
SMITHSONIAN INSTITUTION LIBRARIES
SMITHSONIAN INSTITUTION WASHINGTON DC

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 655–660

PROCEEDINGS of the ENTOMOLOGICAL SOCIETY of WASHINGTON

Volume 95

OFFICERS FOR THE YEAR 1993

President	Russell D. Stewart
President-Elect	Paul J. Spangler
Recording Secretary	M. Alma Solis
Corresponding Secretary	Hollis B. Williams
Treasurer	Norman E. Woodley
Program Chairman	Christopher H. Dietrich
Membership Chairman	Ralph P. Eckerlin
Custodian	Natalia J. Vandenberg
Editor	Thomas J. Henry
Special Publications Editor	A. G. Wheeler, Jr.
Book Review Editor	Gary L. Miller
Past-President	Wayne N. Mathis

Published by The Society
WASHINGTON, D.C.
1993

TABLE OF CONTENTS, VOLUME 95

ARTICLES

ADIS, JOACHIM—See GARCIA, MARCOS V. B. 547
ARNAUD, PAUL H., JR.—See CHAO, CHIEN-MING 48
AHLSTROM, KENNETH R. *and* RICHARD C. McDONALD—A new species of *Pediobius* Walker (Hymenoptera: Eulophidae), associated with tettigoniid eggs 527
BAKER, GERALD T. *and* ANGSUMARN CHANDRAPATYA—Antennal sensilla of the Chinese lantern fly, *Pyrops candelaria* L. (Homoptera: Fulgoridae) 245
BECKER, EDWARD C.—See LEWIS, ROBERT E. 278

BRAILOVSKY, HARRY—New genera and new species of Colpurini (Heteroptera: Coreidae) from the Fiji Islands and New Guinea 435

BRAILOVSKY, HARRY—See SLATER, JAMES A. 590

BROWN, B. V.—See ROBINSON, W. H. 404

BURKE, HORACE R.—See CLARK, WAYNE E. 152

BUTLER, LINDA—Parasitoids associated with the Macrolepidoptera community at Cooper's Rock State Forest, West Virginia: A baseline study 504

CARPINTERO, D. J.—See MALDONADO CAPRILES, J. 223

CARVALHO, CLAUDIO J. B. DE—See MARINONI, LUCIANE 412

CAVE, RONALD D.—See HANSSON, CHRISTER 253

CHANDRAPATYA, ANGSUMARN—See BAKER, GERALD T. 245

CHAO, CHIEN-MING *and* PAUL H. ARNAUD, JR.—Name changes in the genus *Tachina* of the eastern Palearctic and Oriental regions (Diptera: Tachinidae) 48

CLARK, WAYNE E. *and* HORACE R. BURKE—The *Anthonomus cavei* species group (Coleoptera: Curculionidae) 152

COOPER, KENNETH W.—The first *Holcopasites* from western California, *H. ruthae* n. sp., and *H. linsleyi,* a new species from southwestern Arizona (Hymenoptera, Nomadinae) 113

COOPER, KENNETH W.—Description of *Osmia cahuilla,* n. sp., recognition of the male of *O. gabrielis* Sandhouse and the likely female of *O. bridwelli* Sandhouse (Apoidea, Megachilidae) 532

DENNO, ROBERT F.—See HANKS, LAWRENCE M. 79

DIATLOFF, G.—See PALMER, W. A. 1

DIETRICH, CHRISTOPHER H.—A new genus of Neotropical Agalliinae (Homoptera: Cicadellidae) 468

DIETRICH, CHRISTOPHER H.—A new genus of Iassinae from southeastern Brazil: (Homoptera: Cicadellidae) 475

EISENBERG, R. M. *and* L. E. HURD—Relative egg success and implications for distribution of three sympatric mantids (Mantodea: Mantidae) 271

EVANS, HOWARD E.—See MELO, GABRIEL AUGUSTO R. DE 258

FITZGERALD, SCOTT J.—See KONDRATIEFF, BORIS C. 554

FOOTE, B. A.—Biology of *Hyadina albovenosa* (Diptera: Ephydridae), a consumer of Cyanobacteria 377

FROESCHNER, RICHARD C.—The Neotropical lace bugs of the genus *Vatiga* (Heteroptera: Tingidae), pests of Cassava: New synonymies and key to species 457

FROESCHNER, RICHARD C.—See HENRY, THOMAS J. 449

GAGNÉ, RAYMOND J. *and* DONALD R. STRONG—A new species of *Dasineura* (Diptera: Cecidomyiidae) galling leaves of *Lupinus* spp. (Fabaceae) in California 541

GARCIA, MARCOS V. B. *and* JOACHIM ADIS—On the biology of *Penepodium goryanum*(Lepeletier) in wooden trap-nests (Hymenoptera, Sphecidae) 547

GOEDEN, RICHARD D.—Analysis of known and new host records for *Tephritis* from California, and description of a new species, *T. joanae* (Diptera: Tephritidae) 425

GOEDEN, RICHARD D., DAVID H. HEADRICK, *and* JEFFREY A. TEERINK—Life history and descriptions of immature stages of *Tephritis arizonaensis* Quisenberry (Diptera: Tephritidae) on *Baccharis sarothroides* Gray in Southern California 210

GRIMALDI, DAVID A. *and* WAYNE N. MATHIS—Fossil Periscelididae (Diptera) 383

GRISSELL, E. E.—*Zdenekius,* a new genus of Nearctic Torymidae (Hymenoptera: Chalcidoidea) 264

GROGAN, WILLIAM L., JR.—See SPINELLI, GUSTAVO R. 321

HANKS, LAWRENCE M. *and* ROBERT F. DENNO—The white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Homoptera: Diaspididae): Life history in Maryland, host plants, and natural enemies 79

HANSSON, CHRISTER *and* RONALD D. CAVE—First record of *Kratoysma* Hymenoptera: Eulophidae) from the New World, including the description of two new species 253

HARRIS, S. C. *and* S. G. TIEMANN—New species of *Neotrichia* from Texas and Panama, with a preliminary review of the *N. canixa* group (Trichoptera: Hydroptilidae) 286
HEADRICK, DAVID H.—See GOEDEN, RICHARD D. 210
HENRY, THOMAS J. *and* RICHARD C. FROESCHNER—*Dieuches armatipes* (Walker) (Heteroptera: Lygaeidae) newly discovered in the Western Hemisphere 449
HERNÁNDEZ-ORTIZ, VICENTE—Description of a new *Rhagoletis* species from tropical Mexico (Diptera: Tephritidae) 418
HICKS, ANDREW L. *and* ROBERT F. WHITCOMB—The genus *Laevicephalus* (Homoptera: Cicadellidae): Hosts, biogeography, and three new species 481
HICKS, ANDREW L.—See WHITCOMB, ROBERT F. 605
HOLZENTHAL, RALPH W.—See MUÑOZ Q., FERNANDO 564
HORN, DAVID J.—See PURRINGTON, FOSTER FORBES 313
HURD, L. E.—See EISENBERG, R. M. 271
KEFFER, S. L. *and* J. E. McPHERSON—Curictan copulation and waterscorpion higher classification (Heteroptera: Nepidae) 74
KONDRATIEFF, BORIS C. *and* SCOTT J. FITZGERALD—A new species of *Sphecomyiella* (Diptera: Pyrgotidae) from North America 554
LASALLE, JOHN—See SCHAUFF, MICHAEL E. 488
LEWIS, ROBERT E., EDWARD C. BECKER, *and* ROBERT E. SKIDMORE—An annotated catalogue of the siphonapteran primary types in the Canadian National Collection of Insects (Insecta: Siphonaptera) 278
LINLEY, J. R. *and* M. J. TURELL—The eggs of *Aedes dentatus* and *Aedes fowleri* (Diptera: Culicidae) 7
MACDONALD, JOHN F.—Review of the genus *Chelipoda* Macquart of America north of Mexico (Diptera: Empididae; Hemerodromiinae) 327
MACDONALD, JOHN F. *and* WILLIAM J. TURNER—Review of the genus *Neoplasta* Coquillett of America north of Mexico (Diptera; Empididae; Hemerodromiinae) 351
MALDONADO CAPRILES, J.—A new species of *Ghilianella* and the female of *Ghinallelia claviventris* (Bergroth) (Heteroptera: Reduviidae: Emesinae) 558
MALDONADO CAPRILES, J.—Redescription of *Nesocastolus nigrocoris* (Fracker and Bruner) and notes on the genus (Heteroptera: Reduviidae: Harpactorinae) 562
MALDONADO CAPRILES, J. *and* D. J. CARPINTERO—Redescription of the harpactorine genus *Sosius* Champion 1899, with the description of a new species (Heteroptera: Reduviidae) 223
MARINONI, LUCIANE *and* CLAUDIO J. B. DE CARVALHO—A cladistic analysis of *Protodictya* Malloch (Diptera, Sciomyzidae) 412
MATHIS, WAYNE N.—A revision of the shore-fly genera *Hostis* Cresson and *Paratissa* Coquillett (Diptera: Ephydridae) 21
MATHIS, WAYNE N.—See GRIMALDI, DAVID A. 383
McCAFFERTY W. P. *and* A. V. PROVONSHA—New species, subspecies, and stage descriptions of Texas Baetidae (Ephemeroptera) 59
McDONALD, RICHARD C.—See AHLSTROM, KENNETH R. 527
McPHERSON, J. E.—See KEFFER S. L. 74
MELKSHAM, J.—See PALMER, W. A. 1
MELO, GABRIEL AUGUSTO R. DE *and* HOWARD E. EVANS—Two new *Microstigmus* species (Hymenoptera, Sphecidae), with the description of their parasite, *Goniozus microstigmi* sp. n. (Hymenoptera, Bethylidae) 258
MUÑOZ Q., FERNANDO and RALPH W. HOLZENTHAL—New species and records of Costa Rican *Austrotinodes* (Trichoptera: Ecnomidae) 564
NORRBOM, ALLEN L.—Two new species of *Anastrepha* (Diptera: Tephritidae) with atypical wing patterns 52
NORRBOM, ALLEN L.—New synonymy of *Epochra* Loew with *Euphranta* (*Rhacochlaena* Loew) (Diptera: Tephritidae) and description of a new species from Mexico 189

NORRBOM, ALLEN L.—New species and phylogenetic analysis of *Euaresta* Loew (Diptera: Tephritidae), with a key to the species from the Americas south of Mexico 195
PAGANELLI, CELUTA H. *and* CURTIS W. SABROSKY—*Hippelates* flies (Diptera: Chloropidae) possibly associated with Brazilian purpuric fever 165
PALMER, W. A.—On the host range of the delphacid planthopper *Stobaera pallida* Osborn (Homoptera) 241
PALMER, W. A., G. DIATLOFF, *and* J. MELKSHAM—The host specificity of *Rhopalomyia californica* Felt (Diptera: Cecidomyiidae) and its importation into Australia as a biological control agent for *Baccharis halimifolia* L. 1
PEMBERTON, ROBERT W. *and* NATALIA J. VANDENBERG—Extrafloral nectar feeding by ladybird beetles (Coleoptera: Coccinellidae) 139
PETERS, T. MICHAEL—Two new Dixidae (Diptera) from South Korea 17
POINAR, GEORGE O., JR.—See SANTIAGO-BLAY, JORGE A. 70
PRATT, GORDON *and* THOMAS K. WOOD—Genitalic analysis of males and females in the *Enchenopa binotata* (Say) complex (Membracidae: Homoptera) 574
PROVONSHA, A. V.—See McCAFFERTY, W. P. 59
PURRINGTON, FOSTER FORBES, *and* DAVID J. HORN—Canada moonseed vine (Menispermaceae): Host of four roundheaded wood borers in central Ohio (Coleoptera: Cerambycidae) 313
RAMÍREZ-PÉREZ, J.—See VARGAS V., MARIO 175
RAWLINS, JOHN E.—See WHEELER, A. G., JR. 99
RIDDICK, ERIC W.—*Nomada annulata* Smith (Hymenoptera: Anthophoridae), a confirmed cleptoparasite of *Andrena macra* Mitchell (Hymenoptera: Andrenidae) and other *Nomada-Andrena* associations 107
ROBINSON, W. H. *and* B. V. BROWN—Life history and immature stages of two species of *Megaselia* (Diptera: Phoridae) predatory on gall-inhabiting insects 404
RUSSELL, LOUISE M.—Description of *Disiphon*, new genus, and its type species, *Asterochiton dubienus* Bondar (Homoptera, Aleyrodidae) 463
RUSSELL, LOUISE M.—A new species of *Trialeurodes* (Homoptera: Aleyrodidae) from *Phlox* 583
SABROSKY, CURTIS W.—See PAGANELLI, CELUTA H. 165
SALVO, A.—See SCHAUFF, M. E. 587
SANTIAGO-BLAY, JORGE A. *and* GEORGE O. POINAR, JR.—Classification of *Diphleps* (Heteroptera: Miridae: Isometopinae), with the description of *D. yenli*, a new species from Dominican amber (lower Oligocene-upper Eocene) 70
SCHAEFER, CARL W.—Notes on the morphology and family relationships of Lestoniidae (Hemiptera: Heteroptera) 453
SCHAUFF, MICHAEL E. *and* JOHN LASALLE—Nomenclatural notes on genera of North American Eulophidae (Hymenoptera: Chalcidoidea) 488
SCHAUFF, MICHAEL E. *and* A. SALVO—Taxonomic and biological notes on the genus *Phytomyzophaga* (Hymenoptera: Eulophidae) 587
SKELLEY, PAUL E.—A method of genitalia preparation and dry preservation for Coleoptera 131
SKIDMORE, ROBERT E.—See LEWIS, ROBERT E. 278
SLATER, JAMES A., MERRILL H. SWEET, *and* HARRY BRAILOVSKY—Two new species of *Slaterobius* Harrington with comments on the ecology and distribution of the genus (Hemiptera: Lygaeidae) 590
SOBHIAN, R.—Two biotypes of *Bangasternus orientalis* (Coleoptera: Circulionidae) found in Greece 163
SPINELLI, GUSTAVO R. *and* WILLIAM L. GROGAN, JR.—*Borkenthelea*, a new predaceous midge genus from Subantarctic Argentina and Chile (Diptera: Ceratopogonidae) 321
SPINELLI, GUSTAVO R.—See WIRTH, WILLIS W. 611

STRONG, DONALD R.—See GAGNÉ, RAYMOND J. 541
SWEET, MERRILL H.—See SLATER, JAMES A. 590
TEERINK, JEFFREY A.—See GOEDEN, RICHARD D. 210
TIEMANN, S. G.—See HARRIS, S. C. 286
TURNER, WILLIAM J.—See MACDONALD, JOHN F. 351
TURRELL, M. J.—See LINLEY, J. R. 7
VANDENBERG, NATALIA J.—See PEMBERTON, ROBERT W. 139
VARGAS, J. V.—See VARGAS V., MARIO 175
VARGAS V., MARIO, J. V. VARGAS, *and* J. RAMÍREZ-PÉREZ—*Simulium* (*Psilopelmia*) *travisi* (Diptera: Simuliidae) a new black fly species from Costa Rica 175
WHEELER, A. G., JR. and JOHN E. RAWLINS—*Calophya triozomima* Schwarz, a sumac-feeding psyllid new to the eastern United States (Homoptera: Psylloidea: Calophyidae) 99
WHITCOMB, ROBERT F.—See HICKS, ANDREW L. 481
WHITCOMB, ROBERT F. *and* ANDREW L. HICKS—*Flexarida chaotica*, new genus and species of leafhopper (Homoptera: Cicadellidae) from the American Southwest 605
WIRTH, WILLIS W. *and* GUSTAVO R. SPINELLI—The North American species of the *Forcipomyia* (*Lepidohelea*) *bicolor* subgroup (Diptera: Ceratopogonidae) 611
WOOD, THOMAS K.—See PRATT, GORDON 574
WOODLEY, NORMAN E.—A remarkable new species of *Paradejeania* from the Dominican Republic (Diptera: Tachinidae) 182
WOODLEY, NORMAN E.—*Napemyia* Webb, a new synonym of *Dialysis* Walker (Diptera: Xylophagidae) 635
YASUNAGA, TOMOHIDE—Neotype designation for *Adelphocoris variabilis* (Uhler) (Heteroptera, Miridae) 603
YOUNG, DAVID A.—New genus and five new species of mileewine leafhoppers from New Guinea (Homoptera: Cicadellidae) 228

BOOK REVIEWS

CANE, JAMES H.—*Diversity in the Genus Apis* 296
GAGNÉ, RAYMOND J.—*Flycatcher. Memoirs of an Amateur Entomologist* 644
HORMIGA, GUSTAVO—*The Insects and Arachnids of Canada. Part 19. The Ground Spiders of Canada and Alaska (Araneae: Gnaphosidae)* 517
HRIBAR, LAWRENCE J.—*The Biology of Mosquitoes. Volume 1. Development, Nutrition, and Reproduction* 645
SCHAEFER, CARL W.—*The Hemiptera* and *Adults of the British Aquatic Hemiptera Heteroptera: A Key with Ecological Notes* 293
SLATER, JAMES A.—*A Synthesis of the Holarctic Miridae (Heteroptera): Distribution, Biology and Origin, with Emphasis on North America* 513
WOODLEY, NORMAN E.—*The Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, Volumes 3 and 4, Hexapoda* 647

NOTES

ALUJA, MARTÍN—See PIEDRA, ENRIQUE 127
ECKERLIN, RALPH P. *and* HARRY F. PAINTER—The star-nosed mole, *Condylura cristata*, a new host for *Leptinus orientamericanus* (Coleoptera: Leptinidae) in Virginia 639
KASHEFI, JAVID—A new method for determining the sex of living weevils 511
MALDONADO CAPRILES, J.—A newly discovered homonym in *Ectomocoris* (Heteroptera: Reduviidae: Peiratinae) 128
NAKAHARA, SUEO—A new name for a homonym in *Catinathrips* (Thysanoptera: Thripidae) 129

PAINTER, HARRY F.—See ECKERLIN, RALPH P. 639
PALMER, W. A.—A note on the host specificity of the mirid *Slaterocoris pallipes* (Knight) ... 640
PEMBERTON, ROBERT W.—Observations of extrafloral nectar feeding by predaceous and fungivorous mites 642
PIEDRA, ENRIQUE, ALBERTO ZUÑIGA, *and* MARTÍN ALUJA—New host plant and parasitoid record in México for *Anastrepha alveata* Stone (Diptera: Tephritidae) 127
PINTO, JOHN D.—Correct application of the nominal genus *Brachista* Walker (Hymenoptera: Trichogrammatidae) 298
SOBHIAN, R.—A new method for determining the sex of living weevils 511
STAINES, C. L.—Lectotype deisgnation for *Xenochalepus medius* (Chapuis) (Coleoptera: Chrysomelidae, Hispinae) 126
STAINES, C. L.—Replacement name for *Sumitrosis championi* (Weise) (Coleoptera: Chrysomelidae, Hispinae) 297
ZUÑIGA, ALBERTO—See PIEDRA, ENRIQUE 127

OBITUARIES

MARSH, PAUL M.—Barnard DeWitt Burks, 1909–1990 300

MISCELLANEOUS

REPORTS OF OFFICERS 305
SOCIETY MEETINGS 307, 647
MEMBERSHIP LIST 520

VOL. 95 JANUARY 1993 NO. 1
(ISSN 0013-8797)

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY of WASHINGTON

PUBLISHED
QUARTERLY

CONTENTS

CHAO, CHIEN-MING and PAUL H. ARNAUD, JR.—Name changes in the genus *Tachina* of the eastern Palearctic and Oriental regions (Diptera: Tachinidae) 48

COOPER, KENNETH W.—The first *Holcopasites* from western California, *H. ruthae* n. sp., and *H. linsleyi*, a new species from southwestern Arizona (Hymenoptera, Nomadinae) ... 113

HANKS, LAWRENCE M. and ROBERT F. DENNO—The white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Homoptera: Diaspididae): Life history in Maryland, host plants, and natural enemies 79

KEFFER, S. L. and J. E. McPHERSON—Curictan copulation and waterscorpion higher classification (Heteroptera: Nepidae) 74

LINLEY, J. R. and M. J. TURELL—The eggs of *Aedes dentatus* and *Aedes fowleri* (Diptera: Culicidae) 7

MATHIS, WAYNE N.—A revision of the shore-fly genera *Hostis* Cresson and *Paratissa* Coquillett (Diptera: Ephydridae) 21

McCAFFERTY, W. P. and A. V. PROVONSHA—New species, subspecies, and stage descriptions of Texas Baetidae (Ephemeroptera) 59

NORRBOM, ALLEN L.—Two new species of *Anastrepha* (Diptera: Tephritidae) with atypical wing patterns 52

PALMER, W. A., G. DIATLOFF, and J. MELKSHAM—The host specificity of *Rhopalomyia californica* Felt (Diptera: Cecidomyiidae) and its importation into Australia as a biological control agent for *Baccharis halimifolia* L. 1

PETERS, T. MICHAEL—Two new Dixidae (Diptera) from South Korea 17

RIDDICK, ERIC W.—*Nomada annulata* Smith (Hymenoptera: Anthophoridae), a confirmed cleptoparasite of *Andrena macra* Mitchell (Hymenoptera: Andrenidae) and other *Nomada-Andrena* associations 107

SANTIAGO-BLAY, JORGE A. and GEORGE O. POINAR, JR.—Classification of *Diphleps* (Heteroptera: Miridae: Isometopinae), with the description of *D. yenli*, a new species from Dominican amber (lower Oligocene–upper Eocene) 70

(*Continued on back cover*)

THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

ORGANIZED MARCH 12, 1884

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, % 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 $25.00 (U.S. currency).

