral furrows of the postocellar area, and the form of the mesoscutellum (see Figs. 5, 20).

Food plant: Populus nigra Linn. var. *italica* Muenchh.

Larva (Juvenile).—Head dark brown, with lighter-colored area around frons, frons, and mouth parts. Body pale yellow.

(Ultimate).—Length 17.5 mm. Head dark brown, with following parts yellowish white: frons, around frons, and mouth parts except for black mandibles. Body



Figs. 22–26. *Trichiocampus flaviventris.* Larva. 22, Head, front view. 23, Antenna. 24, Epipharynx. 25, Maxilla. 26, The third abdominal segment, lateral view.

pale yellow, with black spots on each side of each segment except for last segment (Fig. 21).

Head: Frontal aspect nearly circular in outline (Fig. 22); vertical furrows nearly absent; antenna conical and with three joints; frons nearly pentagonal, with many setae; labrum symmetrical; epipharynx as in Fig. 24, with four setae; maxilla with large palpifer; palpus 4-segmented; galea rather small (Fig. 25); lacinia broad and rather flattened, with eight rather strong setae along apical margin (Fig. 25). *Thorax:* Prothorax with 2 annulets; meso- and metathorax with 4 annulets. The first to ninth abdominal segments with 4 annulets. *Abdomen:* Third abdominal segment as in Fig. 26.

Trichiocampus populi **Okamoto, 1912**

Figs. 11–18

Trichiocampus dopuli [sic.] Okamoto, 1912. Hokkaido-no-kaiho, p. 120 (in Japanese).

Specimens examined: 1 ♀, data unknown, Miyagi Prefecture, K. Goukon leg.; 1 ♂, Ichinose, Shiramine-mura, foot of Mt. Hakusan, Ishikawa Prefecture, ?.III. 1976, reared from larva feeding on leaves of *Populus maximowiczii* Henry, I. Togashi leg.

Female.—Length 8–9 mm. Body black but tegulae yellowish brown. Antenna black. Wings hyaline, but basal half of forewing smoky; costa of forewing yellowish brown, stigma and other veins blackish brown. Legs yellow to yellowish orange but all coxae black; all tarsi darker.

Head: Postocellar area slightly convex; postocellar furrow slightly depressed; lateral furrows distinct (Fig. 11); interocellar furrow depressed; circumocellar furrow distinct but anterior half absent; OOL : POL : OCL = 1.0:1.2:1.3; area just in front of anterior ocellus distinctly depressed; frontal area gently raised, without lateral walls; median fovea large and deep; lateral foveae large and deep; supraclypeal area distinctly roundly convex; anterior margin of clypeus slightly emarginate. Antenna slightly longer than costa plus stigma of forewing (ratio 1.04: 1.00), relative lengths of segments about 2.0:1.0:7.0:8.0:8.0:6.7:6.0:5.3:4.7. *Thorax:* Mesoscutellum as in Fig. 14, nearly flattened. *Abdomen:* Sawsheath as in Fig. 15; lancet with 20 serrulae (Fig. 16).

Punctation: Head and thorax except for mesoscutellum covered with fine setigerous punctures; punctures on mesoscutellum rather large and sparser than head. Abdominal tergites shagreened.

Male.—Length 6 mm. Closely resembled female except for the coloration of antenna and the sexual organs. Antenna brown but basal two segments black. Male genitalia as in Fig. 17; penis valve as in Fig. 18.

***Trichiocampus pruni* Takeuchi, 1956**

Fig. 19

Trichiocampus pruni Takeuchi, 1956. Ins. Mats. 19: 78, fig. 11A–D.

Specimen examined: 1 ♀, 29.IV.1937, Kyoto, Takeuchi leg.

The larva feeds on *Prunus.* The description and illustrations of the female lancet and male genitalia were given by Takeuchi (1956). The following are supplemental to his description: Postocellar area convex; postocellar furrow depressed; lateral furrows deep; interocellar furrow depressed; circumocellar furrow rather distinct but anterior half absent. Sawsheath as in Fig. 19.

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LITERATURE CITED

Okamoto, H. 1912. Sawfly feeding on poplar. Hokkaido-nô-kaiho 12 (135): 119–121. (In Japanese.)

Smith, D. R. 1974. Sawflies of the tribe Cladiini in North America. Trans. Am. Entomol. Soc. 100: 1–28.

Takeuchi, K. 1952. A generic classification of the Japanese Tenthredinidae. Kyoto. 90 pp.

———. 1956. Sawflies of the Kurile Islands (II). Ins. Mats. 19: 71–81.

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87(4), 1985, pp. 889–892

A NEW SPECIES OF *CATOCALA* (LEPIDOPTERA: NOCTUIDAE) FROM THE GULF SOUTH, U.S.A.

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Abstract.—A new species of *Catocala* Schrank is described from southern United States. This species was previously considered a rare aberration of *Catocala agrippina* Strecker, but is distinct in both maculation and male genitalia.

This newly recognized, most striking and beautiful species has remained a mystery because of lack of material for study since Barnes and McDunnough (1918) figured it as an aberration of *Catocala agrippina* Strecker. Only seven old male specimens were located in scattered collections, three of which are in the National Museum of Natural History (NMNH), labeled only "Texas." Between 1970 and 1984, however, I collected over 100 specimens in Louisiana, including the first known females. This facilitated comparison of a series of adult specimens to *C. agrippina,* thus establishing their distinct status.