PROCEEDINGS.—The *Proceedings of the Entomological Society of Washington* (ISSN 0013-8797) are published quarterly beginning in January by The Entomological Society of Washington. POSTMASTER: Send address changes to the Entomological Society of Washington, % Department of Entomology, NHB-168, Smithsonian Institution, Washington, D.C. 20560. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember subscriptions are $50.00 per year, domestic, and $60.00 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. 218 OF THE JANUARY, 1991 ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Editor: Thomas J. Henry, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Books for Review: Gary L. Miller, Systematic Entomology Laboratory, ARS, USDA, Building 046, BARC-West, Beltsville, MD 20705.

Special Publications: A. G. Wheeler, Jr., Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, PA 17110-9408

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 19 January 1993

Second Class Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

THIS PUBLICATION IS PRINTED ON ACID-FREE PAPER.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 1–6

THE HOST SPECIFICITY OF *RHOPALOMYIA CALIFORNICA* FELT (DIPTERA: CECIDOMYIIDAE) AND ITS IMPORTATION INTO AUSTRALIA AS A BIOLOGICAL CONTROL AGENT FOR *BACCHARIS HALIMIFOLIA* L.

W. A. Palmer, G. Diatloff, and J. Melksham

(WAP) North American Field Station, Queensland Department of Lands, 2801 Arrowhead Circle, Temple, Texas 76502; (GD & JM) Alan Fletcher Research Station, Queensland Department of Lands, 27 Magazine Street, Sherwood, Queensland 4075, Australia.

Abstract.—The cecidomyiid gallformer *Rhopalomyia californica* Felt is endemic to California where its natural host is *Baccharis pilularis.* The midge also develops in *B. halimifolia* and *B. neglecta* in the laboratory and this made it a potential biocontrol agent for *B. halimifolia,* a serious weed in Australia. Host specificity tests indicated that the flies would not oviposit on any of 65 economically important plant species. It was therefore considered safe for introduction into Australia. After two unsuccessful attempts, establishment was achieved in Queensland in 1982. A subsequent large scale mass rearing and releasing effort resulted in the insect being established throughout the range of *B. halimifolia* in Australia by 1986. The insect has given a measure of control particularly in elevated areas and in years when spring and early summer were wetter and cooler.

Key Words: Biological control, Cecidomyiidae, gall, *Rhopalomyia, Baccharis*

The North American woody shrub *Baccharis halimifolia* L. (Family Asteraceae: Tribe Astereae: Sub-Tribe Baccharidinae) is a noxious weed in Queensland and New South Wales, Australia, and is the target of an extensive program to find suitable biological control agents. This program has involved searches in both South America (McFadyen 1979) which is the ancestral home of the genus, and North America (Palmer 1987, Palmer and Bennett 1988) where 20 species, including *B. halimifolia,* are native (Mahler and Waterfall 1964).

In North America, three species (*B. halimifolia, B. neglecta* Britton, and *B. pilularis* DC) are apparently phytochemically very similar because a number of stenophagous insects accept all three as hosts under laboratory conditions (Palmer 1986, Palmer and Tilden 1988, Palmer 1989). Recently, Nesom (1990) placed these three species in the same section, *Baccharis,* of the genus. It was therefore considered that the insect fauna on *B. pilularis* might provide useful biological control agents for *B. halimifolia.*

One such insect was the gall midge *Rhopalomyia californica* Felt (Diptera: Cecidomyiidae) which develops in multi-chambered galls on *B. pilularis* in California and which is one of at least seven species of cecidomyiidae that utilize *Baccharis* spp. in North America (Gagné 1989). This paper describes the host testing procedures and the subsequent successful introduction of this insect into Australia.

Biology and Ecology

The biology of *R. californica* was described by Tilden (1951) and McFadyen (1985). Briefly, adults emerge from the gall

Table 1. Plant species against which *Rhopalomyia californica* was tested in 1968 to obtain permission for its introduction into Australia.

Apiaceae: *Daucus carota* L.; *Pastinaca sativa* L.
Anacardiaceae *Mangifera indica* L.
Asteraceae: *Baccharis halimifolia* L.; *Carthamus tinctorius* L.; *Chrysanthemum* sp.; *Dahlia* sp.; *Helianthus annus* L.; *Lactuca sativa* L.
Brassicaceae: *Brassica oleraceae* (L.) Alef.; *B. rapa* L.
Bromeliaceae: *Ananas comosus* (L.) Merr.
Caricaceae: *Carica papaya* L.
Chenopodiaceae: *Beta vulgaris* L.
Convolvulaceae: *Ipomoea batatas* (L.) Lam.
Cucurbitaceae: *Cucumis melo* L.; *Cucumis sativus* L.; *Curcubita maxima* Duch.
Fabiaceae: *Arachis hypogaea* L.; *Centrosema pubescens* Benth.; *Desmodium canum* (Gmel.); *Glycine wightii* (R. Grah. ex Wight & Arn.) Verdc.; *Dolichos lablab* L.; *Glycine max* (L.) Merr.; *Lotononis* sp.; *Medicago sativa* L.; *Phaseolus atropurpureus* DC.; *Phaseolus vulgaris* L.; *Pisum sativum* L.; *Stizolobium* sp.; *Stylosanthe guianensis* (Aubl.) Swartz; *Trifolium repens* L.; *Vigna catjang* V.
Linaceae: *Linum usitatissimum* L.
Malvaceae: *Gossypium hirsutum* L.
Mimosaceae: *Leucaena leucocephala* (Lam.) de Wit.
Musaceae: *Musa sapientum* M.
Passifloraceae: *Passiflora edulis* Sims
Pinaceae: *Pinus radiata* D. Don.; *P. taeda* L.
Poaceae: *Avena sativa* L.; *Digitaria decumbens* Stent.; *Panicum maximum* Jacq.; *Paspalum dilatatum* Poir.; *Pennisetum clandestinum* Chiov.; *Saccharum officinarum* L.; *Sorghum vulgare* L.; *Triticum aestivum* L.; *Zea mays* L.
Proteaceae: *Macadamia integrifo.* Maid & Betche
Rosaceae: *Fragaria vesca* L.; *Malus sylvestris* Mill.; *Prunus domestica* L.; *P. persica* (L.); *Pyrus communis* L.; *Rosa* sp.
Rutaceae: *Citrus limon* L.; *C. paradisi* Macfady.; *C. reticulata* Blanco; *C. sinensis* (L.)
Sapindaceae: *Litchi chinensis* Sonn.
Solanaceae: *Capsicum annum* L.; *Lycopersicum esculentum* Miller; *Nicotiana tabacum* L.; *Solanum tuberosum* L.
Vitaceae: *Vitis vinifera* L.
Zingiberaceae: *Zingiber officinale* Roscoe.

in the first few hours after daybreak and mate soon after their emergence. Males are particularly short lived (2–4 hours) while females live 12–14 hours and occasionally longer. Females can be recognised by their orange abdomen, the coloration of which is caused by the mass of vermillion colored eggs. They oviposit approximately 100–150 eggs on the surface of meristematic tissue at stem terminals and occasionally in leaf axils. Neonate larvae enter the stem between bud scales and produce a gall on the stem. A number of larvae form a community gall and these galls can contain more than 50 chambers each housing one larva. The larvae complete their development and pupate within the gall. Flies emerge within two months after oviposition.

Ehler (1987) described the ecology of *R. californica* within its native range in California. His life table data suggested that the insect is heavily predated and parasitized and that these mechanisms maintained the population at comparatively low levels under natural conditions; the density of galls never exceeded 2 per 100 terminals. The parasite guild consisted of seven hymenopteran species. However when the fly was released from its parasites and predators by spraying with insecticide, midge populations exploded and in some cases caused the destruction of the host plants (Ehler et al. 1984). This result suggested that this insect, if released without its parasite guild, might have considerable potential as a biocontrol agent.

Host Specificity

Materials and Methods.—A laboratory culture was first established in 1968 at the Archbold Research Station at Lake Placid, Florida. Mature galls on *B. pilularis* near Berkeley, California, were collected and shipped to Florida by air. Emerging flies from these galls were captured and placed in a cage containing potted *B. halimifolia.* These plants became galled and the culture was subsequently maintained on these and replacement plants. Flies from this culture were used for the subsequent experiments.

A comprehensive testing program was designed to satisfy the Australian Department of Health's requirements for introduction into Australia. The requirement involved testing the insect against a list of 66 plant species (Table 1) that were of economic importance in Australia. However, because the adult fly is the only mobile stage and because the larva is the only feeding stage, it was accepted that specificity could be demonstrated satisfactorily by suitable tests of oviposition behavior.

Young actively growing tips were taken from each of the test plants (Table 1) and placed in individual glass vials of water. The 66 plant tips were arranged randomly in a 38 × 22.5 × 25 cm glass and stainless steel aquarium which was placed in a well lit laboratory, the natural light of which was supplemented by "daylight" fluorescent tubes. The top of the aquarium was sealed with cloth and masking tape except for a precut hole that allowed the introduction of the flies. The experiment was replicated twice.

Mature galls from the culture were cut from the plants and placed in containers from which emerging flies were captured early the following morning. Twenty pairs of flies were introduced into each aquarium at 7 a.m. The aquaria were then observed for three hours after which the cloth tops were removed, the plants examined under a microscope and any eggs counted.

Results.—Females quickly recognised *B. halimifolia* as a suitable host plant and spent most of the time resting and ovipositing on it whilst males rested on the glass walls and the cloth covers.

Eggs were freely laid on *B. halimifolia*; more than 30 eggs were laid on each plant. No eggs were laid on any other plant and it was concluded that this fly was sufficiently host specific to be released safely in Australia.

INTRODUCTION INTO AUSTRALIA

Permission to introduce and release *R. californica* was granted by the appropriate authorities in October 1968 and a shipment of galls, collected in Tilden Regional Park near Berkeley, was sent to Australia. A small colony was established at the Alan Fletcher Research Station, Brisbane, and from this, a very small field release of only a few galls was made at a site 30 km north of Brisbane in May 1969. However, the insect failed to establish in the field and the laboratory colony was also lost.

A second consignment of galls collected in Tilden Park was received in Australia in November 1969. Again the laboratory colony was not sustained past a couple of generations and no material was available for field release.

In May 1982 a third attempt at introduction was made. This time about 100 galls were gathered from one plant in the front garden of a residence in Berkeley. The consignment was then hand carried to Australia. Although the galls were moderately parasitized, 654 flies emerged over a period of 9 days after their arrival in Brisbane. These flies were sufficient to produce galls on 48 potted plants placed in an air-conditioned greenhouse kept at 28°C, 55–60% R.H. and a 14 h day length. Third generation galls on 359 plants were moved to outside conditions in August, 1982 (late winter).

Some 320 galled potted plants were distributed between three release sites to the north of Brisbane in September 1982. Successful establishment was recorded at all three sites where galls were found on the surrounding plants in October that year.

During the next three years a very vigorous mass rearing programme was undertaken at the Alan Fletcher Research Station. Ten shadehouses (30 × 10 m) were erected, 6 people were hired and over 50,000 plants were potted and infested with the galls. The infested potted plants were then distributed throughout the range of *B. halimifolia* in Australia. By the 1985–86 summer, the fly was established throughout this range which is approximately the land within 80 km of the Pacific coast between Bundaberg (24°54′S) in the north and Lismore, NSW (28°44′S), in the south, a north-south distance of approximately 600 km.

The effect of the midge has been variable and appears to be related to climatic and other conditions that influence the growth of the plant itself. The midge is favoured when the plant is growing rapidly.

In the first year after its release, 1983, establishment occurred, but no significant effects of the galls were noted. In 1984 McFadyen (1985) noted significant effects of the midge at various experimental sites. At two sites, plants were heavily galled and flower production had been reduced by 93%.

The effect of the midge was most dramatic in 1985. Better than average summer and winter rains were received throughout southeast Queensland that year which created conditions for rapid plant growth. In many areas plants were also experiencing their initial exposure to the midge. Through much of the area plants of all ages became heavily galled. Seedlings were often killed and in shaded areas such as the undercanopy of pine forests, even large plants succumbed to this attack. Even at some distance, stands of *B. halimifolia* could be recognized as being badly affected. Grasses and other plants were also observed growing where pure monocultures of *B. halimifolia* had previously prevailed.

The following year, 1986, was rather dry and much less gall activity was noted. In most areas plants were only lightly galled and there was much less control exerted on them than in 1985. Despite a number of average rainfall years since 1986 there has not been a return to the 1985 levels of gall activity in much of the area. However in some elevated, higher rainfall areas within the range (e.g. Springbrook, Lamington Plateau, Maleny) the midge remained very active and a significant level of control was exerted.

In 1990–91 an assessment of the phenology was undertaken in southeast Queensland. In Queensland the midge is now most active in spring and least active in summer. Activity increases again in autumn and in areas such as Springbook, continues over the winter months at levels sometimes comparable to those of the spring.

One factor associated with the midge's reduced abundance since 1985 has been an increased attack by parasitic wasps. Prior to 1985 relatively low parasitism rates of less than 30% were reported. By 1991, rates as high as 90% had occurred with the highest rates being recorded in areas having the smaller gall populations. At least four parasite species have been recovered from mature galls with *Torymoides* spp. (Hymenoptera: Torymidae) being the major species accounting for 80% of total parasitism. Other species include a platygastrid and a mymarid and the parasite guild in southeast Queensland is similar to that recorded for *R. californica* in its native habitat by Ehler (1982).

A further introduction of the midge was made in 1989 in an attempt to improve the insect's effectiveness under drier conditions. *R. californica* is also endemic in the Sacramento Valley, California, which has a much hotter, drier climate than has the San Francisco area. Strains from this area may complement the existing introductions, but it will be impossible to evaluate the contributions of each strain.

R. californica is the most successful agent released for *B. halimifolia* to date. It might be classified as a partially effective agent because it is effecting some control in the elevated areas but is not effective in coastal areas. However, it is also felt that in the event of a series of cooler, wetter years, more widespread control might occur in those years.

Discussion

A number of comments may be made about the successful introduction of this insect.

Although the insect was quickly proved to be sufficiently stenophagous for importation and release, its successful establishment was not easily achieved. In fact three attempts were made and after the first two failures it was considered unlikely to be a successful agent. Undoubtedly the improved rearing facilities available by 1982 contributed to the eventual success. Laboratory colonies could be reared through winter so that greater populations were available for release in spring. The timing of the releases might also have been important. The failure of the 1969 release might be partly explained by the fact that the release was made in May when the plants had ceased growth for the year. Nevertheless, this case highlights one problem in biological control; just how long should one persist with an insect if establishment is initially unsuccessful. This case suggests that further attempts to rear and establish a difficult insect might be worthwhile.

Gallformers have not always been considered as potentially effective agents. Indeed Harris (1973) considered gallformers and leafminers to be the groups inflicting least damage on weeds. More recently there has been greater appreciation that galls can act as metabolic sinks (Harris 1980). Gallformers have now been reported as causing detriment to at least three other plant species (Caresche and Wapshere 1974, McFadyen 1985, Dennill and Donnelly 1991). This case provides a clear example that gallformers can be effective biocontrol agents. Indeed as many of them have short life cycles and good dispersal rates, they have much to commend them.

This case also provides another example in which an insect collected from a closely related plant has provided control of a weedy species. Hokkanen and Pimental (1984) advocated that it was preferable to search close relatives rather than the target organism itself for biocontrol agents. While we do not support that extreme position, this case does lend support to the philosophy that it is well worth while searching related plants as well as the weedy species itself.

Another aspect considered important in the selection of successful biocontrol agents is that of climate matching. It is generally considered that an organism is more likely to be effective if it comes from a similar climate to that of the areas in which it will be introduced. Indeed, Wapshere (1988) recommended against attempting to utilize insects from northern Mexico for control of *Solanium elaeagnifolium* Cav. in Australia on the basis of considerable climate differences between the two areas. However McFadyen (1985) noted that the climates of southeast Queensland (subtropical, summer rainfall) and California (Mediterranean, winter rainfall) were quite different. This observation was confirmed by conducting a climate match using the CLIMEX model (Sutherst and Maywald 1985, Maywald and Sutherst 1990). This model determined that the natural habitat of *R. californica* best matched areas in Western Australia, South Australia and Victoria and that there were no comparable areas present in Queensland. This example suggests that climatic differences may not always be important and therefore this criterion for selecting agents should be used with caution.

It is also of interest that the initial material for the successful establishment was collected from one isolated plant. The genetic variation of this population was evidently sufficient for the species to establish over a range of climatic conditions.

Acknowledgments

We wish to thank Richard E. Doutt, Lloyd Andres, Lester E. Ehler and Marvin G. Kinsey, all of whom also assisted in shipping the insect to Australia, and gave very helpful advice during the course of this project. Raymond J. Gagné of the Systematic Entomology Laboratory, USDA, provided numerous identifications during the course of this study. Paul J. McFadyen kindly allowed the use of his data.

The propagation and release of the insect in Australia were undertaken by various people at the Alan Fletcher Research Station and not by the authors.

Literature Cited

Caresche, L. A. and A. J. Wapshere. 1974. Biology and host specificity of the *Chondrilla* gall mite *Acera chondrillae* (G. Can.) [Acarina, Eriophyidae]. Bulletin of Entomological Research 64: 183–192.

Dennill, G. B. and D. Donnelly. 1991. Biological control of *Acacia longifolia* and related weed species (Fabaceae) in South Africa. Agriculture, Ecosystems and Environment 37: 115–135.

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

———. 1987. Ecology of *Rhopalomyia californica* Felt at Jasper Ridge (Diptera: Cecidomyiidae). Pan-Pacific Entomologist 63: 237–241.

Ehler, L. E., P. C. Endicott, M. B. Hertlein, and B. Alvarado-Rodriquez. 1984. Medfly eradication in California: Impact of malathion-bait sprays on an endemic gall midge and its parasitoids. Entomologia Experimentalis et Applica 36: 201–208.

Gagné, R. J. 1989. The Plant-Feeding Gall Midges of North America. Cornell University Press, Ithaca. 356 pp.

Harris, P. 1973. The selection of effective agents for the biological control of weeds. Canadian Entomologist 105: 1495–1503.

———. 1980. Effects of *Urophora affinis* Frfld. and *U. quadrifasciata* (Meig.) (Diptera: Tephritidae) on *Centurea diffusa* Lam. and *C. maculosa* Lam. (Compositae). Zeitschrift fur Angewandte Entomologie 90: 190–201.

Hokkanen, H. and D. Pimental. 1984. New approach for selecting biological control agents. Canadian Entomologist 116: 1109–1121.

Mahler, W. F. and U. T. Waterfall. 1964. Baccharis (Compositae) in Oklahoma, Texas and New Mexico. Southwestern Naturalist 9: 189–202.

Maywald, G. F. and R. W. Sutherst. 1990. A computer program for comparing climates and ecology. CSIRO Division of Entomology Report No. 35. CSIRO.

McFadyen, P. J. 1979. South American insects introduced into Australia for the control of the weed *Baccharis halimifolia* L. Ph.D. Thesis. University of Queensland. 398 pp.

———. 1985. Introduction of the gall fly *Rhopalomyia californica* from the USA into Australia for the control of the weed *Baccharis halimifolia*. Proceedings of the VI International Symposium on Biological Control of Weeds, Vancouver, Canada. Agriculture Canada, Ottawa.

McFadyen, R. E. 1985. The biological control programme against *Parthenium hysterophorus* in Queensland. Proceedings of the VI International Symposium on Biological Control of Weeds, Vancouver, Canada. Agriculture Canada, Ottawa.

Nesom, G. L. 1990. Infrageneric taxonomy of North and Central American *Baccharis* (Asteraceae: Astereae). Phytologia 68: 40–46.

Palmer, W. A. 1986. The host range of *Trirhabda flavolimbata* (Mannerheim) and its suitability as a biocontrol agent for *Baccharis* spp. (Asteraceae: Astereae). The Coleopterists Bulletin 40: 149–153.

———. 1987. The phytophagous insect fauna associated with *Baccharis halimifolia* L. and *B. neglecta* Britton in Texas, Louisiana and northern Mexico. Proceedings of the Entomological Society of Washington 89: 185–199.

———. 1989. Food plant specificity and biology of *Itame varadaria* (Walker) (Geometridae), a North American moth introduced into Australia to control the weed *Baccharis halimifolia*. Journal of the Lepidopterists' Society 43: 305–312.

Palmer, W. A. and F. D. Bennett. 1988. The phytophagous insect fauna associated with *Baccharis halimifolia* L. in the eastern United States. Proceedings of the Entomological Society of Washington 90: 216–228.

Palmer, W. A. and J. W. Tilden. 1988. Host specificity and biology of *Prochoerodes truxaliata* (Guenée) (Geometridae), a potential biocontrol agent for the rangeland weed *Baccharis halimifolia* L. in Australia. Journal of the Lepidopterists' Society 41: 199–208.

Sutherst, R. W. and G. E. Maywald. 1985. A computerized system for matching climates in ecology. Agriculture, Ecosystems and Environment 13: 281–299.

Tilden, J. W. 1951. Observations on *Rhopalomyia californica* Felt. Pan-Pacific Entomologist 27: 20–27.

Wapshere, A. J. 1988. Prospects for the biological control of silver-leaf nightshade, *Solanium elaeagnifolium*, in Australia. Australian Journal of Agricultural Research 39: 187–197.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 7–16

THE EGGS OF *AEDES DENTATUS* AND *AEDES FOWLERI* (DIPTERA: CULICIDAE)

J. R. LINLEY AND M. J. TURELL

(JRL) Florida Medical Entomology Laboratory, University of Florida, 200 9th St. S.E., Vero Beach, Florida 32962; (MJT) Dept. of Epidemiology, Disease Assessment Division, U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Frederick, Maryland 21702-5011.