Two other names synonymized with *C. agrippina* were also reviewed to establish that these names do not apply to this new species. I have not seen the holotype of *C. subviridis* Harvey from Texas in the British Museum of Natural History, but Hampson (1913) described the holotype and it is clearly not this new species. Barnes and McDunnough (1918) state *C. agrippina* form *subviridis* is characterized by a greenish suffusion over the forewings. *Catocala barnesi* French is based on two specimens from the Barnes collection reportedly in the NMNH. Two specimens from the Barnes collection corresponding to the original description and with the locality, San Antonio, Texas, are in the NMNH but are not labeled as *C. barnesi.* However, there is little doubt they are the original syntype series of *barnesi.* The original description of *barnesi* and the two syntypes indicate this name does not apply to the new species. Barnes and McDunnough list *barnesi* as a synonym of the *subviridis* form of *agrippina.*

Catocala atocala, NEW SPECIES

Figs. 1A–C

Wing length.—Males: 34.4 mm (33–37 mm, n = 35); females: 36 mm (35–37 mm, n = 3).

Maculation.—Forewing of *atocala* medium brown and light gray (males), or white (females), black postmedial, antemedial and basal lines. Black subterminal band from vein R_4 to anal angle. Area between postmedial line and clearly defined reniform above vein M_2 mostly black. Brown basal area enclosed by black front and brown rear antemedial line. Area between postmedial and subterminal line strongly marked with brown. Slightly paler brown between reniform and ante-

Fig. 1. *Catocala atocala.* A, Holotype male. B, Allotype female. C. Male genitalia.

medial line in discal cell. Inner margin ½ of forewing area between postmedial and antemedial lines distinctly gray in males and white in females. This light area extends basad of the antemedial line below vein A_1 in the form of a narrow band paralleling curved antemedial line and continuing ½ distance to base along inner margin. In worn specimens, entire forewing appears light gray, some lack nearly all brown coloring except basad of antemedial line. Females have at most only a hint of a basal dash. Hindwing black with off-white barred fringe. Undersurface of wings with distinctive gray outer margin band on both forewing and hindwing. Hindwing postmedial band and basal area beige to light tan. Hindwing discal spot most prominent as bulge on the basal side of the postmedial band.

Male genitalia (Fig. 1C).—Costal and cucullar areas of left valva broad and cuneiform, end broadly rounded or squarish with rounded corners. Same areas of right valva broad, terminal edge serrated and cuspidate.

Discussion.—The rear of the upper strongly marked portion of the antemedial line of *atocala* is angled toward the anal angle or outer margin of the forewing, unlike *agrippina* which is angled toward anal angle or inner margin. The antemedial line intersects the costal margin distally on *atocala* compared to *agrippina*. The reniform is more clearly defined in *atocala*. The closed subreniform of *atocala* may be open or closed in *agrippina*. The distinct basal dash of *agrippina* females is nearly absent in *atocala* females. The hindwing undersurface white areas on *agrippina* are beige on *atocala*. The hindwing bulge (discal spot) on *atocala*, is not present on *agrippina*.

The male genitalia of *atocala* are quite different from *agrippina*. The saccular process is significantly larger and more curved than that of *agrippina*. The uncus of *atocala* is slender and less curved than that of *agrippina*. The male genitalia of *agrippina* were figured by Barnes anad McDunnough (1918; pl. 18, figs. 35, 36) and match the genitalia I have seen of Louisiana *agrippina*.

Flight period.—Specimens were taken at light, fermenting bait, and while resting on pecan and oak tree trunks, and appeared two to three weeks later than *agrippina*. Adults were taken 16 June through 13 August at the type locality. Those collected after mid-July usually were worn and tattered.

Range.—*C. atocala* appears to be quite localized where found. Specimens not mentioned in the type series exist from: Houston, Harris Co., Texas; Wayside, Washington Co., Mississippi; and Tallahassee, Florida.

Types.—Holotype ♂ (Fig. 1A) Edgard, St. John the Baptist Parish, Louisiana, 18 June 1982, V. A. Brou Jr., NMNH type no. 100850. Allotype ♀ (Fig. 1B) same data. Paratypes: same locality, 29 ♂♂ and 1 ♀ from June 16 to July 22, 1977–1983; Weyanoke, West Feliciana Parish, Louisiana, 2 ♂♂ 4 July 1980; Mississippi State, Oktibbeha Co., Mississippi, 1 ♂ 17 July 1975. The holotype and allotype are in the NMNH. Paratypes have been deposited in: Florida State Collection of Arthropods, Gainesville, Florida; Louisiana State University, Baton Rouge; and in collections of Bryant Mather, E. C. Welling M., H. A. Freeman, and V. A. Brou Jr.

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LITERATURE CITED

Barnes, W. and J. McDunnough. 1918. Illustrations of the North American Species of the Genus *Catocala*. Mem. Am. Mus. Nat. Hist. New Series, 3: part 1, 47 pp., 22 plates.

Hampson, G. F. 1913. Catalogue of the Noctuidae in the Collection of the British Museum, Vol. 12. London, Taylor and Francis. 626 pp. + xiii.

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, p. 893

NOTE

Nomenclatural Changes for North American Saldidae

The following nomenclatural notes are needed for the forthcoming catalogs of North American Heteroptera and the Leptopodomorpha of the world.

Saldula dispersa (Uhler) 1842, NEW STATUS

Salda dispersa Uhler, 1892. Proc. Entomol. Soc. Wash. 2: 383 (Utah).
Saldula ourayi Drake and Hottes, 1949. Proc. Biol. Soc. Wash. 62: 179 (Type locality: Soap Lake, Washington). NEW SYNONYMY.

In 1955 Drake and Hottes (Bol. Entomol. Venezolana 11: 12) synonymized *Saldula dispersa* (Uhler) with *Saldula arenicola* Scholz, 1847, a synonymy followed by Polhemus and Chapman (1979, Family Saldidae *in* Menke, Bull. Calif. Ins. Surv. 21: 26). The examination of many specimens of *arenicola* from the Old World shows that *dispersa* Uhler is a separate valid species. Further, a comparison with many specimens, including the type, of *Saldula ourayi* Drake and Hottes dictates the synonymy of the latter.

A specimen of *dispersa* in the U.S. National Museum of Natural History bears three labels: "Salt Lake, 14-6-91, Ut" (printed except date); "Cotype NO. 25 239, U.S.N.M." (red, printed except for co-); "Salda dispersa Uhler 772" (handwritten). This specimen is hereby designated lectotype, and my lectotype label added.

Micracanthia bergrothi (Jakovlev)

Salda bergrothi Jakovlev, 1893. Horae Soc. Entomol. Rossicae 27: 304 (Siberia).
Micracanthia ripula Drake, 1957. Bull. So. Calif. Acad. Sci. 56: 142 (Manitoba). NEW SYNONYMY.

The examination of numerous specimens of *Micracanthia bergrothi* Jakovlev from Siberia (kindly furnished by I. M. Kerzhner) with a long series, including the type, of *Micracanthia ripula* Drake from several localities in Canada and the northern United States reveals that the two are synonymous.

Saldula c-album (Fieber)

Salda c-album Fieber, 1859. Wiener Entomol. Monat. 3: 326 (Europe).

Polhemus and Chapman (1979, Family Saldidae *in* Menke, Bull. Calif. Ins. Surv. 21: 26) noted that *c-album* Fieber was considered by Lindskog (in litt.) to be a strictly Old World species. I have consulted further with Dr. Lindskog concerning this problem, examined additional Old World specimens of *c-album*, and concluded that this species should be stricken from the list of American species. The records of it in North America pertain instead to *Saldula saltatoria* (Linnaeus) 1758 or undescribed species (manuscript in preparation).

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NOTE

Haplothrips kurdjumovi Karny in North America with a New Junior Synonym (Thysanoptera: Phlaeothripidae)

Stannard (1968, Ill. Nat. Hist. Surv. Bull. 29: 215–552) synonymized *Haplothrips faurei* Hood under *H. subtilissimus* (Haliday). Both names have been used in United States (U.S.) and Canada for a thrips predaceous on mite and moth eggs. Hood (1914, Proc. Biol. Soc. Wash. 27: 151–172) described *H. faurei* from specimens collected in New York. *Haplothrips subtilissimus* (Haliday) is a European species recorded for the first time in North America from Pennsylvania and New Jersey by Moulton in 1927 (Bull. Brooklyn Entomol. Soc. 22: 181–202).

After examining the types and identified material of *H. faurei*, identified material of *H. subtilissimus* from U.S. and Europe, and identified material of two other closely related species, *H. chinensis* Priesner from Japan and *H. kurdjumovi* Karny from Europe, I conclude that *faurei* is a junior synonym of *kurdjumovi* (Karny, 1913, Poltava Agric. Soc., Poltava Agric. Exp. Sta. work no. 18, part 7, pp. 3–10) (NEW SYNONYMY). R. zur Strassen (pers. comm.) also came to the same conclusion after examining the types of *faurei*, *kurdjumovi*, and European material of *kurdjumovi*. The specimens examined from U.S. of *subtilissimus* are misidentifications of *kurdjumovi*. *Haplothrips kurdjumovi* was previously reported from Saskatchewan, Canada by zur Strassen (1973, Senckenb. Biol. 52: 247–254). Although both sexes of this species occur in Europe, only females have been found in U.S. and Canada.

Stannard's (1968) description of *subtilissimus* represents *kurdjumovi*. *Haplothrips kurdjumovi* will run to *subtilissimus* in his key to the species of *Haplothrips*. These two species closely resemble each other in color and morphology and differ only in a few details. *Haplothrips kurdjumovi* has a small, subapical tooth on the inner side of the foretarsus, the pronotum has poorly developed anteromarginal setae, mid- and hindtibiae are completely brown, and the mid- and hindtarsi are brown or yellowish brown. *Haplothrips subtilissimus* does not have a tooth on the foretarsus, the pronotum has usually well developed anteromarginal setae, the apical ⅕ of mid- and hindtibiae are yellowish brown, and the mid- and hindtarsi are yellow or yellowish brown.

In Canada *kurdjumovi* reported previously as *faurei* or *subtilissimus* preys on the eggs of moths, *Carpocapsa pomonella* (L.), *Grapholitha molesta* (Busck) and *Spilonota ocellana* (Denis & Schiffermuller), eggs of mites, *Bryobia arborea* Morgan & Anderson, *B. praetiosa* Koch, *Panonychus ulmi* (Koch) and *Typhlodromus caudiglans* Schuster, and on an eriophyid mite, *Aculus cornutus* (Banks) (MacPhee, 1953, Can. Entomol. 85: 33–40; Putman, 1965, Can. Entomol. 97: 1208–1221). According to zur Strassen (pers. comm.), *kurdjumovi* preys on mites in Europe.

Haplothrips kurdjumovi is known from Europe to Central Asia, Azores, Madeira Is., Bermuda, Canada (Manitoba, New Brunswick, Nova Scotia, Ontario, Saskatchewan), and the U.S. (Delaware, Connecticut, District of Columbia, Georgia, Iowa, Illinois, Maryland, Massachusetts, Michigan, Minnesota, New Jersey, New

York, North Dakota, Pennsylvania, South Carolina, Vermont, Washington, Wisconsin).