Abstract.—Descriptions illustrated by scanning electron micrographs are given of the eggs of *Aedes* (*Aedimorphus*) *dentatus* and *Ae.* (*Adm.*) *fowleri.* The ventral surface in both species is slightly more curved than the dorsal, and the outer chorionic cells, which are elongated in the longitudinal axis of the egg, are uniform in detailed structure over the entire egg. Each cell in *Ae. dentatus* contains several large tubercles with very few small ones; *Ae. fowleri* cells have several large, central, often partially fused tubercles, surrounded by many peripheral small ones. The micropylar collar is low and very inconspicuous in *Ae. dentatus,* elevated and prominent in *Ae. fowleri.*

Key Words: Insecta, mosquito, egg, scanning electron microscopy

---

The two *Aedes* (subgenus *Aedimorphus*) species studied in this contribution, *Ae. dentatus* (Theobald) and *Ae. fowleri* (Charmoy) are widely distributed in the Ethiopian Region (Knight and Stone 1977), where both are of concern as vectors of human pathogens. Isolations of Orungo virus at the same time as human isolations have been obtained from *Ae. dentatus* in Nigeria (Tomori and Fabiyi 1977) and, in addition, this species has yielded isolations of Rift Valley fever virus (Meegan and Bailey 1989), as well as Pongola, Semlike Forest, Shokwe and Wesselbron viruses (Karabatsos 1985). *Aedes fowleri* has proven in laboratory experiments to be a competent vector of Rift Valley fever virus (Turell et al. 1988) and also has provided isolations of Pongola, Simbu and Zika viruses (Karabatsos 1985). The larval and adult stages of both species are, of course, known (see Knight and Stone 1977), but no information on the egg of either appears to have been published. As one of us (MJT) was able to collect eggs, we took the opportunity to provide the following descriptions, illustrated by scanning electron micrographs.

MATERIALS AND METHODS

Aedes dentatus eggs were obtained by decapitation from gravid but unmated females reared after flooding eggs collected by the method of Horsfall (1956) from soil samples taken from natural habitats in Kenya. The infertile eggs so obtained were kept for 24 h on wet filter paper, fixed in alcoholic Bouin's fixative, then sealed in small vials and mailed to Vero Beach. On receipt, eggs were washed in three changes of 80% ethanol to remove picric acid, and were then completely dehydrated in absolute ethanol and dried by the critical point method. To obtain the required orientations on stubs, individual eggs were lifted with a fine artist's brush and touched to sticky tape already fixed and trimmed on the stub surfaces. With

Ae. fowleri, fertile eggs were collected by allowing laboratory colony females to oviposit on damp filter paper. This colony originated from specimens collected in eastern Senegal in 1983 (Turell et al. 1988). Fixation was not required for these specimens, as they resisted desiccation well. Individual live eggs were therefore placed on stubs as already described and, for both species, specimens were then dried finally over calcium chloride (20 min) before being coated with gold and examined in a Hitachi S-510 scanning electron microscope.

All measurements were made from micrographs using a digitizing tablet and SigmaScan software (Jandel Scientific, Corte Madera, CA). Means cited in the text are given ±SE and were derived from an equal number of measurements from 5 eggs of each species. Outer chorionic cell lengths are the dimension in the longitudinal axis of the egg, widths are the circumferential dimension. Tubercles were measured across the widest point, including the base, which is noticeably wider in *Ae. dentatus* than the top. We have used the terminology of Harbach and Knight (1980) and, additionally, the terms "anterior ring" and "outer chorionic cell field" (Linley 1989) and "micropylar dome" (Linley et al. 1991).

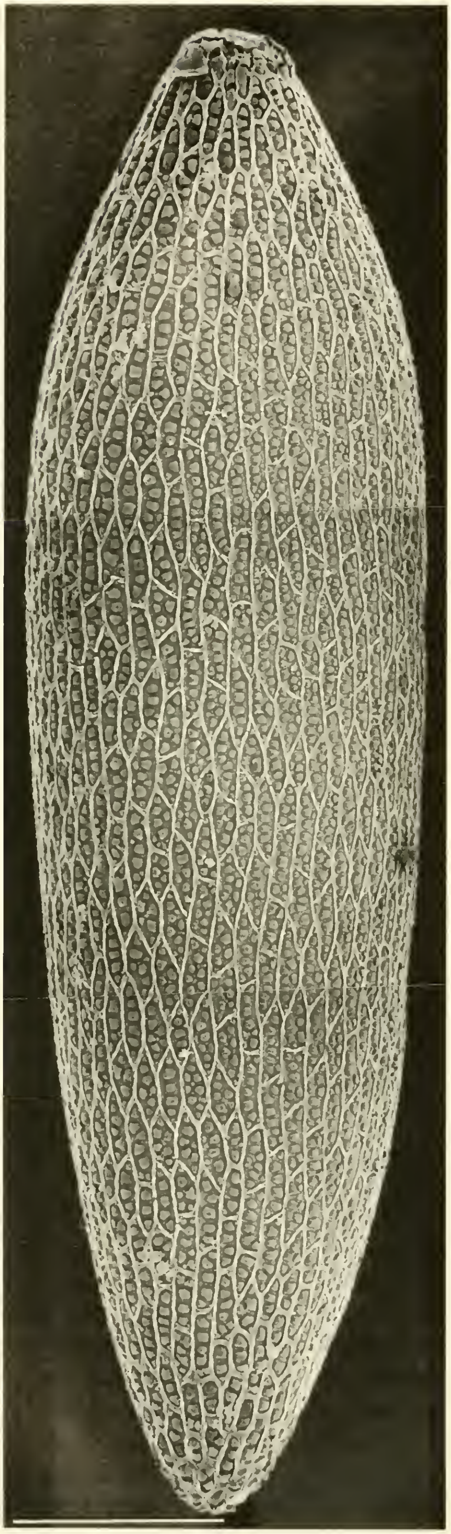
RESULTS

Aedes (*Aedimorphus*) *dentatus*
(Figs. 1–3)

Size: as in Table 1.

Color: dull black.

Shape, overall appearance: cigar-shaped, widest at about anterior 0.25, anterior end distinctly conical, posterior taper slight from widest point to posterior 0.3, then more rapid, posterior end slightly pointed (Fig. 1). Lateral view shows ventral surface scarcely more curved than dorsal (Fig. 2a). Outer chorionic cells regular, easily visible, elon-



←

Fig. 1. *Aedes dentatus.* Entire egg, ventral view, anterior end at top. Scale = 100 μm.

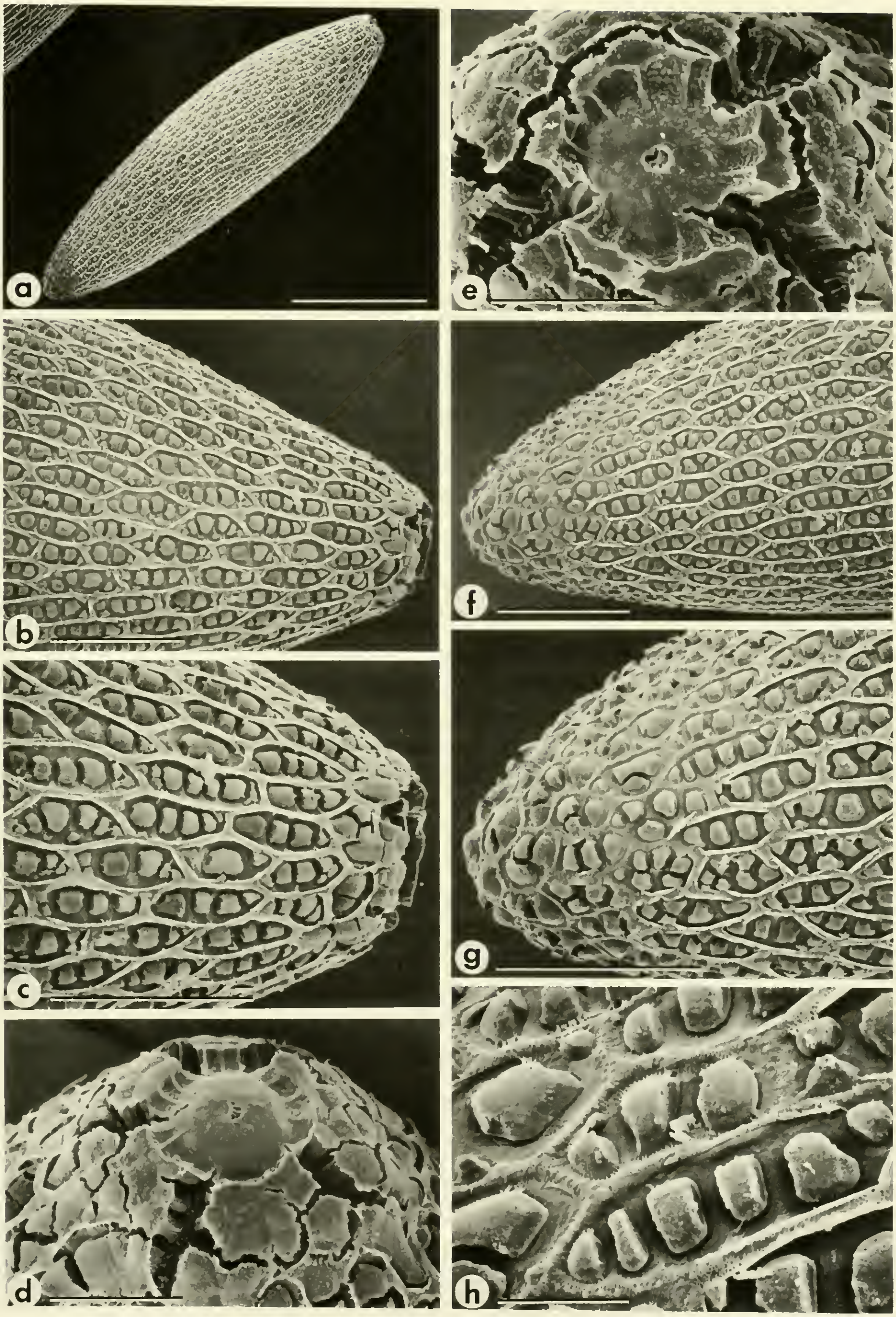


Fig. 2. *Aedes dentatus.* (a) Entire egg, lateral view, ventral side at top, anterior end at right; (b) anterior end, lateral view, ventral side at top; (c) anterior end, chorionic cell detail; (d) micropylar apparatus, showing disk and indistinct dome; (e) micropylar apparatus, detail of collar inner wall, disk surface; (f) posterior end, lateral view, ventral side at top; (g) posterior end, chorionic cell detail. Scale = 200 μm (a), = 50 μm (b, c, f, g), = 20 μm (d, e), = 10 μm (h).

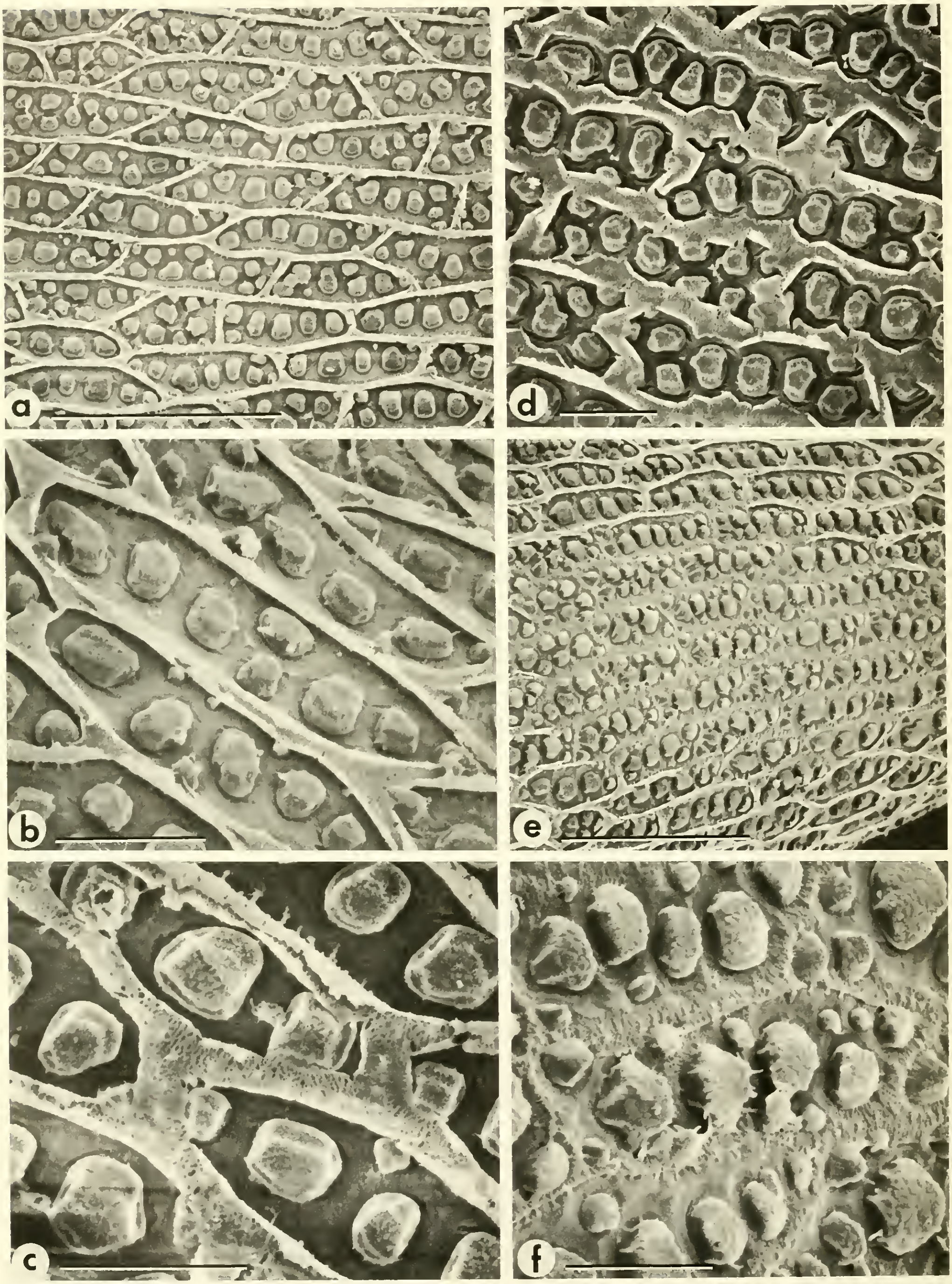


Fig. 3. *Aedes dentatus.* (a) Outer chorionic cells, ventral surface, middle of egg; (b) detail, chorionic cells and tubercles; (c) detail, tubercles and outer chorionic reticulum; (d) atypical chorionic reticulum seen in some eggs on dorsal surface; (e) lateral patch, as seen in a few eggs, with atypical reticulum; (f) detail, atypical reticulum. Scale = 50 μm (a, e), = 10 μm (b, c, d, f).

Table 1. Dimensions of eggs of *Ae. dentatus* (n = 12) and *Ae. fowleri* (n = 10).

Species	Length (μm)		Width (μm)		L/W ratio	
	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range
Ae. dentatus	819.2 ± 8.4	766.4–876.2	237.2 ± 2.8	223.4–251.6	3.46 ± 0.06	3.15–3.78
Ae. fowleri	751.8 ± 10.3	681.8–795.4	234.5 ± 3.0	218.2–249.9	3.21 ± 0.05	2.99–3.31

gate in longitudinal axis of egg and each with several tubercles, reticulum narrow (Fig. 1). Collar of micropyle very indistinct.

Chorion, ventral, lateral and dorsal surfaces: all surfaces very similar (Figs. 1, 2a). Outer chorionic cell length, 23.8–45.2 μm (mean 36.1 ± 1.5 μm, n = 15), greater than width, 8.9–12.4 μm (mean 10.6 ± 0.2), length/width ratio 2.17–4.55 (mean 3.43 ± 0.18). Cell shape pentagonal or quadrilateral, longitudinal corners often very narrowly pointed (Figs. 1, 3a), cell fields 1.2–2.2 μm less in each dimension. Tubercles in each cell medium sized, a few small (Fig. 3a), located generally in the central part of the cell field, but a few peripherally positioned, sometimes fused with reticulum (Fig. 3a, b). Number of tubercles 4–13 (mean 8.4 ± 0.4, n = 25), diameter 1.4–5.7 μm (mean 3.2 ± 0.1 μm, n = 50), shapes irregular, tending to be rectangular, the base of each tubercle around some of its sides conspicuously wider than the top (Fig. 3a, b, c). Bases fairly smooth, tops of some with scarcely discernible nodular sculpturing (Fig. 3b, c). Chorionic reticulum 1.2–2.4 μm wide, moderately raised, consisting of a very fine meshwork, frequently folded over at the edges, with central line of papillae (Fig. 3c). Edges of reticulum in some places connected to cell floor by very thin pillars (Fig. 3b, c). On dorsal surface, a few eggs with areas of chorion in which reticulum variable in width but considerably wider (2.4–4.1 μm) overall, appearing ragged (Fig. 3d). Patches of chorion occasionally seen on some eggs in which reticulum again atypical (Fig. 3e), meshwork closely applied to cell surface, edges not raised, central papillae and small pillars along edges more prominent (Fig. 3f).

Anterior end, micropyle: chorionic cells smaller near anterior end, narrower, tubercles fewer (Fig. 2b), but structure relatively little modified except immediately posterior to micropylar collar, where cells very small, fields almost completely filled by tubercles (Fig. 2c). Collar of micropyle discontinuous, gaps present in all eggs examined (Fig. 2d, e), posterior edge very difficult to distinguish, invariably cracked and fused with adjacent cells (Fig. 2c, d). Height of collar (where recognizable) 1–4 μm, width 27–34 μm, wall width (where present) 1–6 μm, surface slightly rough (Fig. 2e). Collar internal diameter 24–26 μm, interior wall excavated, surface rough, nodular (Fig. 2e). Micropylar disk fairly prominent, diameter 13–15 μm, edges clearly raised in some specimens (Fig. 2d), dome inconspicuous (Fig. 2d, e), diameter about 10 μm, orifice 2.4 μm wide.

Posterior end: chorionic cells smaller towards posterior end, tubercles fewer (Fig. 2g), reticulum often becoming appressed to cell floor, central papillae more prominent (Fig. 2g, h). Tubercles often partially fused in cells very near end of egg, extreme end cells with a single, smooth tubercle that completely fills field (Fig. 2g).

Aedes (*Aedimorphus*) *fowleri*
(Figs. 4–6)

Size: as in Table 1.

Color: matte black.

Shape, overall appearance: broadly cigar-shaped in ventral and dorsal view (Fig. 4), ventral side somewhat more curved in lateral view (not shown). Widest at about anterior 0.3, anterior end only slightly conical, little posterior taper until posterior 0.25, then taper greatly increased (Fig. 4). Outer chorionic cells longer than broad, reticulum

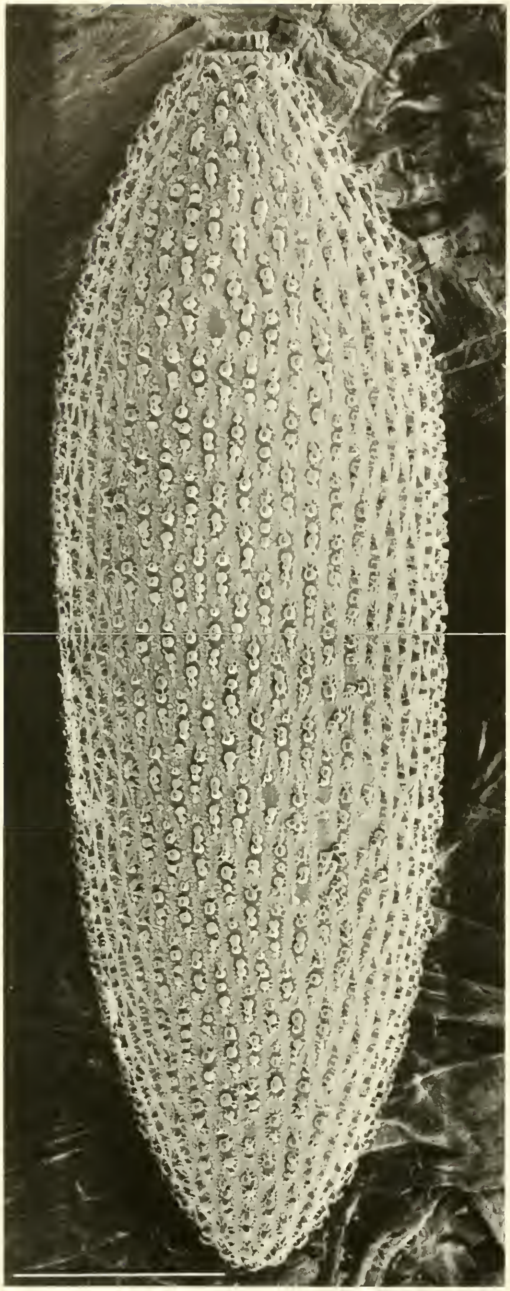


Fig. 4. *Aedes fowleri.* Entire egg, ventral view, anterior end at top. Scale = 100 μm.

fairly wide and boundaries of cells not distinct, several large tubercles visible in each cell, aligned longitudinally (Fig. 4). Micropylar collar conspicuous, sides erect, not conforming to taper of egg (Fig. 4).

Chorion, ventral, lateral and dorsal surfaces: all surfaces very similar (Fig. 5a, c). Outer chorionic cells elongate, length 28.6–51.2 μm (mean 43.4 ± 1.7 μm, n = 15) greater than width, 11.8–15.9 μm (mean 13.8 ± 0.3 μm), length/width ratio 1.98–3.75 (mean 3.15 ± 0.13). Shape of cells hexagonal or pentagonal, anterior and posterior corners often very pointed (Fig. 5a, b), cell fields 2–4 μm less in each dimension. Large tubercles 4–7 in number (mean 5.2 ± 0.3, n = 15), more or less round, arranged in line in central longitudinal axis of cell (Fig. 5a, b), diameter 1.6–5.4 μm (mean 3.6 ± 0.1 μm, n = 50). Many tubercles separate, but multiples formed of 2 or 3 contiguous or partially fused tubercles quite common (Fig. 5a, b, c), largest tubercles usually in middle of cell. In detailed structure each tubercle with base sometimes slightly larger than top, sides of tubercle vertical or almost so, walls rough (Fig. 5b, e, f), top domed, sculptured with small, flat nodules (Fig. 5d, e, f). Small tubercles 15–32 in number (mean 22.9 ± 1.1, n = 15), diameter 0.3–1.9 μm (mean 1.0 ± 0.04 μm, n = 50), fairly evenly spaced around periphery of cell, sometimes not touching reticulum, but often touching it and overlain by its meshwork (Fig. b, d, f). Small tubercles more or less round, low, smooth-surfaced (Fig. 5b, d, e), many with bridges extended to nearby large tubercles (Fig. 5b, c, d, e). Outer chorionic reticulum low, flat, fairly wide, 2.0–4.3 μm, consisting in most places of an intricate and delicate mesh appressed to the cell surface (Fig. 5c, d, f), but often in some places raised to produce perforations (Fig. 5d, e), both forms often found round same cell (Fig. 5b, e). Meshwork with a sometimes indistinct central line of tiny papillae (Fig. 5c, d).

Anterior end, micropyle: chorionic cells progressively smaller in size approaching anterior end, large and small tubercles fewer (Fig. 6a), the former tending to be more abutting or fused. Anterior ring well developed, diameter 51–54 μm, width 9.5–14.0 μm, tubercles in outer ring anteriorly curved,

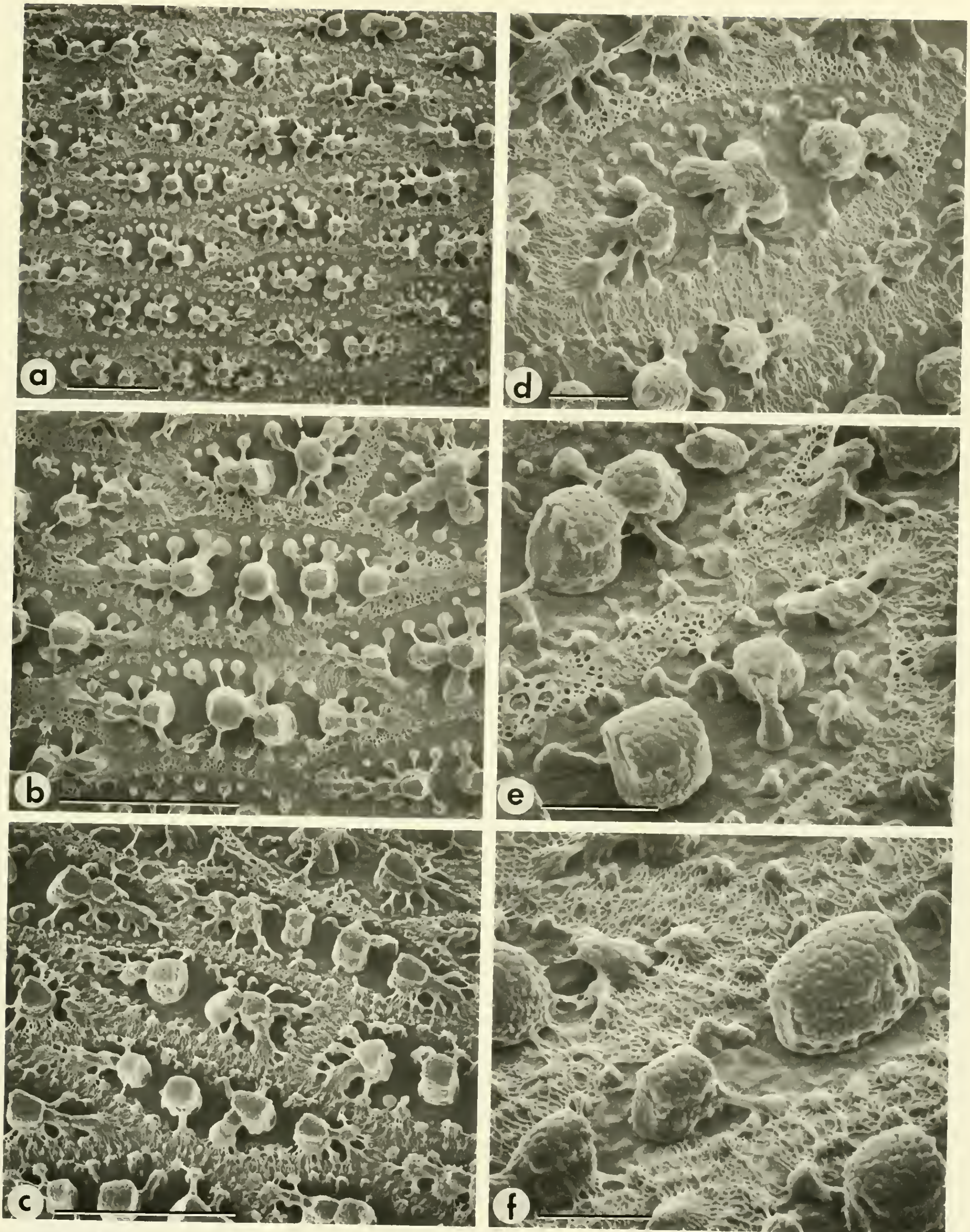


Fig. 5. *Aedes fowleri.* (a) Outer chorionic cells, ventral surface, middle of egg; (b) detail, chorionic cells and tubercles; (c) outer chorionic cells, dorso-lateral surface, middle of egg; (d) detail, single chorionic cell, showing fused tubercles, reticulum mostly of flat, unperforated type; (e) detail, large and small tubercles, some reticulum of perforated type; (f) extreme detail, large tubercles, meshwork of reticulum. Scale = 20 μm (a, b, c), = 5 μm (d, e, f).

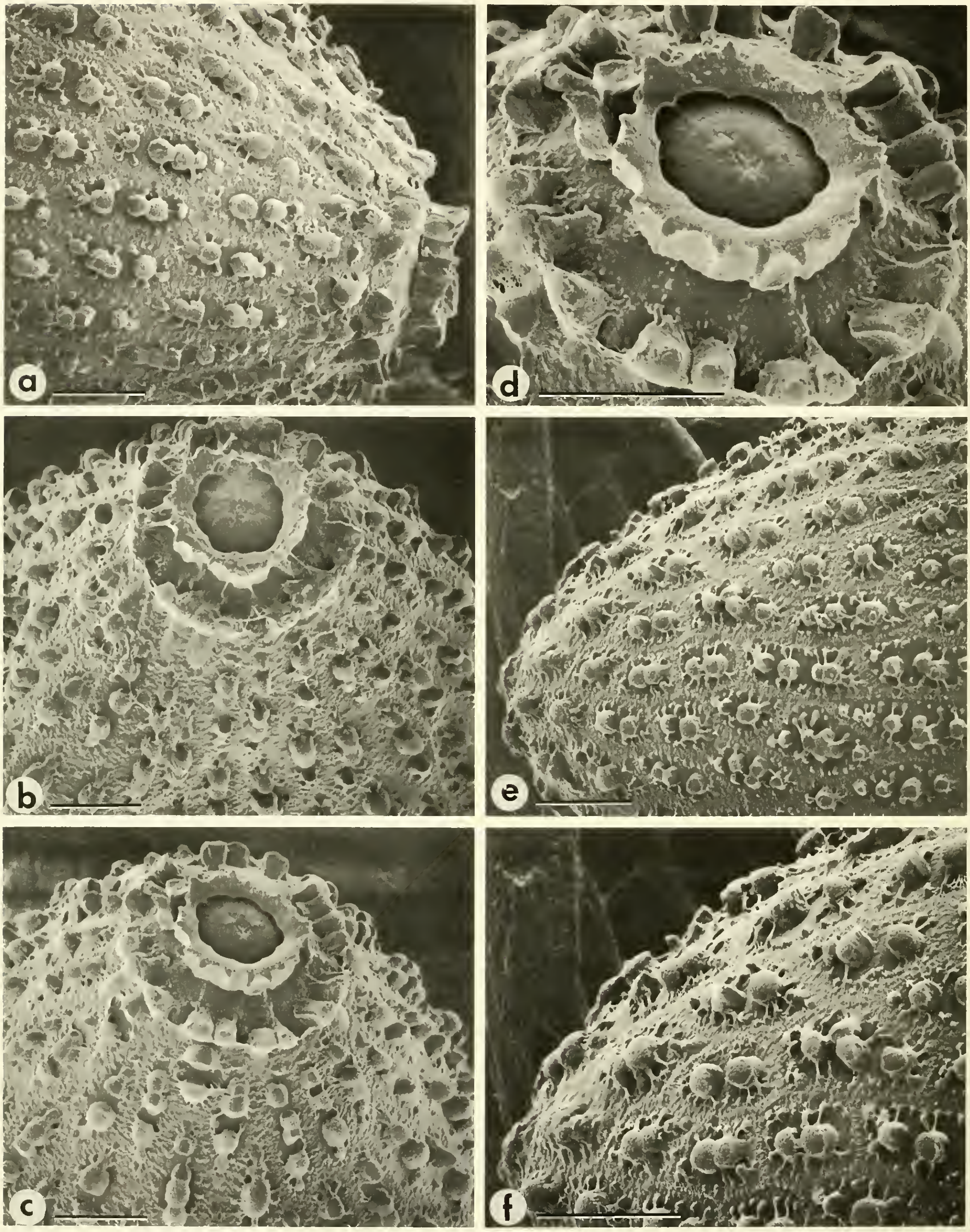


Fig. 6. *Aedes fowleri.* (a) Anterior end, lateral view, ventral surface at top; (b) anterior ring and micropylar apparatus, collar with single gap; (c) anterior ring and micropylar apparatus, collar continuous; (d) detail, micropylar apparatus; (e) posterior end, lateral view, ventral surface at top; (f) posterior end, chorionic cell detail. Scale = 20 μm.

tops blunt, rather square (Fig. 6b, c, d). Micropylar collar prominent, erect or more often outwardly flared (Fig. 6a, c, d), usually continuous (Fig. 6c) but a small gap occasionally present (Fig. 6b), height 5.5–10.0 μm, outer wall fluted, fairly smooth (Fig. 5d). Collar diameter 23–31 μm, anterior wall downwardly sloped towards interior (Fig. 6d), width 2.3–6.5 μm, collar internal diameter 19–22 μm. Micropylar disk 17–19 μm in diameter, edges very indistinct, surface slightly rough, dome only slightly raised, edge very obscure, diameter about 11 μm, micropylar orifice trilobed, diameter 2.5 μm.

Posterior end: chorionic cells smaller, narrower, large and small tubercles fewer (Fig. 6e), large ones contiguous or fused, cell fields obliterated or almost so in most posterior cells (Fig. 6f). Structure of reticulum often indistinct in cells at extreme end of egg, surface appearing smoother (Fig. 6f).

DISCUSSION

Apart from the 2 species of *Aedimorphus* considered here, the eggs of only 2 others in this subgenus appear to have been described. *Aedes vexans* (Meigen) was examined in several earlier studies in which the outer chorion was stripped away before the chorionic cell outlines were recorded either by phase contrast microscopy (Craig and Horsfall 1960, Myers 1967, Kalpage and Brust 1968), or scanning electron microscopy (Horsfall et al. 1970). However, the intact outer chorion, as well as other details of the undamaged egg, have only recently been illustrated (Linley 1990). Reinert (1972) resourcefully extracted 3 eggs of *Aedes domesticus* (Theobald) from the abdomen of a museum specimen and provided a brief description illustrated by good line drawings of the reticular chorionic pattern.

To the extent that any common characteristics can be observed in these eggs, they appear to be as follows. Ventral surfaces are slightly more curved, dorsal surfaces flatter (*Ae. domesticus* may be the exception), this being most pronounced in *Ae. vexans* (Linley 1990), less so in *Ae. fowleri*, and very little in *Ae. dentatus*. Anterior ends tend to be noticeably conical. The chorionic cells are very uniform in structure over the entire egg, and are relatively simple in shape, elongate in the longitudinal axis of the egg, with often sharply narrowed, pointed anterior and posterior corners. *Aedes domesticus* is interesting in that while the cells in about the anterior and posterior 0.25 are greatly elongate longitudinally, those in the middle 0.25 are longer circumferentially, with transitional types grading to the anterior and posterior areas (Reinert 1972). In the structure of the tubercles, *Ae. dentatus* resembles *Ae. vexans*; only the occasional tubercle in a cell is small and the large tubercles are rather irregular in shape, many tending to be rectangular and their bases larger than their tops. *Aedes fowleri* is different in that its cells have many small, peripheral tubercles and the large tubercles are more or less round without expanded bases. No information is available for *Ae. domesticus.* A point of marked difference between species is the anterior end and micropylar apparatus. *Aedes fowleri* possesses a well developed anterior ring, but in *Ae. vexans* it is poorly formed and often incomplete, while in *Ae. dentatus* it is absent (no details of the anterior end have been provided for *Ae. domesticus*). In similar order of development, the micropylar collar in *Ae. fowleri* is very prominent, less so in *Ae. vexans* and very inconspicuous in *Ae. dentatus.*

ACKNOWLEDGMENTS

Our thanks are due to Bonnie Pattock for printing the micrographs, Tom Logan for collecting the *Ae. dentatus* eggs in Kenya, and Kenneth Linthicum for identifying the mosquitoes. This paper is University of Florida, Institute of Food and Agricultural Sciences Experiment Stations Journal Series No. R-02229.

LITERATURE CITED

Craig, G. B., Jr. and W. R. Horsfall. 1960. Eggs of floodwater mosquitoes. VII. Species of *Aedes* common in the southeastern United States (Diptera: Culicidae). Annals of the Entomological Society of America 53: 11–18.

Kalpage, K. S. and R. A. Brust. 1968. Mosquitoes of Manitoba. I. Descriptions and a key to *Aedes* eggs (Diptera: Culicidae). Canadian Journal of Zoology 46: 699–718.

Karabatsos, N. 1985. (Ed.) International Catalog of Arboviruses Including Certain Other Viruses of Vertebrates, ed. 3. American Society of Tropical Medicine and Hygiene, San Antonio, Texas. 1,147 pp.

Knight, K. L. and A. Stone. 1977. A Catalog of the Mosquitoes of the World (Diptera: Culicidae). Entomological Society of America, The Thomas Say Foundation. Vol. VI, 611 pp.

Harbach, R. E. and K. L. Knight. 1980. Taxonomists' Glossary of Mosquito Anatomy. Plexus Publishing Inc., Marlton, New Jersey. 415 pp.

Horsfall, W. R. 1956. A method for making a survey of floodwater mosquitoes. Mosquito News 16: 66–71.

Horsfall, W. R., F. R. Voorhees, and E. W. Cupp. 1970. Eggs of floodwater mosquitoes. XIII. Chorionic sculpturing. Annals of the Entomological Society of America 63: 1709–1716.

Linley, J. R. 1989. Comparative fine structure of the eggs of *Aedes albopictus, Aedes aegypti* and *Aedes bahamensis* (Diptera: Culicidae). Journal of Medical Entomology 26: 510–521.

Linley, J. R. 1990. Scanning electron microscopy of the eggs of *Aedes vexans* and *Aedes infirmatus* (Diptera: Culicidae). Proceedings of the Entomological Society of Washington 92: 685–693.

Linley, J. R., M. J. Geary, and R. C. Russell. 1991. The eggs of *Aedes funereus, Aedes notoscriptus* and *Aedes alternans* (Diptera: Culicidae). Proceedings of the Entomological Society of Washington 93: 592–612.

Meegan, J. M. and C. L. Bailey. 1989. Rift Valley Fever, pp. 51–76. *In* Monath, T. P., ed., The Arboviruses: Epidemiology and Ecology. Vol IV. CRC Press, Boca Raton, Florida.

Myers, C. M. 1967. Identification and descriptions of *Aedes* eggs from California and Nevada (Diptera: Culicidae). Canadian Entomologist 99: 795–807.

Reinert, J. F. 1972. Description of the egg of *Aedes* (*Aedimorphus*) *domesticus* (Theobald) (Diptera: Culicidae). Mosquito Systematics 4: 60–62.

Tomori, O. and A. Fabiyi. 1977. Orungo virus, a new agent from mosquitoes and man in Uganda and Nigeria. Nigerian Medical Journal 7: 5–8.

Turell, M. J., M. E. Faran, M. Cornet, and C. L. Bailey. 1988. Vector competence of Senegalese *Aedes fowleri* (Diptera: Culicidae) for Rift Valley fever virus. Journal of Medical Entomology 25: 262–266.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 17–20

TWO NEW DIXIDAE (DIPTERA) FROM SOUTH KOREA

T. Michael Peters

Department of Entomology, University of Massachusetts, Amherst, Massachusetts 01003.

Abstract.—Two new species, ***Dixa dolichostyla*** and ***Dixa byersi***, are described with illustrations of their distinguishing morphological characteristics. *Dixa longistyla* Takahashi is reported from China and another species, *Dixa obtusa* Takahashi, is reported from South Korea.

Key words: Insecta, Diptera, Dixidae, *Dixa*

The Dixidae of eastern Asia are poorly known. Only the Japanese fauna has been adequately described (Takahashi 1958), a total of 12 species. Aside from these, only *Dixa guttipennis* Thomson has been reported, as well as two new species known only from North Korea (Peters 1992).

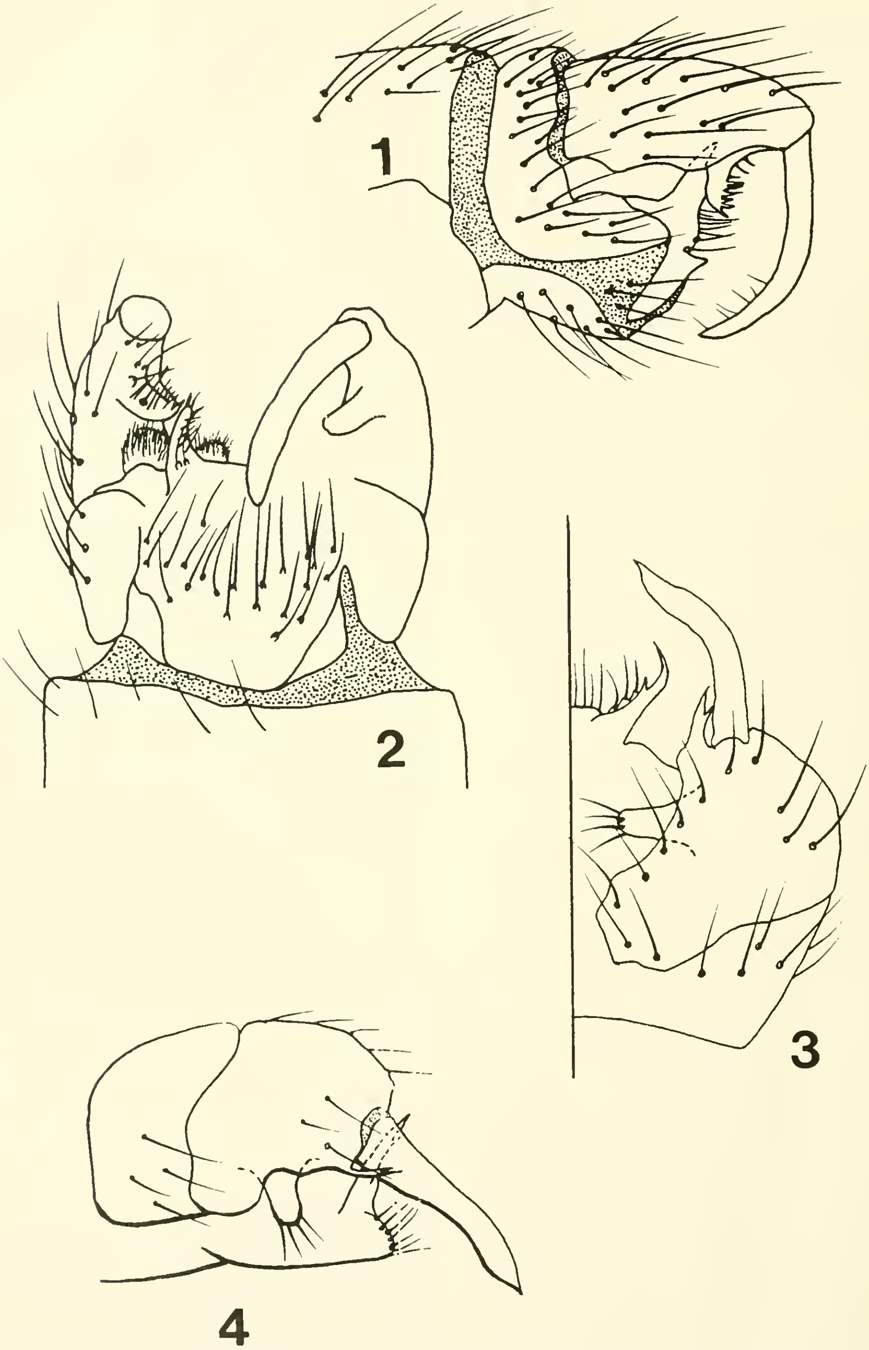
The paucity of dixid specimens from the Korean peninsula seems odd for two reasons. First, a number of medical entomologists from the U.S. were stationed in Korea during the Korean conflict. Second, at that time, dixids were considered by many entomologists to be a subfamily of Culicidae, a family widely studied by entomologists in the military. Therefore, one might expect that fair numbers of dixids exist in one or more major U.S. repositories.

The U.S. National Museum has only one dixid specimen from South Korea, identified by me as *Dixa obtusa* Takahashi. I discussed my frustrations in locating more Korean dixids with George W. Byers at the first dipterists' conference in Florida. He said he had been stationed in Korea while he was in the military and would check through his Korean material for dixids. Not long afterwards, I received a loan from the Snow Museum initiated by George Byers. It consisted of two previously undescribed dixid species, the subject of this paper.