I thank R. zur Strassen, Forschungsinstitut Senckenberg, Federal Republic of Germany, for the information on *kurdjumovi*; W. H. Ewart, University of California, Riverside, for reviewing the manuscript and for additional information on the distribution; and M. B. Stoetzel and T. J. Henry, Systematic Entomology Laboratory, Agricultural Research Service, Beltsville, Maryland for reviewing the manuscript.

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NOTE

The Correct Spelling for *Adelius* Haliday (Hymenoptera: Braconidae)

The generic name *Adelius* Haliday was published in 1833 (Entomol. Mag. 1: 259–276) but shortly afterwards was emended by its author (Haliday, A. H., 1834, Entomol. Mag. 2: 225–259) to *Acaelius,* with a third spelling, possibly a typesetter's error, producing *Acoelius.* The spellings *Acaelius* and *Acoelius* were most popular during the 19th century but the use of *Adelius* has dominated in the 20th century. However, since van Achterberg has recently (1976, Tijdschr. Entomol. 119: 33–78; 1984, Entomol. Tidskr. 105: 41–58) revived the name *Acaelius* without any explanation I think that a review of the facts is needed to establish uniform usage.

In April 1833 Haliday published the new genus *Adelius* (Entomol. Mag. 1, pt. III, p. 262). Part III is dated April, and the date is evidently accurate because Haliday wrote a letter, dated May 6th, commenting on remarks made by the editor in the April issue and this letter appears in the July issue, p. 424. Two more issues, dated July (pt. IV) and October (pt. V), completed volume I. At the end of the volume I is bound an unpaginated errata sheet carrying an emendation stating that "*Adelius*" should read "*Acaelius.*" Perhaps it is not bound with all copies of the magazine, for I cannot find reference to it in the literature. The errata sheet also carries corrections to articles that appeared in part IV, proving that it must have been published later than part III. Part III of the volume (pages 217–320) carries not the slightest clue that the name *Adelius* was a lapsus, in fact the name is printed twice with identical spelling on page 262. Article 32 applies to the case, ruling that *Adelius* is the correct original spelling and must be retained. The emendation on the unnumbered errata sheet for volume 1 is clearly intentional but since it must have been published subsequent (by about 6 months) to the April issue of the magazine it is "an external source of information" and not part of the "original publication itself" (Art. 32 (b) & (c) Intl. Code Zool. Nomencl. 3rd Ed., 1985). Therefore *Acaelius* is an unjustified emendation (Art. 33 (a)) and is a junior objective synonym of *Adelius.*

In volume 2 (1834) of Entomological Magazine (p. 231) Haliday repeats the emendation *Acaelius* with the same results as before. The name *Acaelius* is repeated, in capital letters in the unpaginated list of new genera published at the end of volume 2. However, the name *Acoelius* appears in lower case in the index to volume 2 (p. 539). The diphthongs ae and oe were each set in print as a single character in the nineteenth century and the characters in lower case form were notoriously difficult for the typesetter to distinguish. In this case I believe *Acoelius* is really a printer's error but still according to the rules it is an "incorrect subsequent spelling" (Art. 33 (c) Intl. Code Zool. Nomencl. 3rd Ed., 1985) and thus has no status in nomenclature.

My conclusion is that the rules in this case lead unequivocally to the use of *Adelius* Haliday as the correct spelling.

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BOOK REVIEW

Invertebrate-Microbial Interactions, edited by J. M. Anderson, A. D. M. Rayner, and D. W. H. Walton (British Mycological Society Symposium 6). Cambridge University Press, New York. 1984. 349 pp. Cost: $79.50.

This book, as aptly stated in the preface, concerns the diverse animal-microbial interactions that are dominant features of our world, affecting most aspects of our health, wealth, and natural environment. The significance of these cryptic and complex relationships among some 2 million species of invertebrates (1 million arthropods), 100,000 species of fungi and inestimable numbers of bacteria and other microbes is not very well appreciated by scientists and the public. The authors' varied perceptions and interests include descriptive biosystematics, experimental physiology, biochemistry, ecology, and modeling, all in chapters with a strong functional emphasis. The 11 chapters, each of 16 to 42 pages, have evidently been carefully edited, so that the stylistic unevenness and verbosity that are common features of published proceedings of symposia are not evident in this volume. Original data abound in all chapters along with comprehensive, timely reviews.

In the first chapter, M. F. Madelin describes the little-studied relationships of Myxomycetes (slime molds) with other organisms, emphasizing their microbial prey and the insects that eat slime molds. In another chapter, D. C. Coleman, R. E. Ingham, J. F. McClellan, and J. A. Trofymow discuss the roles of vascular plants, microbes, and nematodes in the cycling of inorganic and organic nutrients in soils, and include several original graphs. Researchers will find the section 'implications and opportunities for future research' on trophic interaction processes (p. 53), thought provoking. Experimental research on nutrient mobilization in forest soils and litter by microorganisms and the invertebrates (especially Collembola) that eat them are covered by J. M. Anderson and P. Ineson. These authors conclude (pp. 80–81) that ". . . soil invertebrates have important roles in nutrient cycles of temperate grasslands and deciduous forests on base rich soils where their biomass equals or exceeds that of microorganisms and the decomposition rates of high quality litters are fairly rapid. It would therefore appear to merit serious consideration that animal-microbial interactions are functionally important in these sites and that manipulation of the soil fauna through management practices could provide a means of altering the balance of immobilization/mobilization processes."