Dixa dolichostyla Peters, New Species

Figs. 1–2

Adult.—*Head:* dark brown; antenna $2.3^{+}\times$ length of thorax, first flagellomere cylindrical, slightly fusiform, width: length 1:8. *Thorax:* Uniformly dark brown in type, without distinct vittae, but in paratype three dark brown vittae with pruinose areas between on scutum; anterior pronotum with 2 setae subequal to width of sclerite; scutellum with transverse row of 7 setae, with two setae in longitudinal line behind central one. *Wing:* With slight pigmentation around base of R 2+3, length of wing blade 3.45–3.6 mm (♂); Sc joins C basad to fork of Rs, m-cu broken; A_1 faintly distinguishable; few widely spaced macrotrichia on M basad of r-m; R_{2+3}:R_3 as 1:1.21–1.25; M_{3+4}:M_{1+2} as 1:1.57–1.62; M_{3+4}:Mst as 1:1.29–1.62. *Halter:* Hyaline. *Legs:* Distal spiniform seta on tarsomeres 3 and 4 of foreleg, on 1–4 of middle and hind leg; weak basal recurved spiniform seta on tarsomere 5 of fore and middle leg, absent on hind leg. Tarsomere 1 of foreleg with one very long seta near base, located about its own length from basal end of tarsomere, 2× length of other leg setae; claws of fore and middle leg long, with 4 long teeth on venter, hind claws much



Figs. 1–4. *Dixa dolichostyla* lateral view (Fig. 1), ventral view (Fig. 2); *Dixa byersi* dorsal view (Fig. 3), lateral view (Fig. 4).

smaller, with few weak hairs; femur : tibia : tarsus length of forelegs as 1:1.18:1.5, middle legs as 1:1.0:1.5, hind legs as 1:1.13:2.0. *Terminalia:* gonocoxite without basal lobe; apical lobe pointed, with spines on posterior margin; gonostylus simple, curved, elongate; tergite 10 with heavily sclerotized nonsegmented cerci; ejaculatory duct short, heavily sclerotized; as in Figs. 1–2.

Specimens examined.—Holotype, off Hwy. #20, 8 mi SW of Kangnung, So. Korea. 128°47′E, 37°42′N, 1925′ elevation. Collected by George W. Byers on 8 June 1954. One male paratype from Central National Forest, 18 mi NE of Seoul, So. Korea. Collected at 400–500′ elevation on 29 May 1954 by George W. Byers. Deposited in the University of Michigan Zoology Museum, Division of Entomology.

Dixa byersi Peters, New Species
Figs. 3–4

Adult.—*Head:* dark brown; flagellum missing. *Thorax:* distinct dark brown vittae on scutum, pruinose and yellowish-brown between; anterior pronotum dark brown, with 5 short setae; dark-brown posterior pronotum with a short seta on upper mesal area; pre-episternum with 3 setae; scutellum with transverse row of eleven setae, ½ as long as width of halter pedicel. *Wing:* without pigmentation; length of wing blade 2.7 mm (♂); Sc joins C basad to fork of Rs, m-cu incomplete, but not broken in middle as in most other species with broken m-cu, with portion of m-cu from Cu1 solid, that from M is missing; M in basal radial cell with macrotrichia on distal ⅔; R_{2+3}:R_3 as 1:1.75; M_{3+4}:M_{1+2} as 1:1.55; M_{3+4}:Mst as 1:1.91. *Legs:* Only tarsomere 1 of pro- and mesothoracic legs present, without distal spiniform setae; all other tarsomeres missing. Femur: tibia length of foreleg as 1:1.14, of midleg as 1:1.0, of hind leg as 1:1.06. *Terminalia:* basal lobe of gonocoxite large, rounded, with 4 prominent apical setae; apical lobe smaller than basal lobe, slender, sharply pointed apically, with another subapical spinose projection; gonostylus without setae, curved, sharply pointed apically; tergite 10 with prominent unsegmented cerci, spinose on posterior margin; ejaculatory duct sclerotized, very long, severely twisted in middle; as in Figs. 3–4.

Specimens examined.—Holotype, 18 miles NE of Seoul, South Korea, in the Central National Forest. Collected by George W. Byers on 14 August 1954 at 400′–500′ elevation. Deposited in the University of Michigan Zoology Museum, Division of Entomology.

I take pleasure in naming this species after George Byers to honor his dedication to entomology, taxonomy and the Nematocerous Diptera.

The 2 species described above increase the number of dixid species collected on the East Asian mainland to 7. Two species previously known only from Japan have been collected on the mainland: *Dixa obtusa* Takahashi in South Korea and *Dixa longistyla* Takahashi in China. *Dixa guttipennis* Thomson is known only from China. Two other species, *Dixa orientalae* Peters and *Dixella corensis* Peters, have only been collected in North Korea.

Some readers may question my placement of *D. byersi* in the genus *Dixa*, since the antennal flagella are missing. Most keys to adult Dixidae rely heavily on antennal characters to determine genus, with some others split out by venational differences. Thus, *Neodixa* Tonnoir and *Nothodixa* Edwards are separable from the other genera by venational differences (unbranched R_{2+3} in the former, r-m basal to fork of Rs in the latter). This leaves *Dixa* Meigen, *Meringodixa* Nowell, *Paleodixa* Contini, *Mesodixa* Belkin and *Dixella* Dyar and Shannon. Of these, *Dixella* Dyar and Shannon is without pre-epistermal setae, and *Meringodixa* Nowell, *Mesodixa* Belkin, and *Paleodixa* Contini lack a basal lobe on the gonocoxite. For these reasons, and because of a lack of associated larvae, *D. byersi* is placed in the genus *Dixa* Dyar and Shannon.

The two species described herein may be distinguished from the 4 other "meniscus midges" (Disney, 1975) of the genus *Dixa* known from the Asian palearctic mainland by the following: *Dixa guttipennis* Thomson is the only species with elaborately patterned wings, *Dixa longistyla* Takahashi is the only known species with a group of 3 long setae on tarsomere one of the foreleg, *Dixa orientalae* Peters is the only species with a basal spiniform seta on tarsomere 3 of the middle leg, and *Dixella obtusa* Takahashi is the only species with a distinct swelling in the middle of flagellomere 1.

Literature Cited

Disney, R. H. L. 1975. A Key to the Larvae, Pupae and Adults of the British Dixidae (Diptera). The Meniscus Midges. Freshwater Biology Association Sci. Publ. No. 31. 78 pp.

Peters, T. M. 1992. Two new Dixidae (Diptera) from North Korea. Proceedings of the Entomological Society of Washington 94: 157–161.

Rozkosny, R. 1990. Family Dixidae, pp. 66–77. *In* Soos, A. and L. Papp, eds., Catalog of Palaearctic Diptera. Vol. 7. Elsevier, N.Y.

Takahashi, M. 1958. Revision of Japanese Dixidae. Mushi 32:1–18 with 6 plates.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 21–47

A REVISION OF THE SHORE-FLY GENERA *HOSTIS* CRESSON AND *PARATISSA* COQUILLETT (DIPTERA: EPHYDRIDAE)

WAYNE N. MATHIS

Department of Entomology, NHB 169, Smithsonian Institution, Washington, D.C. 20560.

Abstract.—The shore-fly genera *Hostis* Cresson and *Paratissa* Coquillett are revised. These genera, now placed in the tribe Psilopini, are sister groups to each other. *Hostis,* which is monotypic, occurs on maritime beaches of the Pacific and Indian oceans. *Acanthonotiphila scotti* Séguy is a junior synonym of *Hostis guamensis* Cresson. *Paratissa,* comprising four species, includes ***P. neotropica,*** which is newly described (type locality: Belize. Stann Creek District: Carrie Bow Cay); also, *P. coriacea* (Lamb), *P. semilutea* (Loew), and *P. pollinosa* (Williston). The latter three species had been considered to be conspecific but are here shown to be valid species.

Key Words: Diptera, Ephydridae, shore flies, *Hostis, Paratissa,* phylogeny

With three notable exceptions (*Hydrellia* Robineau-Desvoidy with 206 species, *Notiphila* Fallén with 147 species, and *Scatella* Robineau-Desvoidy with 141 species), no genera of shore flies presently include more than 100 species. Far more genera, to the contrary, are monotypic or have just a few species (nearly 45 genera, representing over one-third of all known shore-fly genera, have three or fewer species). Two genera in the latter category are *Hostis* Cresson and *Paratissa* Coquillett, the subjects of this revision. These two genera are also linked in more significant ways of which the most important from a phylogenetic standpoint is their relationship as sister groups in the tribe Psilopini (see discussion of character evidence below). They also occur exclusively on maritime beaches, usually associated with the strand line, throughout much of the tropical and subtropical regions of the world. An exception is the west coast of the Western Hemisphere where no species of these genera are known to occur.

The purpose of this paper is to present a revision of these two genera. Species of both genera are being treated in faunal studies that I am conducting on shore flies of the Caribbean and the Republic of Seychelles. These faunal studies prompted this study, which is needed to ensure accurate determinations of the included species. Other objectives of this study are to further unravel the phylogenetic relationships of these taxa and to utilize characters from the male terminalia, which have never been described or illustrated previously.

Little is known about the natural history of either genus, especially their immature stages. Adults, and probably the eggs, larvae, and puparia, occur on maritime beaches, nearly always in association with debris at the strand line. Accumulated seaweed and other organic material at the high tide mark seem to be the preferred habitat, and at times the adults occur there in great abundance, frequently in association with members of the family Tethinidae.

The paucity of information and research on these genera makes their published history relatively simple. Thus, previous work on their systematics, especially phylogenetic studies, is relatively brief, straightforward, and is summarized in the following paragraphs.

Coquillett (1900) described *Paratissa* in the twilight of the 19th century and selected *Drosophila pollinosa* Williston as the type species. Until then, this species had been treated in the genus *Drosophila,* although in the original description, Williston (1896: 414) noted that this species was probably an ephydrid. Williston preferred describing *pollinosa* in *Drosophila,* however, because some of its characters would ". . . lead one to search for the species in this genus." Coquillett's precedent of considering this species as an ephydrid was followed by virtually all subsequent workers, although neither Coquillett nor any predecessor verified the identity of Williston's species by actual study of Williston's primary types. The specimens Williston studied were collected on St. Vincent by H. H. Smith while the latter was in the employ of the West Indian Committee, which was established in part to investigate the "Flora and Fauna of the West Indies" (Williston 1896: 253). In 1923, Sturtevant reported that the primary types of this species were apparently lost. With the exception of Sturtevant and Wheeler (1954), who reviewed *Paratissa* as part of a synoptic study of North American Ephydridae, no substantive paper was published on this genus between 1923 and 1965. Wirth (1965: 740), in the most recent catalog of North American shore flies, listed *D. pollinosa* as a junior synonym of *Cacoxenus semiluteus* Loew, a species first described in the family Drosophilidae and also based on specimens from the Caribbean (Cuba). Wirth studied many of Loew's primary types at the Museum of Comparative Zoology (Cambridge, Massachusetts) and noted, evidently, that Loew's species is an ephydrid and further, that it is very similar externally to, and is probably conspecific with, *D. pollinosa.* Some years later, Mathis (1977) suggested that *Paratissa* is related to a few genera in the tribe Psilopini, and Cogan (1980: 658) listed one additional junior synonym of *P. semilutea, Acanthonotiphila coriacea* Lamb (1912: 316), the first species of this group to be recognized as an ephydrid when it was initially described. Lamb described a separate genus for his species, however. Cogan, who had ready access to Lamb's primary types, was correct in listing *Acanthonotiphila* as a junior synonym of *Paratissa,* even though the former was described from specimens collected on the Seychelles, several thousands of kilometers from the Caribbean. In the same paper, Cogan also listed *Acanthonotiphila scotti* Séguy (1955), which was described from specimens collected on Tromélin, as a congener but with status as a valid species. These are the primary workers and papers that have dealt with the systematics of *Paratissa.* A few papers reported the occurrence of *P. pollinosa* on the Hawaiian Islands, although in each case the species was misidentified (Adachi 1952, Hardy 1952, as *Hostis guamensis* Cresson; Tenorio 1980, as *P. semilutea*) and of *P. pollinosa* from islands of the Pitcairn Group and Hawaii (Mathis 1989a, b).

Hostis has a more abbreviated history than *Paratissa.* Cresson (1945) described *Hostis* as a monotypic genus with *H. guamensis* as its type species. Cogan and Wirth (1977) listed the genus and species in their catalog of Oriental shore flies, Mathis (1977) suggested that *Hostis* is closely related to *Paratissa,* and more recently Mathis (1989a) reported the occurrence of the genus on several islands of Oceania and on beaches of Australia and the Seychelles (Mahé). Aside from these listings, the genus and species have not appeared in the literature except as a misidentified species of *Paratissa* (Adachi 1952, Hardy 1952).

Methods.—The descriptive terminology, with the exceptions noted in Mathis (1986), follows that published in the *Manual of Nearctic Diptera* (McAlpine 1981). The descriptions of species are composite, not based solely on the holotypes. Two venational ratios are used commonly in the descriptions and are defined here (all ratios are averages of three specimens):

1. Costal Vein Ratio: the straight line distance between the apices of R_{2+3} and R_{4+5}/distance between the apices of R_1 and R_{2+3}.
2. M Vein Ratio: the straight line distance along M between crossvein dm-cu and r-m/distance apicad of crossvein dm-cu.

The phylogenetic analysis was performed with the assistance of Hennig86 (copyrighted), a computerized algorithm that produces cladograms on the basis of parsimony. Before performing the analysis, the character data were arranged in transformation series and then polarized primarily using outgroup procedures.

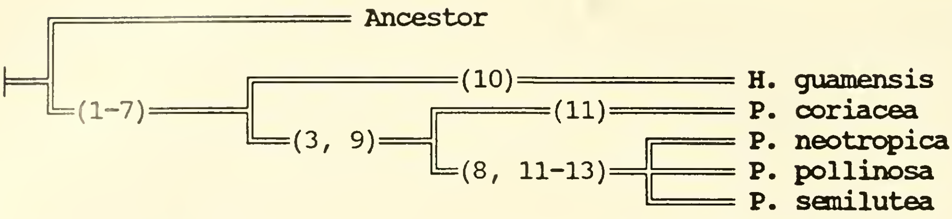
Terminology for structures of the male terminalia is provided directly on the first illustration of these structures (Figs. 14–18, *Hostis guamensis*). It is not repeated for comparable illustrations of the remaining species.

Most specimens for this study are in the National Museum of Natural History, and deposition for these, unless part of divided series, is not indicated in the text. Numerous others were borrowed, particularly type specimens of species described previously. The institutions from which these were borrowed and the acronyms used in the text are as follows:

BMNH	The Natural History Museum, formerly the British Museum (Natural History), London, England (Brian Pitkin)
BBM	Bernice P. Bishop Museum, Honolulu, Hawaii (N. L. Evenhuis)
CNC	Canadian National Collection, Ottawa, Canada (J. R. Vockeroth)
MCZ	Museum of Comparative Zoology, Harvard, University, Cambridge, Massachusetts (David Furth)
MNHN	Muséum National d'Histoire Naturelle, Paris, France (Loïc Matile)
TAU	Tel Aviv University, Tel Aviv, Israel (Amnon Freidberg)
USNM	National Museum of Natural History, formerly the United States National Museum, Smithsonian Institution, Washington, D.C.

Systematics

Before proceeding with the descriptive treatment of *Paratissa* and *Hostis,* a few remarks are needed to explain the tribal assignment and phylogenetic relationships of these two genera and their included species within the tribe Psilopini. Most authors (Cresson 1945, Sturtevant and Wheeler 1954, Wirth 1965, 1968, Cogan 1980, Cogan and Wirth 1977) assigned *Paratissa* and *Hostis* to the tribe Discocerinini Cresson. With recharacterization of that tribe on the basis of synapomorphies and its establishment as a monophyletic lineage (Mathis 1977, Mathis and Zuyin 1989), *Paratissa* and related genera were excluded and placed in Psilopini (Mathis 1977, 1989a). Psilopini was recently divided (Zatwarnicki 1992) into two tribes, with *Paratissa* and related genera being placed in the tribe Discomyzini. Within Discomyzini, *Paratissa* and *Hostis* are apparently related to genera that (1) have one to five setulae (usually 3–4) inserted on vein R_{2+3} basad of crossvein r-m and (2) have well-developed pseudopostocellar setae (sometimes inserted within the ocellar triangle but usually behind and with orientation variable). Frequently there is also a moderately to well-developed supra-alar seta, a character that is probably a symplesiomorphy, however. Other genera, in addition to *Paratissa* and *Hostis,* that are included in this group are: *Actocetor* Becker, *Clanoneurum* Becker, *Clasiopella* Hendel, *Discomyza* Meigen, *Eremomusca* Mathis,



tree length 16; consistency index 100; retention index 100

Character	1	2	3	4	5	6	7	8	9	10	11	12	13
Steps	1	1	2	1	1	1	1	2	1	1	2	1	1

Fig. 1. Cladogram depicting hypothetical phylogenetic relationships among species of the genera *Hostis* and *Paratissa* (an analysis of the cladogram and characters is also provided).

Guttipsilopa Wirth, *Helaeomyia* Cresson, *Mimapsilopa* Cresson, *Rhysophora* Cresson, and *Trypetomima* de Meijere.

Within this assemblage of genera, *Paratissa* and *Hostis* are sister taxa (Fig. 1; numbers for characters correspond with those used in the text) based on the following synapomorphies (Table 1) that establish this relationship and their monophyly (plesiomorphic condition indicated by 0, relative apomorphic condition(s) indicated by a 1 or 2):

1. Number of dorsal aristal branches: 0) 6–10 or more; 1) few, usually 3–4, occasionally with a much reduced 5th.

2. Orientation of pseudopostocellar setae: 0) lateroclinate, in the same plane of the vertex (weakly developed); 1) proclinate and only slightly divergent, sometimes almost parallel (strongly developed).

3. Number and orientation of fronto-orbital setae: 0) usually 2, a proclinate seta and larger reclinate seta. Occasionally there is a second proclinate seta that is smaller than the first and which is inserted in front of or behind the first. 1) 3 setae (anterior seta proclinate, 2nd reclinate, 3rd proclinate; *Hostis*); or 2) 4 (anterior 2 setae proclinate, 3rd lateroclinate, 4th lateroreclinate; *Paratissa*).

Table 1. Matrix of characters and taxa used in the phylogenetic analysis (numbers for characters correspond with those used in the text).

Character Matrix

Taxa	Characters		
	12345	67890	123
Ancestor	00000	00000	000
H. guamensis	11111	11101	000
P. coriacea	11211	11110	100
P. neotropica	11211	11210	211
P. pollinosa	11211	11210	211
P. semilutea	11211	11210	211

4. Placement of 2 large facial setae: 0) frequently 1 to several setae, usually 2, but at least one of these setae is usually inserted near the mid-height of the face; 1) inserted toward lateroventral margin of face and relatively close together (distance between them subequal to that between posterior ocelli).

5. Strength of supra-alar seta: 0) the supra-alar seta well developed, subequal to length of postalar seta; 1) evident but not strongly developed. This seta is only slightly larger than the surrounding setulae and considerably less developed than the postalar, posterior dorsocentral, and prescutellar acrostichal setae.

6. Presence or absence of setulae on vein R_{2+3} basad of crossvein r-m: 0) vein usually bare of setulae; 1) bearing 3–4 black setulae on dorsal surface. This character, as noted previously, is shared by *Hostis* and *Paratissa* and a few other genera of Psilopini.

7. Shape and arrangement of setulae on middle femur of male: 0) as in female, lacking a ridge that bears distinctive setulae; 1) bearing a row of closely set, peg-like setae,

sometimes curved toward apex, that are inserted on a distinct ridge along the apical ¼ to ⅓ of posteroventral surface.

8. Coloration of legs: 0) dark colored, blackish brown to black, essentially concolorous with pleural areas or abdomen; 1) legs pale, much lighter than coloration of pleural area or abdomen.

9. Presence of intrafrontal setae: 0) usually lacking, as in *Hostis*; 1) present, as in species of *Paratissa*; 1 pair, inserted anterior of ocellar setae.

10. Coloration of maxillary palpus: 0) yellow, as in *Paratissa*; 1) brown, as in *Hostis.*

11. Shape of postgonite: 0) short, only slightly longer than wide, as in *Hostis*; 1) a single long process, as in *Paratissa coriacea*; 2) postgonite with 2 processes, an anterior one that is long, slender, and curved medioposteriorly, and a posterior one that is short and finger-like.

12. Shape of the surstylus: 0) roughly rectangular; 1) roughly triangular and with short prongs or processes.

13. Shape of aedeagus: 0) gradually tapered on apical half, relatively bluntly rounded from a dorsal view; 1) apical half a very narrow, parallel sided process from a dorsal view.

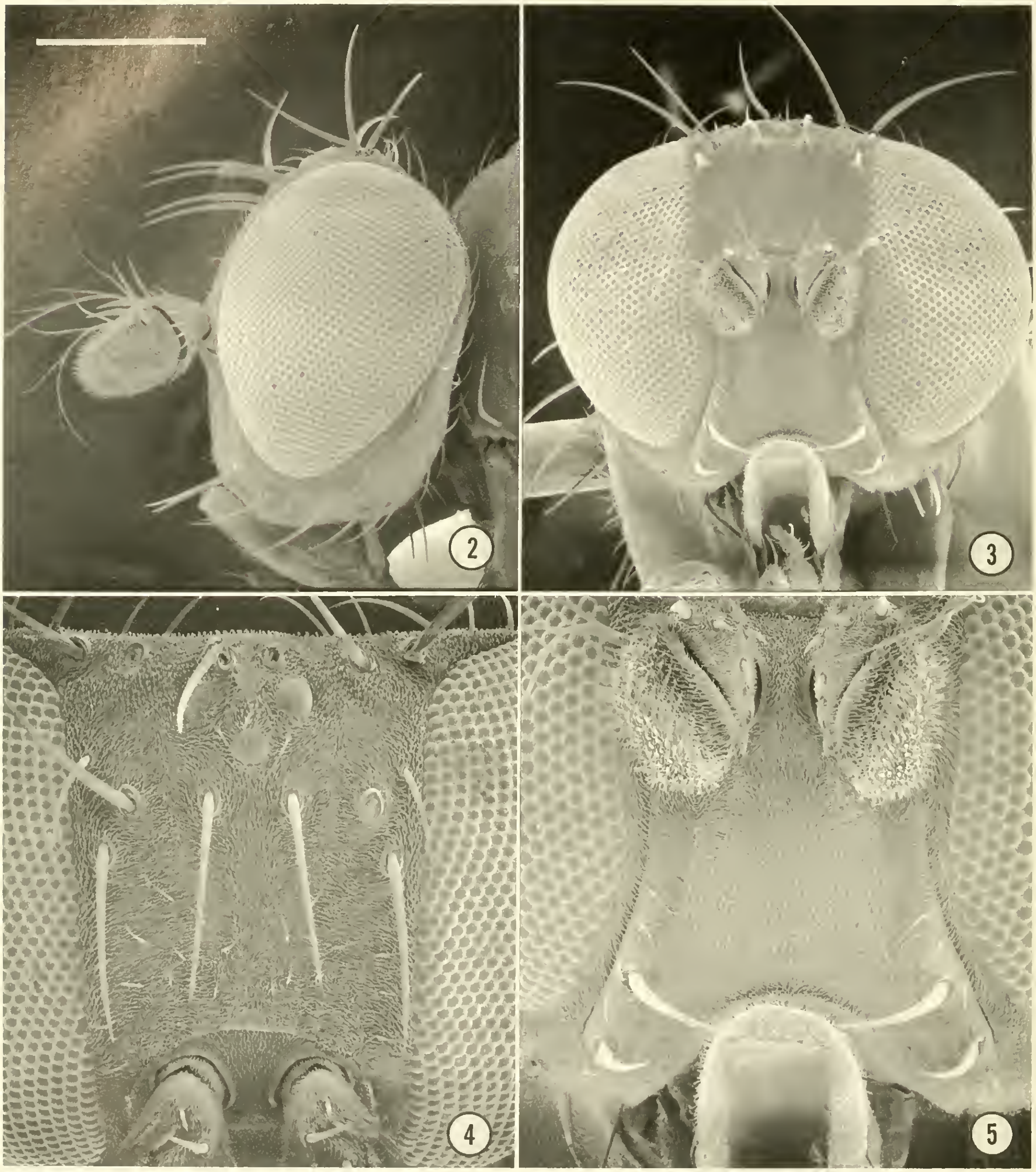
Paratissa and *Hostis* may be distinguished from each other by differences in characters 3, 9, 10, and 11. These characters are also synapomorphies that establish the monophyly of *Paratissa* (characters 3, 9, and 11) and *Hostis* (character 10).

Although the relationships among the four species of *Paratissa* are not fully resolved (there is one trichotomy), the characters considered in this study, all morphological and primarily from the male terminalia, indicate the following relationships (Fig. 1). The basal lineage and sister group to the remaining species of the genus comprise a single species, *P. coriacea.* This species is most similar to the outgroup, *Hostis guamensis,* especially the dark colored legs (character 8) and shape of the surstylus (character 12) and aedeagus (character 13). The surstylus is roughly rectangular, as in *H. guamensis.* Furthermore, the postgonite (character 11) of *P. coriacea,* although long and slender, does not bear a posterior, shorter prong, as in the other three species (*P. neotropica, P. pollinosa,* and *P. semilutea*). The other three species, all from the Western Hemisphere and a few islands in the Pacific, have a surstylus (character 12) that is more or less triangular with distinct prongs, and the gonite is two pronged, with the anterior prong much longer (its basal portion setulose and the apical portion nearly parallel sided and curved medially and then posteriorly). The posterior gonal process is shorter, straight, and finger-like. In addition, the aedeagus (character 13) from a dorsal view has the apical half very narrow and essentially parallel sided.

Genus *Hostis* Cresson

Hostis Cresson, 1945: 64. Type species: *Hostis guamensis* Cresson, 1945, by original designation.—Cogan and Wirth, 1977: 327 [Oriental catalog].—Mathis, 1989a: 6434 [Australasian/oceanian catalog].

Diagnosis.—Specimens of *Hostis* are similar to those of *Paratissa* and related genera but are distinguished by the following combination of characters: *Head.* Fronto-orbital setae 3 (anterior seta proclinate, 2nd reclinate, 3rd proclinate); intrafrontal setae lacking; dorsal aristal hairs 3–5 (if a 5th is present it is greatly reduced), usually 4; pseudopostocellar setae proclinate and only slightly divergent; facial setae 2, both well developed, ventral seta slightly smaller, both inserted toward ventrolateral corner of face and relatively close together, distance between about equal to that between posterior ocelli. Palpus brown. *Thorax.* Supra-alar seta 1, only moderately well developed, shorter than postalar seta; prescutellar acrostichal setae well separated; wing uniformly hyaline or very lightly infumate; vein R_{2+3} basad of crossvein r-m bearing 3–4 black setulae on dorsal surface; alula normally developed. *Abdomen.* 5th tergite bearing 4–6 erect setae



Figs. 2–5. Scanning electron micrographs of *Hostis guamensis* (scale length in parenthesis; bar scale for all photographs = Fig. 2). 2, Head, lateral view (0.27 mm). 3, Same, anterior view (0.27 mm). 4, Frons, anterodorsal view (150 μm). 5, Face, anterior view (136 μm).

along posterior margin on each side; 2nd sternite of male with a membranous circular area on anterior ⅓. Male terminalia as follows: surstylus more or less rectangular; gonite divided, pregonite small, situated between base of hypandrium and postgonite; postgonite only slightly longer than wide, length about equal to that of cercus and not with a second, more posterior process.

Hostis guamensis Cresson
Figs. 2–19

Hostis guamensis Cresson, 1945: 64.—Cogan and Wirth, 1977: 327 [Oriental catalog].—Mathis, 1989a: 643 [Australasian/oceanian catalog].

Acanthonotiphila scotti Séguy, 1955: 11. **New Synonym.**

Paratissa scotti.—Cogan, 1980: 658 [generic combination].

Description.—Small to moderately small shore flies, body length 1.75 to 2.80 mm.

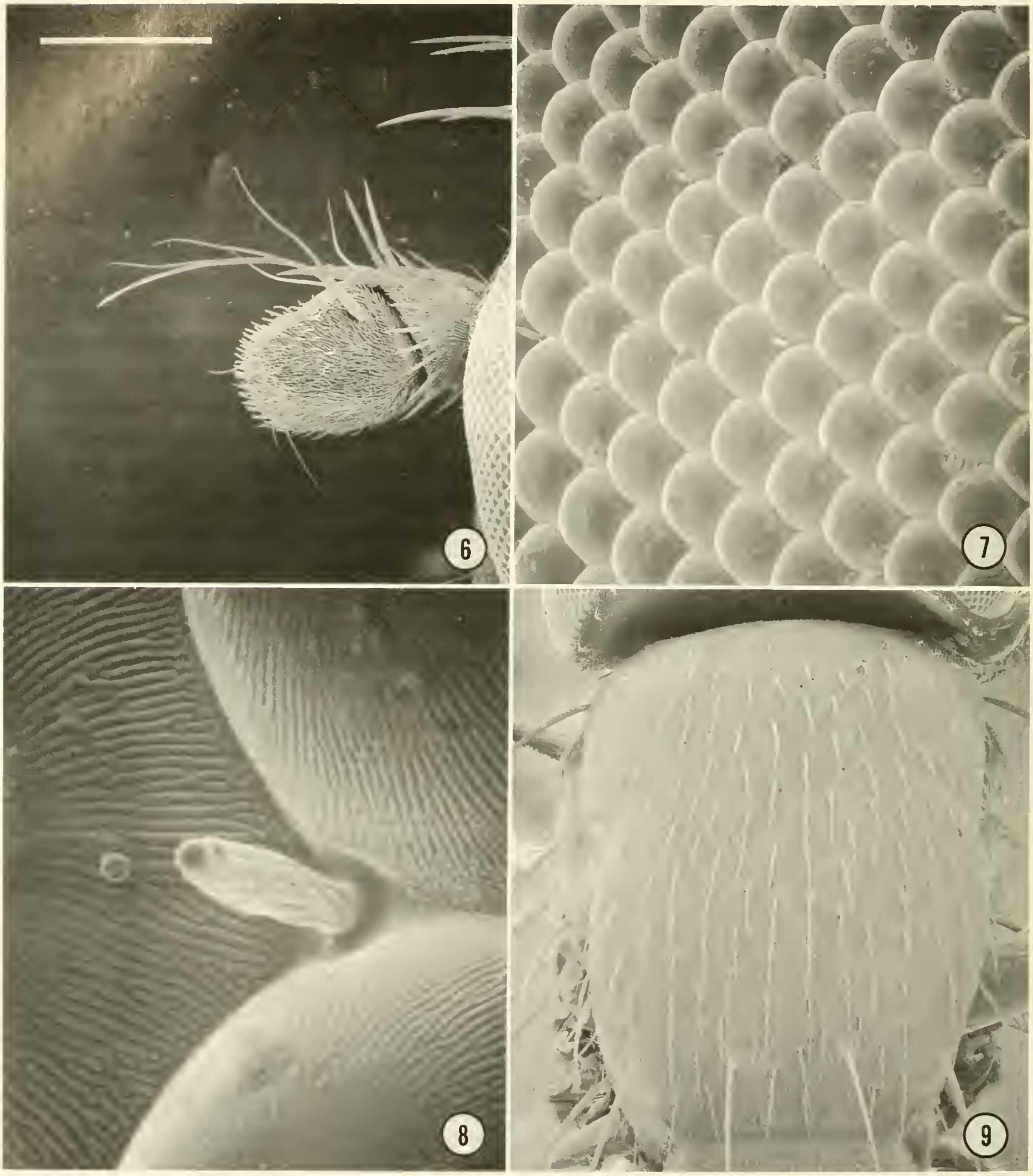
Head (Figs. 2–8): Frons (Figs. 3–4) mostly gray, with some brownish coloration laterad of lateral ocelli near vertex, and lower fronto-orbits silvery gray; 2 proclinate fronto-orbital setae, posterior seta smaller; reclinate seta well developed, inserted medial to proclinate setae and at level between proclinate setae; ocellar setae inserted laterad and in front of anterior ocellus; pseudopostocellar setae proclinate, at most very slightly divergent. Antenna (Fig. 6) with scape and pedicel yellow; flagellomere 1 mostly yellow but darkened apically; arista with 4, occasionally 5 dorsal rays. Face (Figs. 3, 5) gray, slightly lighter than frons; facial shape nearly flat, with very shallow, rounded vertical carina, ventral margin emarginate; facial setae 2, these inserted on ventral ⅓ of face and close together, distance between about equal to that between posterior ocelli, ventral seta slightly smaller; clypeus black with moderately densely microtomentose; palpus brown.

Thorax (Figs. 9–12): Bicolored, mesonotum (Figs. 9–10) densely microtomentose, gray, pleural area blackish brown. Wing mostly hyaline or very slightly infumate; costal vein ratio 0.75; M vein ratio 0.78. Legs generally dark colored, blackish brown to black, concolorous with pleural coloration, tarsi of middle and hind legs extensively yellowish; middle femur with row of 6–8 closely set setae on a raised, arched ridge along posteroventral surface.

Abdomen (Figs. 13–18): First sternite bare, wider than long; 2nd sternite with an unsclerotized circular area on anterior ⅓; 3rd and 4th sternites very slightly and gradually enlarged posteriorly, posterior margin rounded, setulae larger laterally and on posterior ⅓; 5th sternite distinctly but gradually becoming wider posteriorly, posterior margin truncate to slightly concave. Male terminalia (Figs. 14–18) as follows: epandrium (Figs. 14–15), in lateral view, enlarged ventrally, broadly rounded, in posterior view, widest at level of dorsal margin of cercus; cercus (Figs. 14–15) well sclerotized, roughly bacilliform, pointed dorsomedially; surstylus (Figs. 14–17), in posterior view, with median margin slightly concave, setulose, laterally rounded and bare, connected with opposite surstylus by partially sclerotized ventral margin of cercal area that has a narrow and short gap at middle, in lateral view as a subrectangular process, ventral margin rounded; gonite divided, pregonite much smaller, between base of hypandrium and postgonite, with a ventrally directed short process that bears 1–2 setulae; postgonite (Figs. 15–16) as long as cercus, wider basally, bearing numerous small setulae, especially on anterior half, joined with postgonite on opposite side with an arched bridge above aedeagus; aedeagus (Figs. 16, 18), in lateral view, boot shaped, in posterodorsal view, narrowly triangular; aedeagal apodeme (Fig. 16) triangular in lateral view, with a short process anterodorsally; hypandrium (Figs. 15–16) a broad, concave plate.

Type material.—The holotype female of *Hostis guamensis* is labeled "Guam Sumay RGOakley IX-26-1938 [date handwritten]/ China Clipper Ports AlamedaCal.Hon. Midway [handwritten]/Guam No 1327 [number handwritten]/Lot No3818297/ 1265 ICM/Hostis guamensis Cresson HOLOTYPE [handwritten, black submargin]/ recovered from ANSP by CWS [Curtis W. Sabrosky] Dec 1951 [handwritten]/TypeNo 70453 USNM [red, number handwritten]." The holotype is double mounted (pointed), is in good condition, and is deposited in the USNM (70453).

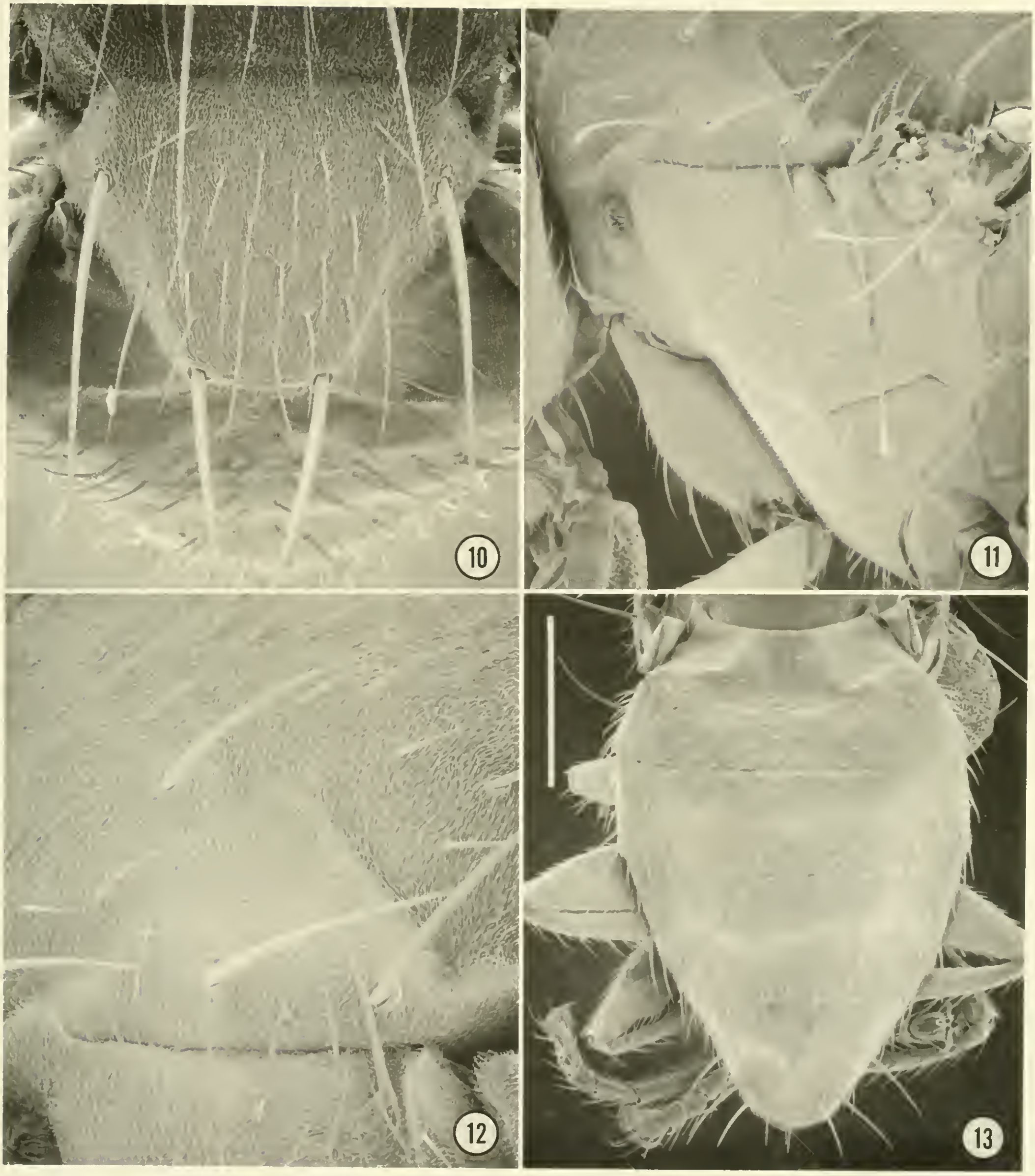
The holotype female of *Acanthonotiphila scotti* is labeled "Ile Tromélin xi[Nov].[19]53 (R.P.) [handwritten]/INSTITUT SCIENI-



Figs. 6–9. Scanning electron micrographs of *Hostis guamensis* (scale length in parenthesis; bar scale for all photographs = Fig. 6). 6, Antenna, lateral view (150 μm). 7, Eye, ommatidia with occasional setulae, lateral view (30 μm). 8, Same, enlargement of setula, lateral view (3.0 μm). 9, Scutum, dorsal view (0.27 mm).

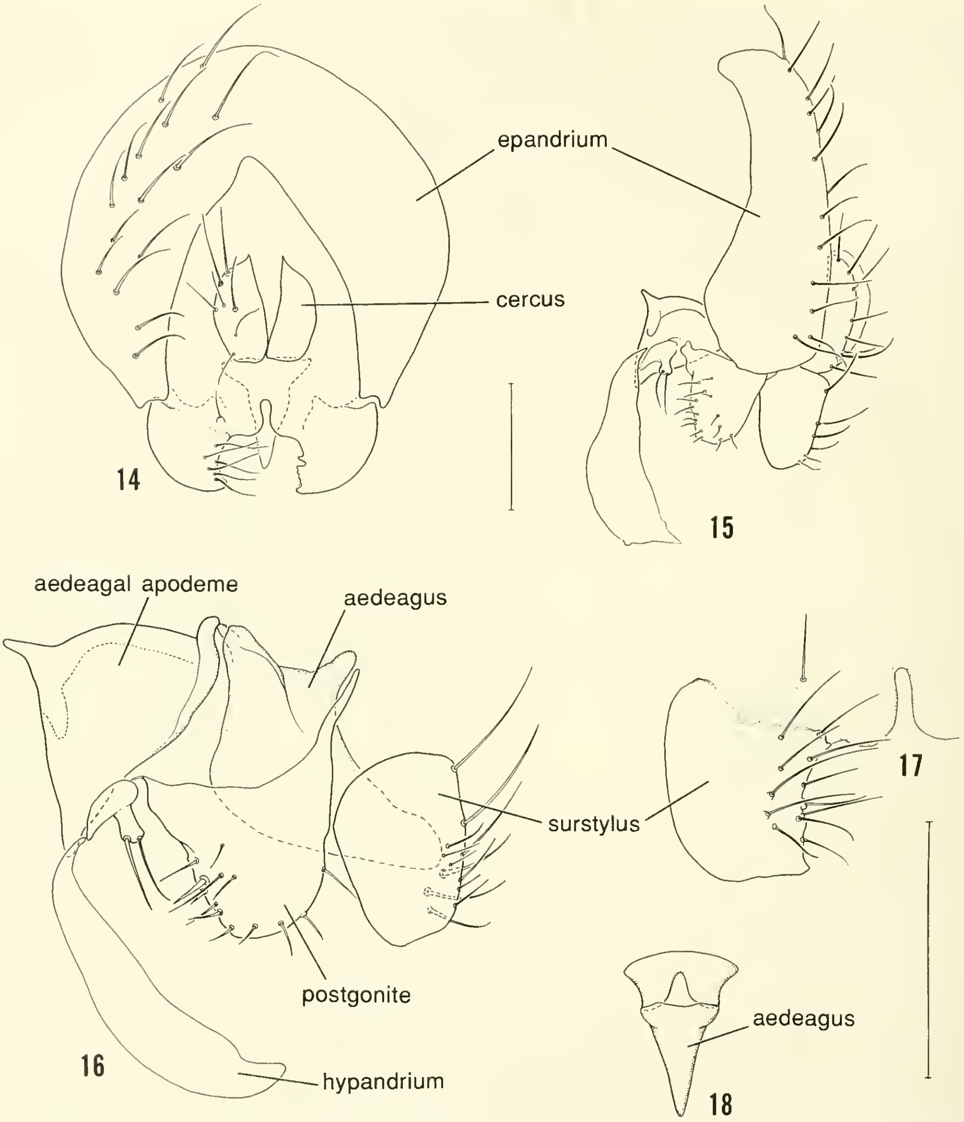
FIQUE MADAGASCAR [light blue]/TYPE [red]/Acanthonotiphila Scotti ♀ TYPE n.sp. 54 E.Séguy vid [handwritten except for "E.Séguy vid"]." The holotype is double mounted (pin in a rectangular block of plastic foam), is in good condition, and is deposited in the MNHN.