Interactions between saprophytic fungi and animals during the various stages of wood decay are clearly described by M. J. Swift and L. Boddy, and the roles of Diptera, Coleoptera, and Isoptera are elucidated. The scolytid beetle-fungus-host tree relationship is described by P. Dowding to illustrate the way that living trees are attacked by pathogenic fungi and is compared with other such timber-destroying associations. An interesting chapter by M. M. Martin covers the use by Macrotermitinae, Siricidae, and Attini of enzymes secreted by their ingested mutualistic fungi for digesting plant materials. However, we wish to point out that the fungus spherules on the termite fungus combs are not conidia or conidiophores (as stated by Martin) but rather are morphological entities that bear conidiophores which in turn bear conidia. The biochemical roles of the protozoa and bacteria that are essential for wood and fiber digestion and nutrient metabolism in most termites are explained by J. A. Breznak. It is truly astonishing that the impact of termite biomass on the environment may surpass that of grazing mammals; or that methanobacteria in termite guts "could make a significant contribution to local methane emission" in its total annual global production of 3–12 × 10^{14} g (p. 183). The structure and chemistry of the guts of various arthropods and how guts function as microhabitats for microbes are described by D. E. Bignell. A. K. Charnley covers the physiology of pathogenesis by fungi that attack insects, including means of invasion by the parasite and defensive mechanisms of the hosts. Dutch elm disease is used by J. F. Webber and C. M. Brasier to illustrate in detail many aspects of a notorious arthropod-microbial association and its impact on our environment. D. F. Perry and G. H. Whitfield conclude with a discussion of systems modeling as a method to analyze arthropod-microbial interactions, with the population dynamics of spruce budworm and its entomophthoraceous parasite as an example.

In general, this book is well-written, -edited, -illustrated, -indexed, and -printed. Only some ten typos or other minor mistakes were noticed (in addition to those in the "Errata" slip). These reviewers recommend it for the edification of graduate and undergraduate students, teachers and researchers in the fields of general biology, ecology, biochemistry, microbiology, entomology, soil science, and forestry. It is a fascinating book and a pleasure to read. We believe it is worthy of both the bedside and the laboratory libraries.

S. W. T. Batra, *Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, USDA, Bldg. 476, BARC-E, Beltsville, Maryland 20705* and L. R. Batra, *Mycology Laboratory, PPI, ARS, USDA, Bldg. 011A, BARC-W, Beltsville, Maryland 20705.*

PROC. ENTOMOL. SOC. WASH.
87(4), 1985, pp. 899–902

Book Review

Check List of the Lepidoptera of America North of Mexico, edited by Ronald W. Hodges et al. E. W. Classey Limited and the Wedge Entomological Research Foundation, London. 1983. xxiv + 284 pp. Soft cover. Cost: $88.00.

Forty-five years have elapsed since McDunnough published his check list of Lepidoptera. (McDunnough, J. 1938. *Check List of the Lepidoptera of Canada and the United States of America.* Part I. Macrolepidoptera. *Mem. So. Calif. Acad. Sci.* Vol. 1, 1–272; 1939. *Check List of the Lepidoptera of Canada and the United States of America.* Part II. Microlepidoptera. *Mem. So. Calif. Acad. Sci.* Vol. 2: 1–171). The appearance of the "Check List of the Lepidoptera of America North of Mexico" is an important event in the sphere of Lepidoptera studies; in this review I will describe its contents and discuss some issues which the 1983 check list raises. The introduction contains some very useful information, including a short discussion on the current status of the classification of the order, short notes on each family (often explaining the basis for the classification), and a four-page list of the important literature. Within the check list itself, each family lists the name of the taxonomist responsible for compiling that section. Each individual entry for a species (and subspecies where indicated) is complete with a check list number, name, author, date, and descriptors such as "new combination," where needed.

Including the date as well as the author makes it very convenient for getting the original description of a species. Synonymy is included at the generic level and below with each entry. A complete index including synonyms occupies 123 of the 308 pages in the book. The work covers Canada, continental United States, and Greenland.

The 1983 check list includes a large number of changes from the McDunnough check list. New species, new introductions, and revisionary work published since McDunnough's check list are included, along with a substantial amount of revisionary work included here for the first time. In a word, this new check list is indispensable for almost everyone working with Lepidoptera.

Total species listed in McDunnough in 1938–1939 are 9876; in addition, approximately 1437 subspecies were listed. In the new check list there are 11,233 species listed and approximately 1820 subspecies. Combining both taxa, the new check list reflects a 15% increase in number of species and subspecies. The McDunnough check list did not list a classification higher than superfamily. The new check list includes the equivalent of suborders. The subordinal classification employed represents a balanced solution to the differing opinions on this subject and uses Zeugloptera, Dacnonypha, Exoporia, Monotrysia, and Ditrysia. This is fairly similar to the scheme employed by the British (Kloet, G. S. and W. D. Hincks, 1972. *A Check List of British Insects,* 2nd edition (revised), Part 2, Lepidoptera, R. Entomol. Soc. Lond. Handbook, II, 153 pp.) and French (Leraut, P. 1980. *Liste systematique et synonymique des Lepidoptères de France, Belgique et Corse. Alexanor,* Supplement, 334 pp.) check lists except for splitting out the Hepialidae to Exoporia and combining Nepticuloidea and Incurvarioidea under the Monotrysia. In the introduction D. R. Davis provides a good treatment of an alternate subordinal scheme proposed by Kristensen and Nielsen (Kristensen, N. P. and E. S. Nielsen. 1980. The ventral diaphragm of primitive (non-ditrysian) Lepidoptera. A morphological and phylogenetic study. *Z. Zool. Syst. Evolutionsforsch.* 18: 123–146), who grouped the superfamilies about the same as others but organized them in a different hierarchy with some new or unfamiliar names. Quite a few changes in the placement of subfamilies and of some genera are recorded. Olethreutinae has been reduced to subfamily status, as have Ctenuchinae, Adelinae, Nolinae, among others. Many large, important genera have been changed, such as *Cydia* for *Laspeyresia, Idaea* for *Sterrha, Caloptilia* for *Gracillaria, Properigea* for *Neperigea, Idia* for *Epizeuxis, Lesmone* for *Bendis. Cryphia* and *Cobubatha* have reworked status, part of *Scotogramma* is now in *Discestra, Endopiza* replaces much of *Polychrosis* or *Lobesia, Apotomis* replaces *Aphania, Phaneta* replaces *Thiodia, Pelochrista* replaces part of *Eucosma, Petrophila* replaces *Parargyractis, Donacaula* replaces *Schoenobius, Eusarca* replaces *Apicia*, Cochylidae replaces Phaloniidae, and *Cameraria* and *Phllonorycter* replace *Lithocolletis* (see the check list for the exact synonymies involved). While much of this is fairly common knowledge to a few people, to those who rarely work with such genera as these the new check list will be indispensable. Other changes include putting *Batrachedra* in Coleophoridae and *Glyphidocera* and other genera in Blastobasidae. The Rhopalocera follow Miller and Brown (Miller, L. D. and F. M. Brown. 1981. A Catalogue/Checklist of the Butterflies of America North of Mexico. *Lepid. Soc., Mem.* 2, 280 pp.) very closely. One rather radical approach of these authors is to give generic status to many former subgenera. The Noctuidae and Pyralidae have few changes.

A number of changes have been made to bring the gender of the species-group name into concord with the generic name, such as *Ennomos subsignaria* for *Ennomos subsignarius*. Some cases where gender is not the same are those where the species-group name is considered a diminutive noun and thus need not agree. As was pointed out by Steyskal (1984, *Proc. Entomol. Soc. Wash.* 86: 728–729) a few listings where gender concord is not maintained do occur. Nomenclatorial changes reported for the first time are so indicated in the new check list by a descriptor which follows the entry. Commonly used descriptors are: misplaced, new combination, new synonymy, questionable synonymy, and revised status. These are listed in the Introduction. However, I did find a number of descriptors used sporadically throughout the check list which were not listed in the Introduction. These included: form, race, var., n.stat., rev., syn., and new name. Whether these descriptors represent some additional, subtle nuance or whether the contributors simply strayed from the standard list of descriptors is not clear.

Workers in areas of economic entomology will be surprised by a number of changes in names of economically important insects. Although the "Common Names of Insects and Related Organisms, 1982" published by the Entomological Society of America has been keeping abreast of nomenclature changes, a number of changes have occurred since their last publication. I noticed seven names in the ESA list which differed from the names in the new check list, and there are probably a dozen or so more.

I noted the following typographical errors: 314 Busck, 1903 should be Busck, 1904; 390 Busck, 1933 should be Busck, 1934; 406 *straminella* should be *straminiella*; 481 *robinella* should be *robiniella*; 590 1944 should be 1949; 1357 *angentialbella* should be *argentialbella*; 2141 *dimissae* should be *demissae*; 8473 a. *concoloralis* should be b. *concoloralis.* Undoubtedly a few others will be discovered and the editors would welcome receiving notice of them. The appearance of so few typographical errors is a credit to the editor and his colleagues. *Phyllonorycter felinelle* (Heinrich, 1920) is an incorrect original spelling; the correct spelling is used in two other places in Heinrich's 1920 article.

In addition to reflecting the results of selected published revisions and new descriptions, the new check list contains many changes that reflect "the results of study of type specimens, taxonomic revisions in progress or incidental knowledge gained by the authors." Here is where the average worker is going to find a serious drawback to this list. In effect he will be forced to use nomenclature which is based on: a) completely unpublished evidence, b) evidence found in foreign journals that may be difficult to locate or translate, or c) unpublished judgments as to which of various taxonomists around the world is correct. Thus, the changes published for the first time in this check list are extremely vexing. Species are put into synonymy and taken out of synonymy without any explanation. Genera are put into different families. Subfamilies, subgenera, etc., are given new status with no explanation. This not only renders many keys and other publications outdated, it does not give the worker any clues as to how to accommodate these changes. There has been a great deal of published discussion recently in the newsletter "News of Lepidopterists' Society" by various lepidopterists on this point as it relates to the Rhopalocera. This section of the new check list follows closely the catalogue of Miller and Brown which in turn has been criticized for proposing a number of changes without adequate supporting evidence. The same criticism can be leveled at the treatment of the moths in this new check list. The genus *Homosetia* (Tineidae) is a good example: *fuscocristatella* Chambers was taken out of synonymy and made a good species with the descriptor "identity uncertain." Why this was taken out of synonymy is not clear; in addition, there is no descriptor indicating that this is a change. Also in this genus, *H. marginimaculella* (Chambers) should be listed as a new combination. In fact, however, adding this descriptor still does not tell the reader any more about the basis for the change except that it is made in the judgment of the author of this section.

If one considers the spirit of Article 13 in the International Code of Zoological Nomenclature, which requires publication of characters that differentiate a new taxon, then one would think that taxonomic changes should also be required to include such empirical documentation (except perhaps in the case of replacement names). If this was required, perhaps then the numerous nomenclatorial changes that do occur now would occur much less often.