Other specimens examined.—Afrotropical. *MADAGASCAR.* Antseranana: Nosy Tanikely, 6 Apr 1991, A. Freidberg, F. Kaplan (8 ♂, 4 ♀; TAU, USNM). *COSMOLEDO.* Manai Island: Station, 26 Mar 1986, W. N. Mathis (1 ♀). Australasian. *AUSTRALIA.* Queensland: Cairns, Ellis Beach,



Figs. 10–13. Scanning electron micrographs of *Hostis guamensis* (scale length in parenthesis; bar scale for all photographs = Fig. 13). 10, Scutellum, dorsal view (176 μm). 11, Pleural area, lateral view (250 μm). 12, Notopleuron, lateral view (120 μm). 13, Abdomen, dorsal view (0.38 mm).

28 Apr 1957, W. W. Wirth (1 ♀). Oceanian. *FIJI.* Taveuni, Feb 1968, J. C. Hitchcock (1 ♀). *FEDERATED STATES OF MICRONESIA.* Kapingamarangi Atoll: Hare Islet, 3 Aug 1946, H. K. Townes (1 ♀). *FRENCH POLYNESIA.* Society Islands: Tahiti, Bain Loti, Apr 1961, J. N. Belkin (1 ♂). *GUAM.* Sumay, R. G. Oakley, 26 Sep 1938 (1 ♀); (at light) 2 Oct 1938, A. Abarge (1 ♀). *HAWAI'I.* Oahu: Honolulu (on planes from the south), 1944 (1 ♂, 6 ♀). Lanihai (on rocks at beach), 29 Dec 1945, W. W. Wirth (1 ♀). *LINE ISLANDS.* Palmyra Atoll: Palmyra, Feb 1948, N. L. H. Krauss (1 ♂). *MAR-*



Figs. 14–18. Male terminalia of *Hostis guamensis*. 14, Epandrium, cerci, and surstylus, posterior view. 15, Epandrium, cerci, surstylus, postgonite, and hypandrium, lateral view. 16, Surstylus, postgonite, aedeagal apodeme, aedeagus, and hypandrium, lateral view. 17, Surstylus, posterior view. 18, Aedeagus, dorsal view. Scales equal 0.1 mm.

SHALL ISLANDS. Eniwetok Atoll: Parry Island, Aug–Sep 1955, M. R. Wheeler (1 ♀). Jaluit Atoll: Jabor Island, 24–30 Apr 1958, J. L. Gressitt (1 ♂, 2 ♀). Kwajalein Atoll, 19 Feb 1958, N. L. H. Krauss (1 ♂); Kwajalein Island, 16 Aug 1946, H. K. Townes (1 ♀). Majuro Atoll: Uliga Island, Aug–Sept 1955, M. R. Wheeler (1 ♀). Rongelap Atoll: Kebelle Island, Aug–Sep 1955, M. R. Wheeler (1 ♂, 1 ♀). *PALAU.* Koror Island, 16 May 1957, C. W. Sabrosky (1 ♀). Ngerkabesand Island (mangrove), 24 Apr 1957, C. W. Sabrosky (1 ♂). Ngurukdabel Island, Ngaremediu (beach), 24 Apr 1957, C. W. Sabrosky (2 ♂). *SAMOA* (*American*). Alega, Tutuila, 22 Feb 1954, C. Hoyt (1 ♀). Ori-

Fig. 19. Distribution map for *Hostis guamensis.*

ental. *PHILIPPINES.* Calicoan Island (ex. Mallow tree), F. F. Bibby (1 ♂).

Distribution (Fig. 19).—Old World. Afrotropical: Aldabra (Cosmoledo), Madagascar, Seychelles, Tromélin. Australasian/oceanian: Australia (QLD). Federated States of Micronesia, Fiji, French Polynesia (Society Islands), Guam, Hawaiian Islands, Line Islands, Marshall Islands, Samoa. Oriental: Philippines.

Remarks.—This species ranges widely throughout the western Pacific and Indian oceans. Because of its widespread distribution, I was initially skeptical that all specimens were conspecific. Careful examination of external characters and those of the male terminalia indicates a single species that is distinguished by the characters noted in the generic diagnosis and illustrations.

Genus *Paratissa* Coquillett

Paratissa Coquillett, 1900: 36. Type species: *Drosophila pollinosa* Williston, 1896, by original designation.—Williston, 1908: 307 [key to genus].—Sturtevant, 1923: 10 [discussion, types apparently lost, identity uncertain].—Sturtevant and Wheeler, 1954: 251 [review, discussion, placed in Discocerinini near *Discocerina*].—Wirth, 1965: 740 [nearctic catalog]; 1968: 9 [neotropical catalog].—Mathis, 1977: 943–944 [discussion, placed in Psilopini near *Hostis*]; 1989a: 643 [Australasian/oceanian catalog].

Acanthonotiphila Lamb, 1912: 316. Type species: *Acanthonotiphila coriacea* Lamb, 1912, by original designation.—Cogan, 1980: 658 [synonymy with *Paratissa*].

Diagnosis.—Species of *Paratissa* are similar to those of *Hostis* and related genera but are distinguished by the following combination of characters: *Head.* Fronto-orbital setae (Fig. 30) 4 (anterior 2 proclinate, 3rd lateroclinate, 4th lateroreclinate); intrafrontal setae 1 pair, inserted anterior of ocellar setae; dorsal aristal hairs 3–4; pseudopostocellar setae proclinate and only slightly divergent; facial setae 2, both inserted ventrally toward lateral corner and relatively close together. *Thorax.* Supra-alar seta 1, moderately well developed, but not as long as postalar seta; prescutellar acrostichal setae well separated; wing uniformly hyaline or lightly infumate; vein R_{2+3} basad of crossvein r-m bearing 3–4 black setulae on dorsal surface; alula normally developed; middle femur of male with a row of closely set setae on a ridge along the apical portion of the posteroventral surface. *Abdomen.* 2nd sternite of male subdivided, anterior portion a narrow, transverse band, ventral portion more or less rectangular, longer than wide, and with anterior margin deeply concave; male terminalia as follows: postgonite long and slender and apical portion curved medioposterioraly; aedeagal apodeme slender, more lunate than distinctly angulate at a right angle; hypandrium longer than wide.

Discussion.—The species of *Paratissa* are very similar externally, and so far as I can determine, those from the Western Hemisphere lack any distinguishing characters except for structures of the male terminalia. Probably for this reason most previous workers confused these species, which were usually thought to comprise just one very widespread species, *P. semilutea.* Characters of the male terminalia indicate otherwise, however, and these characters are the primary bases for recognition of the various species. Only characters of the male terminalia have been found to distinguish the few known species. Thus, I have not included a key but refer readers to the figures of these structures and to the remarks sections that accompany each species' description.

Paratissa coriacea (Lamb)
Figs. 20–26

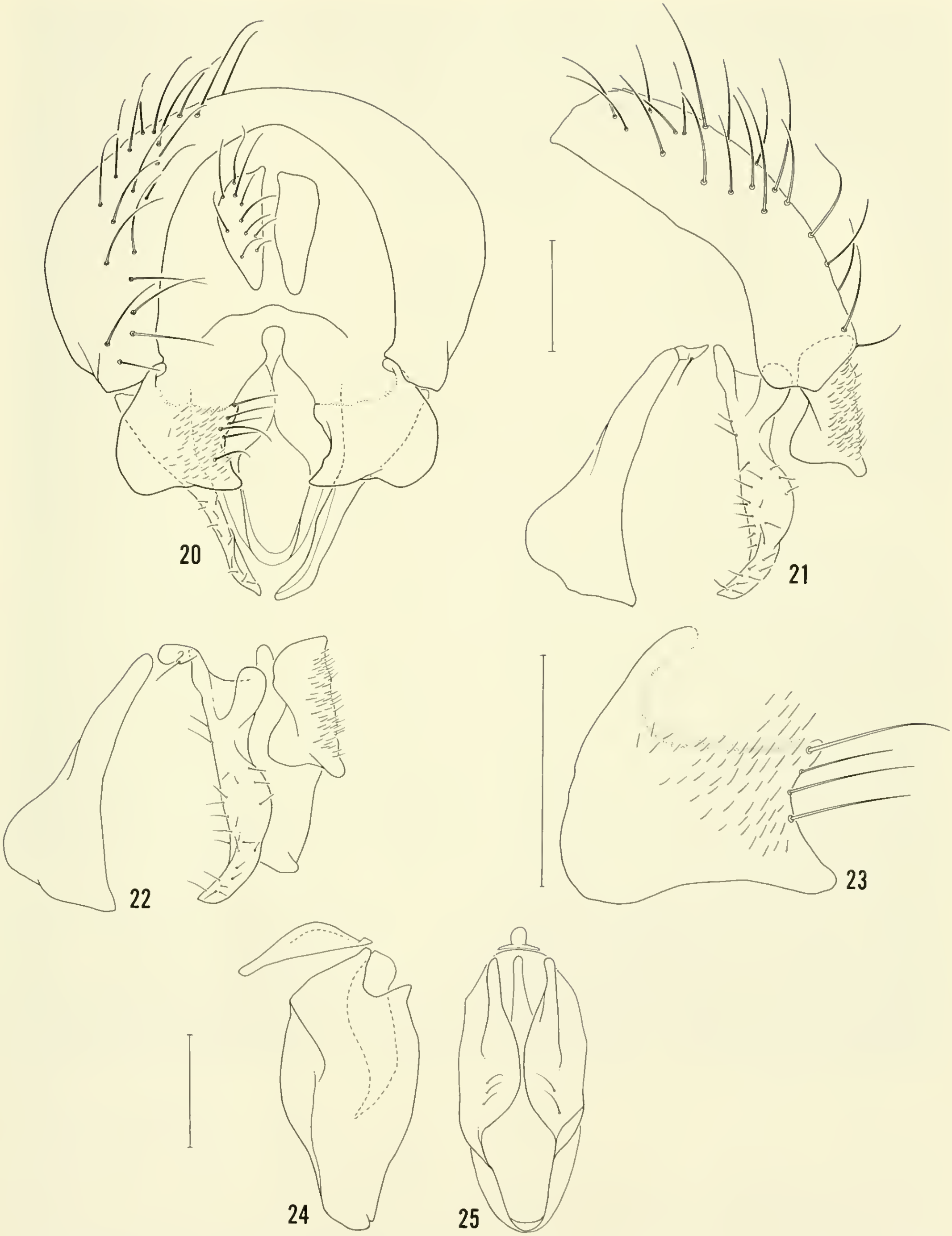
Acanthonotiphila coriacea Lamb, 1912: 316.
Paratissa semilutea of authors [misidentification in part].—Cogan, 1980: 658 [afrotropical catalog; synonymy of *coriacea* with *semilutea*].

Description.—Small to moderately small shore flies, body length 1.95 to 2.85 mm. As in *P. neotropica* except as follows:

Thorax: Legs dark colored, mostly blackish, concolorous with pleuron; middle femur of male with row of 8–10 closely set short, peg-like setae along apical ⅓ of posteroventral surface on a slight ridge. Wing: Costal vein ratio averaging 0.80; M vein ratio averaging 0.65.

Abdomen: Male terminalia (Figs. 20–25) as follows: epandrium (Figs. 20–21), in lateral view, more or less parallel sided, shallowly curved, in posterior view broadly rounded, widest at midlevel of cercus; cercus (Fig. 20) well sclerotized, roughly lunate, pointed dorsomedially; surstylus (Figs. 20–23), in posterior view, roughly rectangular with median margin slightly concave, setulose, laterally rounded and bare, connected with opposite surstylus by partially sclerotized ventral margin of cercal area that has a narrow, short gap at middle, in lateral view as a subrectangular process, posteroventral angle slightly produced; gonite divided, pregonite much smaller, between base of hypandrium and postgonite, with a ventrally directed short process that bears 1 setula; postgonite (Figs. 20–22) a single, long, and slender process, length greater than cercus, oriented medially from posterior view, slightly curved anteriorly subapically and pointed apically, bearing small setulae, joined with postgonite on opposite side with an arched bridge above aedeagus; aedeagus (Figs. 24–25), in lateral view, slipper shaped, in posterior view, narrowly oval; aedeagal apodeme (Fig. 24) narrowly and shallowly triangular to lunate in lateral view; hypandrium (Figs. 21–22) a broad, concave plate that is more deeply produced anteroventrally.

Type material.—The lectotype female, here designated, is labeled "Type H.T. [round label with a red border]/Mahe, '08–9. Seychelles Exp./Seychelles Is. Prof. J. S. Gardiner. 1914-537/TYPE [blue label glued to a larger one] Acanthonotiphila coriacea. det C.G.L. [except for the "TYPE" label, handwritten]." The lectotype is double mounted (pin mounted in a paper-covered, rectangular block of cork with the number "140" handwritten on top), is in fair condition (much of the mesonotum is partially cracked because of the large pin), and is in the BMNH. In addition to the lectotype, there are four additional females (2 with "201," 2 with "140") in the BMNH with



Figs. 20–25. Male terminalia of *Paratissa coriacea.* 20, Epandrium, cerci, surstylus, and postgonite, posterior view. 21, Epandrium, surstylus, postgonite, and hypandrium, lateral view. 22, Surstylus, postgonite, aedeagus, and hypandrium, lateral view. 23, Surstylus, posterior view. 24, Aedeagus, lateral view. 25, Aedeagus, dorsal view. Scales equal 0.1 mm (larger scale is for Fig. 23 only).

Fig. 26. Distribution map for *Paratissa coriacea.*

the same locality label data. The latter four specimens, as former syntypes, become paralectotypes automatically. Lamb (1912: 317) reported this species from Mahé: Anonyme Island (seaweed on beach), Jan 1909.

Other specimens examined.—Afrotropical: *ALDABRA.* Grande Terre: Anse Mais, 17 Mar 1986, W. N. Mathis (1 ♀); Anse Cedre, shoreline at beach, 17–19 Jan 1968, B. H. Cogan, A. M. Hutson (1 ♀; BMNH); Dune Jean-Louis, at light, 13–20 Mar 1968, B. H. Cogan, A. M. Hutson (3 ♂, 6 ♀; BMNH); Takamaka Grove, 1–17 Feb 1968, B. H. Cogan, A. M. Hutson (1 ♂; BMNH); Takamaka, at light, 1–17 Feb 1968, B. H. Cogan, A. M. Hutson (7 ♂, 4 ♀; BMNH); Takamaka Pool, 1–17 Feb 1968, B. H. Cogan, A. M. Hutson (3 ♂, 1 ♀; BMNH); Cinq Cases, dune, 23–29 Jan 1968, B. H. Cogan, A. M. Hutson (1 ♀; BMNH). Malabar: near East Channel, 13–16 Jan 1968, B. H. Cogan, A. M. Hutson (2 ♂; BMNH). Picard: La Gigi, 19–20 Mar 1986, W. N. Mathis (3 ♂, 9 ♀); Settlement, 15–21 Mar 1986, W. N. Mathis (1 ♀). *KENYA.* Gazi (60 km S Mombasa, Rt. A14), 5 May 1991, A. Freidberg, F. Kaplan (1 ♀). Mombasa, Yadini Beach, 15 Jan 1983, A. Valdenberg (1 ♀); Takaugu (50 km N Mombasa), 3 Dec 1989, A. Freidberg, F. Kaplan (1 ♀). *MADAGASCAR.* Antseranana: Nosy Bé, Ambatoloaka Beach, 4–7 Apr 1991, A. Freidberg, F. Kaplan (2 ♀); Nosy Tanikely, 6 Apr 1991, A. Freidberg, F. Kaplan (1 ♂, 4 ♀). Toliara: Fort Dauphin, Libanona Beach, 20 Apr 1991, A. Freidberg, F. Kaplan (1 ♂, 3 ♀). *SEYCHELLES.* Mahé: Cascade, 10 Mar 1965, W. T. Tams, I. B. Nye (3 ♂; BMNH).

Distribution (Fig. 26).—Old World. Indian Ocean basin: Islands of the Seychelles (Mahé) and Aldabra Group, Kenya, and Madagascar.

Natural history.—On Aldabra, this species is associated with mangrove swamps that are in protected areas, primarily along the shore of the inner lagoon and away from the direct impact of wave action.

Remarks.—This is the only species of this genus that I can distinguish without examination of the structures of the male terminalia. The legs are dark colored, usually blackish brown to black, and are concolorous with the pleural area. The structures of the male terminalia (Figs. 20–25) also distinguish it, especially the shape of the surstylus, which is similar in shape to that of *H. guamensis,* being roughly rectangular in posterior view but with the lateral margin rounded and the median margin slightly concave; and the postgonite has one long process.

***Paratissa neotropica* Mathis,**
NEW SPECIES
Figs. 27–46

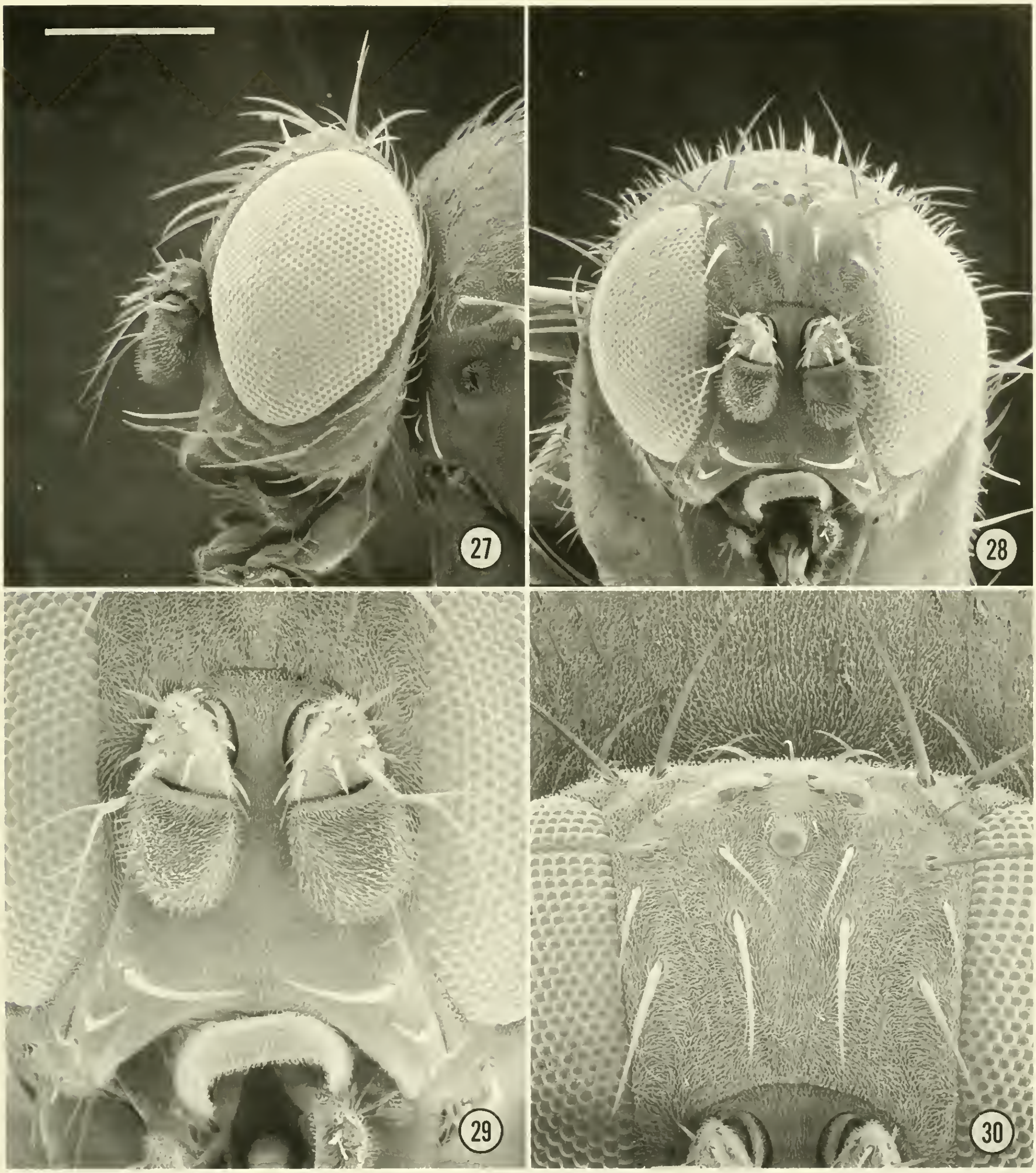
Paratissa pollinosa of authors [misidentification in part].—Wirth, 1956: 9 [list, distribution].

Paratissa semilutea of authors [misidentification in part].—Wirth, 1965: 740 [nearctic catalog]; 1968: 9 [neotropical catalog].

Description.—Small to moderately small shore flies, length 1.70 to 2.20 mm.

Head (Figs. 27–33): Frons (Figs. 28, 30); antenna (Figs. 27–29, 31); face (Figs. 28–29).