Another rather frustrating occurrence, although to be expected, is the appearance of new records in the list. One is never sure whether this is a new introduction or the results of past misidentifications. It would be interesting to know why, for example, *Coleophora caespititiella* Zeller is still listed since its misidentification was reported by McDunnough in 1940 and again in 1957, when he stated that the true *caespititiella* was not known to occur in North America. Thus, has this species been introduced more recently or is McDunnough incorrect? I did find two entries in the Noctuidae with the descriptor "n. record," but these were the only two entries I could find.

In comparing the British and French check lists of Lepidoptera we find a great deal of agreement, although in a number of cases the authors of the United States check list have chosen not to follow the Europeans. For example, the French list has Ethmiidae, Blastodacnidae, Symmocidae, Batrachedridae, Ctenuchidae, Nolidae, and Phyllocnistidae as families; they are subfamilies in the United States check list.

A major purpose of a check list is to provide a list of the species that occur in a given region. These species are imbedded in higher taxonomic categories and the check list includes these higher categories. The classificatory aspect of the new check list should not carry as much weight as the distribution aspect; however, most readers will tend to think both aspects are authoritatively represented and thus give them equal emphasis.

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PROC. ENTOMOL. SOC. WASH.
87(4), 1985, pp. 903-906

SOCIETY MEETINGS

910th Regular Meeting—January 3, 1985

The 910th Regular Meeting of the Entomological Society of Washington was called to order by President Donald M. Anderson in the Naturalist Center, National Museum of Natural History, at 8 p.m. on January 3, 1985. Nineteen members and eight guests were present. Minutes of the previous meeting were read and approved. Membership Chairman G. B. White read the names of the following applicants for membership: Richard Brown family, Washington, D.C.; and Kevin J. Sweeney, Crofton, Maryland.

T. E. Wallenmaier reported on the status and activities of the committee on the biological survey of the United States. President Anderson requested that this committee continue to remain active.

President Anderson reported that the Executive Committee has agreed to increase page charges in light of a deficit in the publication costs for the proceedings. All manuscripts received after the publication of the January 1985 issue of the proceedings will be subject to page charges as follows: immediate publication—$55 per page; regular publication—$35 per page. In addition, the domestic subscription price is increased to $30 per year and the foreign subscription price is increased to $35 per year. There is no change in membership dues.

The speaker for the evening was the immediate past President, Neal O. Morgan, Livestock Insects Laboratory, USDA, Agricultural Research Service, Beltsville, Maryland. His talk was entitled "Errant Insect, Whither Goest Thou?" Aircraft disinsection activities by the USDA represent the use of pesticides in various aircraft compartments to reduce the danger of insect pests being artificially spread within the United States and around the world through aircraft flights. Tests are held each year involving a variety of insect pests. Cages insects are placed in test planes or in substitutes such as containerized tractor-trailers where various rates and kinds of aerosols are used to determine efficacy. Increased speed and volume of air traffic has resulted in an increased threat of introduction of foreign pests into the United States. Recent examples of introduction threats are *Musca vitripennis* and *Hippobosca longipennis,* both of which accompanied importations into the United States. Dr. Morgan emphasized that the problem of hitchhiking arthropods is a complex one and prevention depends on the cooperation of shipping and airline personnel. Many excellent slides were shown.

T. J. Spilman reported on recent articles in *Antenna* that described the responses of insects to manmade sounds, such as jingling keys, applause, human voices, clarinet playing, party noisemakers, and Strauss waltzes. The audience was asked to report on similar experiences.

A certificate was presented to Neal O. Morgan, the immediate past President of the Society, in appreciation for his year of dedicated service as President.

The meeting was adjourned at 9:15 p.m. after which refreshments were served.

Thomas E. Wallenmaier, *Recording Secretary*

911th Regular Meeting—February 7, 1985

The 911th Regular Meeting of the Entomological Society of Washington was called to order by President Donald Anderson in the Naturalist Center, National Museum of Natural History, at 8 p.m. on February 7, 1985. Twenty-four members and twelve guests were present. Minutes of the previous meeting were read and approved. Membership Chairman Geoffrey White read the names of the following applicants for membership: William L. Downes, Lansing, Michigan; Claire Levesque, Fleurimont, Quebec; J. E. McPherson, Department of Zoology, Southern Illinois University, Carbondale, Illinois; Christopher Hansson, Zoological Institute, Department of Systematics, Lund, Sweden.

J. Aldrich noted a paper on freeze-drying immature insects by M. Blum. D. Sutherland exhibited a copy of the latest edition of "Fundamentals of Applied Entomology."

The speaker for the evening was Thomas K. Wood, Department of Entomology and Applied Ecology, University of Delaware, Newark, Delaware. His talk was entitled "The Role of Host Plants in Speciation: an Example from Treehoppers." Eight characters of species of treehoppers (Membracidae) have been related to host trees. A number of studies have been done with *Enchenopa binotata* (Say) involving cage experiments and up to seven different host plants. Females chose host plants they were reared on for oviposition. Electrophoretic tests showed a pattern of divergence of the biotypes of this species. Various factors were studied to account for reproductive isolation. These included allochronic egg hatch and differences in flight activity. Hybridization experiments did not achieve significant success.

R. Gagné expressed the appreciation of all the members for the excellent and dedicated service of the departing Program Chairman, Jeffrey Aldrich. The meeting was adjourned at 9:30 p.m. after which refreshments were served.

Thomas E. Wallenmaier, *Recording Secretary*

912th Regular Meeting—March 7, 1985

The 912th Regular Meeting of the Entomological Society of Washington was called to order by President Donald M. Anderson in the Naturalist Center, National Museum of Natural History, at 8 p.m. on March 7, 1985. Twenty-nine members and ten guests were present. Minutes of the previous meeting were read and approved with one correction.

John Fales exhibited a copy of the recently released "Threatened and Endangered Plants and Animals of Maryland," which is the proceedings of a symposium held in Maryland in 1981. Edd Barrows, Banquet Committee Chairman, reported that this year's banquet is planned for June 6, 1985, on the Georgetown University campus.

The speaker for the evening was M. Delfinado-Baker, USDA, Agricultural Research Service, Bioenvironmental Bee Laboratory, Beltsville, Maryland. Her talk was entitled "Mites on Honey Bees: Potential Threat to Beekeeping and Pollination." Statistics on the importance of beekeeping in the United States were presented. Seven species of mites were mentioned as attacking species of *Apis*.

Acarapis woodi (Rennie) is the only internal mite parasite of bees; dissection techniques and the recent history of the mite's introduction into the United States were discussed. Other mites such as *Varroa jacobsoni* (Oudemans) and *Tropilaelaps clareae* Delfinado and Baker were discussed. Difficulties in control of these mites were mentioned.

The meeting was adjourned at 9:15 p.m. after which refreshments were served.

Thomas E. Wallenmaier, *Recording Secretary*

913th Regular Meeting—April 4, 1985

The 913th Regular Meeting of the Entomological Society of Washington was called to order by President Donald M. Anderson in the Naturalist Center, National Museum of Natural History at 8 p.m. on April 4, 1985. Twenty-three members were present. Minutes of the previous meeting were read and approved. Membership Chairman G. B. White read the names of the following applicants for membership: Michael S. Arudser, Department of Biology, University of Missouri–St. Louis; Jerome A. Klun, Agricultural Research Service, USDA, Beltsville, Maryland; Carl W. Schaefer, Biological Science Group, University of Connecticut, Storrs, Connecticut.

Edd Barrows informed the members that the annual banquet would be held on June 6 in the Galleria Building on the Georgetown University campus. Edd also exhibited a voodoo lily, a very exotic-looking plant which had bloomed that day.

The speaker for the evening was Robert Whitcomb, USDA, Agricultural Research Service, Plant Pathology Laboratory, Beltsville, Maryland, whose talk was entitled "Evolution and Ecology of Leafhoppers in North American Grasslands." Host ranges of various species in grassland habitats in the United States were discussed in order to provide answers to questions on the effect which changes from grassland to agricultural ecosystems have had on the insect fauna. Changes in host range were observed with changes in geographical location of a population. For example, some species which are monophagous in Maryland are polyphagous in Florida. The genus *Flexamia* was discussed in detail. The genus contains about 35 species and is used frequently in Dr. Whitcomb's laboratory. Most of the species are phloem specialists although some exhibit xylem feeding behavior and are general feeders. Factors involved in explaining the generalist feeding patterns of xylem feeders were discussed.

The meeting was adjourned at 9:45 p.m. after which refreshments were served.

Thomas E. Wallenmaier, *Recording Secretary*

914th Regular Meeting—May 2, 1985

The 914th Regular Meeting of the Entomological Society of Washington was called to order by President Donald M. Anderson in the Naturalist Center, National Museum of Natural History, at 8 p.m. on May 2, 1985. Fifteen members and ten guests were present. Minutes of the previous meeting were read and approved. Membership Chairman G. B. White read the names of the following applicants for membership: Larry D. Corpus, Department of Entomology, Kansas

State University, Manhattan, Kansas 66506; Charles E. Turner, USDA Biological Control of Weeds, 1050 San Pablo Avenue, Albany, California 94706.

T. J. Spilman exhibited a copy of *American Insects, A Handbook of the Insects of America North of Mexico* by Ross H. Arnett, Jr. Among other valuable features, Mr. Spilman pointed out that every genus of insects in the United States is listed in this book. T. Bissell showed the wing of a neuropteran that he found in the Systematic Entomology Laboratory in Beltsville, Maryland.

The speaker for the evening was P. Juliette Weinstein, Behavioral Medicine Branch, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland. Her talk was entitled "Sex and the Single Wasp, or a Passion for India." *Pediobius foveolatus* (Crawford) is a hymenopterous parasite of the Mexican Bean Beetle. It was described in 1912 in India and in 1956 was identified as an effective biocontrol agent. Dr. Weinstein described the life history of the parasite in detail and then gave a detailed report of her research on courtship behavior. Various results were presented, including the fact that without competition, small males elicit female receptivity sooner and mate longer, while with competition the larger males are more successful. Many other details of this courtship behavior such as wing fanning were related to the overall mating and courtship behavior pattern. The talk included interesting slides and was followed by a discussion period.

Two visitors were introduced at the close of the meeting: Edvard Sylvén of the Entomology Department, Swedish Museum of Natural History, Stockholm, Sweden, and Neal Evenhuis of the Bishop Museum, Honolulu, Hawaii. As President of the Entomological Society in Stockholm, Dr. Sylvén conveyed to us the best wishes of that Society.

The meeting was adjourned at 9:30 p.m. after which refreshments were served.

Thomas E. Wallenmaier, *Recording Secretary*

PROCEEDINGS
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Cynipid Galls of the Southwest, by Lewis H. Weld	3.00
Both papers on cynipid galls	6.00
Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	1.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal	2.00

Memoirs of the Entomological Society of Washington

No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 167 pp. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
No. 8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No. 9.	The Flower Flies of the West Indies (Diptera: Syrphidae), by F. Christian Thompson. 200 pp. 1981	10.00
No. 10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky. Edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No. 11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kanmiya. 370 pp. 1983	18.00
No. 12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $25.00 per volume to non-members and $13.00 per volume to members of the Society.

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