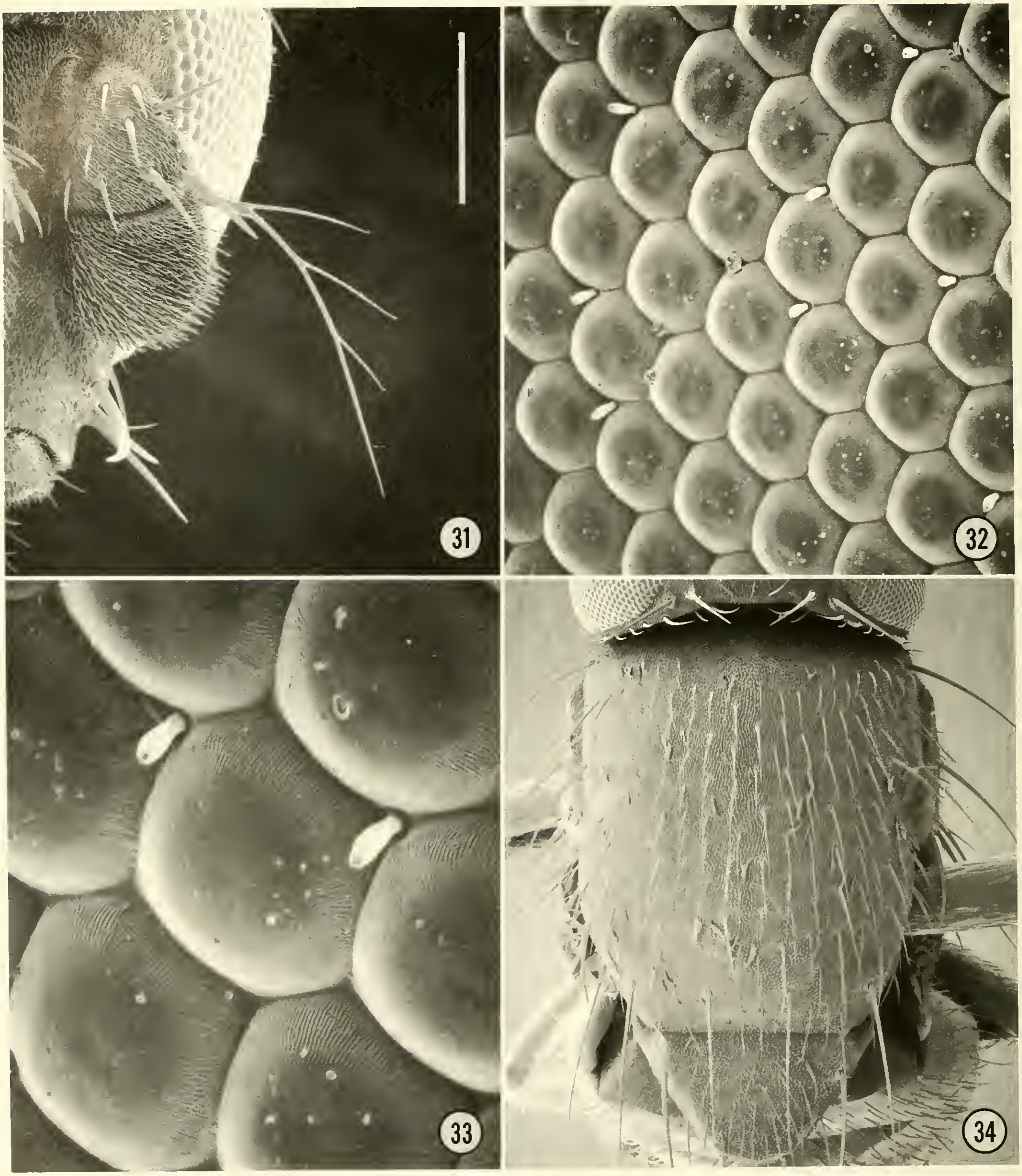
Thorax (Figs. 34–38): Scutum (Fig. 34).



Figs. 27–30. Scanning electron micrographs of *Paratissa neotropica* (scale length in parenthesis; bar scale for all photographs = Fig. 27). 27, Head, lateral view (0.27 mm). 28, Same, anterior view (0.30 mm). 29, Face, anterior view (150 μm). 30, Frons, anterodorsal view (150 μm).

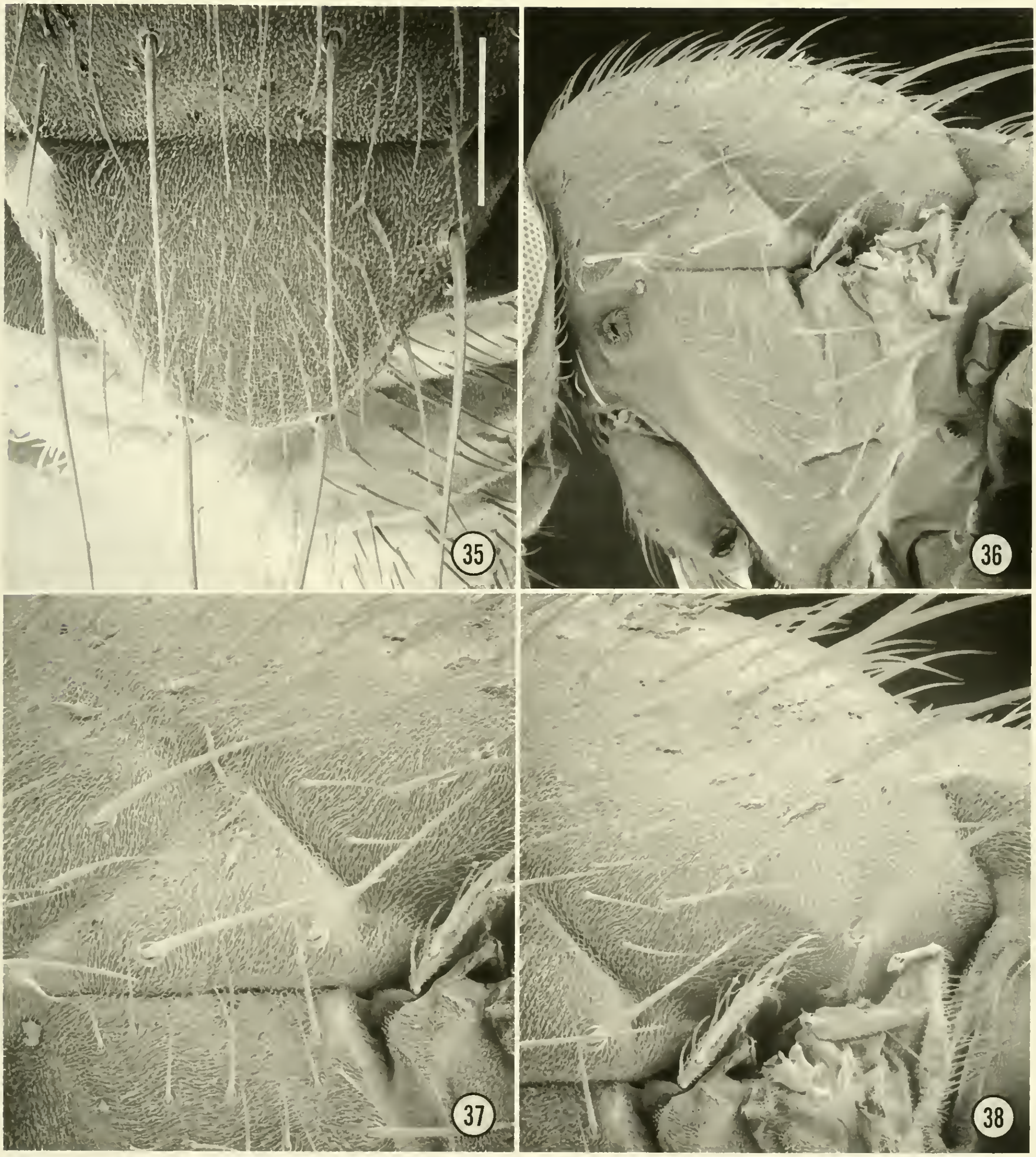
Wing hyaline; costal vein ratio 0.75; M vein ratio 0.65. Legs pale colored, yellowish to slightly brownish; middle femur of male with a short row of 5–7 short, peg-like setae along apical ¼ of posteroventral surface on a slightly raised ridge.

Abdomen (Figs. 39–45): Male terminalia (Figs. 41–45) as follows: epandrium (Figs. 41–42), in lateral view, more or less parallel sided, gently and shallowly curved, in posterior view broadly rounded, widest at midlevel of cercus; cercus (Figs. 41–42) moderately well sclerotized, roughly lunate, pointed dorsomedially; surstylus (Figs. 41–43), in posterior view, with ventromedial projection narrowly developed, shallowly



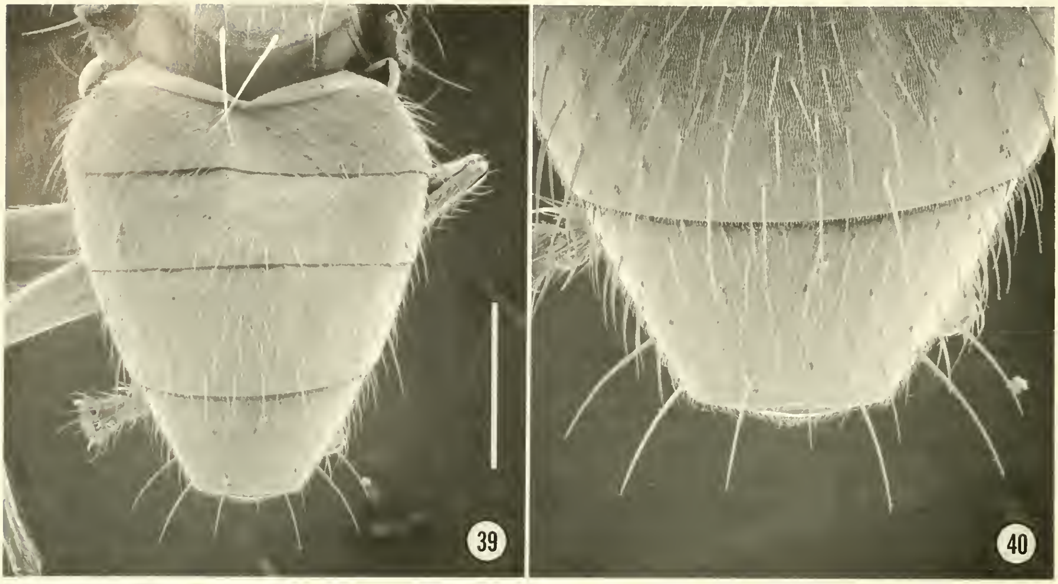
Figs. 31–34. Scanning electron micrographs of *Paratissa neotropica* (scale length in parenthesis; bar scale for all photographs = Fig. 31). 31, Antenna, medial view (120 μm). 32, Eye, ommatidia and occasional setulae, lateral view (23.1 μm). 33, Same, enlargement (10 μm). 34, Mesonotum, dorsal view (0.33 mm).

sinuous, apex rounded; ventral spur with oblique, ventromedial orientation, forming a distinct V-shaped (angle acute) pocket between spur and posteroventral projection, surstylar spur moderately long and narrowly tapered to bluntly rounded apex; gonite divided, pregonite much smaller, between base of hypandrium and postgonite, with a ventrally directed short process that bears 1 setula; postgonite (Fig. 42) with 2 processes, anterior process long, slender, and curved medially then posteriorly after basal



Figs. 35–38. Scanning electron micrographs of *Paratissa neotropica* (scale length in parenthesis; bar scale for all photographs = Fig. 35). 35, Scutellum, dorsal view (150 μm). 36, Pleural area, lateral view (0.30 mm). 37, Notopleuron, lateral view (136 μm). 38, Supra-alar and postalar area of mesonotum, lateral view (150 μm).

⅓, basal portion thickened, bearing setulae, apical portion nearly parallel sided, lacking setulae, posterior process short, not more than twice as long as wide and bearing 2 apical setulae; aedeagus (Figs. 44–45), in lateral view, enlarged basally, tapered abruptly to form a slender apex, in dorsal view, rectangular on basal ½–⅔, apical corners of basal portion pointed and with concave shoulders at juncture with narrow apex, apical portion abruptly narrowed, forming a slender median, parallel-sided process; aedeagal apodeme (Figs. 42, 44) slender, narrowly triangular to lunate in lateral view; hypandrium (Fig. 42) longer than wide, roughly rectangular, evenly and shallowly concave.



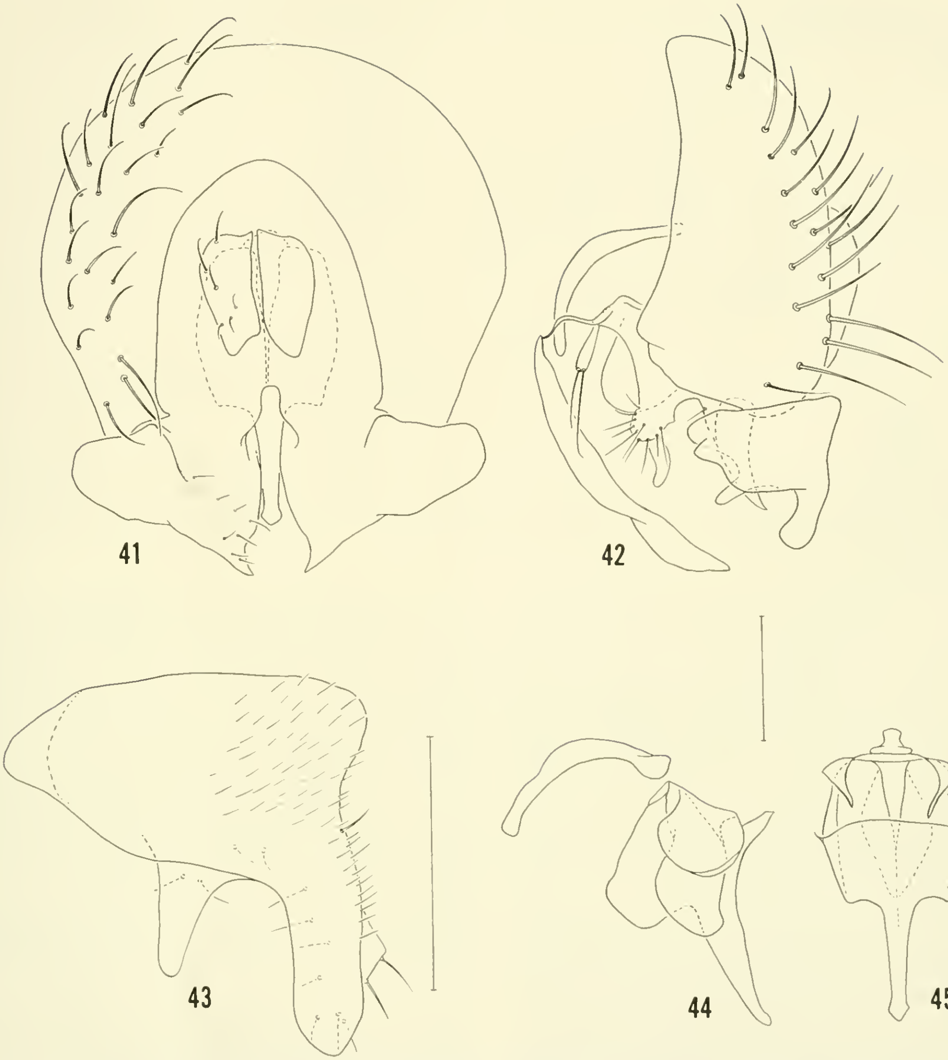
Figs. 39–40. Scanning electron micrographs of *Paratissa neotropica* (scale length in parenthesis; bar scale for all photographs = Fig. 39). 39, Abdomen, dorsal view (0.38 mm). 40, Fifth tergite, dorsal view (200 μm).

Type material.—The holotype male is labeled "BELIZE. Stann Creek District: CarrieBow Cay 21–30 Jul 1989 Wayne N. Mathis/HOLOTYPE Paratissa neotropica ♂ W.N.Mathis USNM [specific name and gender symbol handwritten, red]." The allotype female and 21 paratypes (8 ♂, 13 ♀) bear the same locality label data as the holotype. Other paratypes (90 ♂, 37 ♀) are from the type locality but with differing dates (15 Jan–30 Jul 1984–1990) and in some cases different collectors (R. Faitoute, C. Feller, D. Mathis, P. J. Spangler, H. B. Williams). The holotype is double mounted (minuten in a plastic block), is in excellent condition, and is deposited in the USNM.

Other specimens examined.—Neotropical: *BAHAMAS.* Crooked Island: Landrail Point, 5 Mar 1953, G. B. Rabb (2 ♂). South Bimini: May 1951, M. Cazier, W. Gertsch (1 ♂). Rum Cay: near Port Nelson, 16 Mar 1953, E. B. Hayden, L. Giovannoli (1 ♂). *BRITISH VIRGIN ISLANDS.* Barbuda: Spanish Point, 29 Apr 1958, J. F. G. Clarke (4 ♂, 1 ♀). Virgin Gorda: Prickley Pear Island, Vixen Point, 14 Apr 1956, J. F. G. Clarke (1 ♀); Prickley Pear Island (at light), 5 Apr 1958, J. F. G. Clarke (1 ♂). *MEXICO.* Quintana Roo: Nizue (seaweed), 8 Jan 1974, D. J. Pletsch (1 ♂); Xcaret, 13 Jan 1992, J. R. Vockeroth (2 ♂, 2 ♀; CNC). *PANAMA.* Darien Province: Jaque, 28 Jul 1952, F. S. Blanton (1 ♂). *WEST INDIES. Anguilla.* Blowing Point (18°10′30″N, 63°05′50″W), 29 Mar 1992, W. E. Steiner, J. M. Swearingen (15 ♂, 19 ♀); Long Pond Bay (18°13′00″N, 63°01′00″W), 29 Mar 1992, W. E. Steiner, J. M. Swearingen (3 ♂, 2 ♀); Sandy Ground (18°12′20″N, 63°05′30″W), 27 Mar 1992, W. E. Steiner, J. M. Swearingen (1 ♀). *Antigua.* near airport, 19 Mar 1989, A. Freidberg, W. N. Mathis (14 ♂). *St. Martin.* Cay Bay 11 Feb 1978, S. A. Marshall (2 ♂, 2 ♀; CNC).

Distribution (Fig. 46).—New World. Neotropical: Circumcaribbean: Bahamas, Belize, British Virgin Islands, Mexico (Quintana Roo), Panama, and West Indies (Anguilla, Antigua, St. Martin).

Natural history.—This is one of the most abundant shore flies occurring on the Belizean cays. The species is found in the littoral zone, especially where organic debris, usually algae and sea grass, has accumulated,



Figs. 41–45. Male terminalia of *Paratissa neotropica.* 41, Epandrium, cerci, and surstyli, posterior view. 42, Epandrium, cercus, surstylus, postgonite, and hypandrium, lateral view. 43, Surstylus, posteroventral view. 44, Aedeagus and aedeagal apodeme, lateral view. 45, Same, dorsal view. Scales equal 0.1 mm (larger scale is for Fig. 43 only).

and I found specimens to be most abundant on *Turbinaria* that had washed ashore on the west and north shores of Carrie Bow Cay.

Remarks.—I can distinguish this species from congeners only by reference to the characters of the male genitalia, especially the shape of the surstylus: surstylus (Fig. 43), in posteroventral view, with ventromedial angle acutely pointed; ventral spur moderately long and narrow and with oblique, ventromedial orientation.

Paratissa pollinosa (Williston)
Figs. 47–50

Drosophila pollinosa Williston, 1896: 414.
Paratissa pollinosa.—Coquillett, 1900: 36 [generic combination].—Sturtevant, 1923: 10 [types lost, not in London, New York, or Kansas].—Mathis, 1989a: 643 [Aus-

Fig. 46. Distribution map for *Paratissa neotropica*.

tralasian/oceanian catalog].—Mathis and Edmiston, 1991: 828 [review, neotype designation].

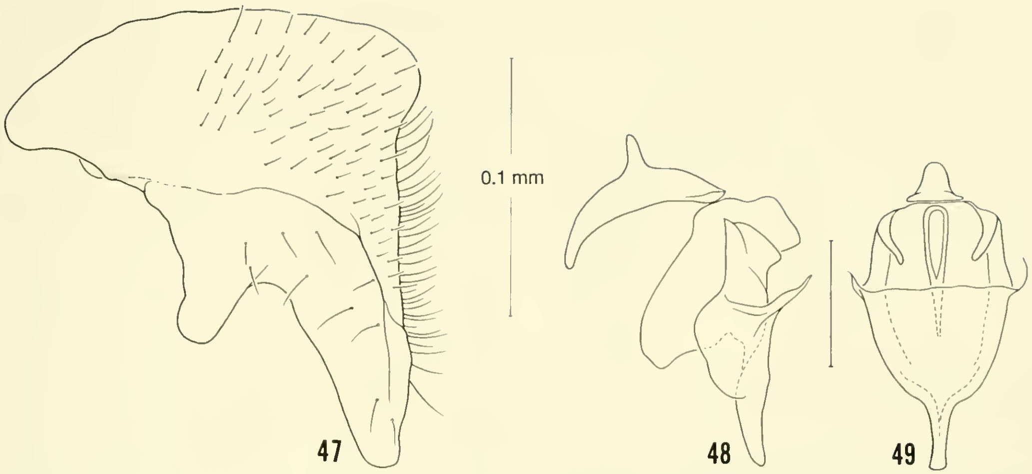
Paratissa semilutea of authors [misidentification in part].—Wirth, 1965: 740 [nearctic catalog; synonymy of *pollinosa* with *semilutea*]; 1968: 9 [neotropical catalog]; 1969: 590–593 [review of species from the Galápagos Islands].—Tenorio, 1980: 280 [review of Hawaiian species].

Hostis guamensis of authors [misidentification].—Adachi, 1952: 353 [list from Hawaii].—Hardy, 1952: 467 [list from Hawaii].

Description.—As in *P. neotropica* except as follows: Small to moderately small shore flies, body length 1.80 to 2.60 mm.

Thorax: Legs generally pale colored, yellowish to brownish yellow. Costal vein ratio 0.65; M vein ratio 0.60.

Abdomen: Male terminalia (Figs. 47–49) as follows: epandrium, in lateral view, more or less parallel sided, gently and shallowly curved, in posterior view broadly rounded, widest at midlevel of cercus; cercus moderately well sclerotized, roughly lunate, pointed dorsomedially; surstylus (Fig. 47), in posterior view, with ventromedial angle acutely pointed, narrowly rounded in posteroventral view, surstylar spur with oblique,



Figs. 47–49. Male terminalia of *Paratissa pollinosa*. 47. Surstylus, posteroventral view. 48, Aedeagus and aedeagal apodeme, lateral view. 49, Same, dorsal view. Scales equal 0.1 mm (larger scale is for Fig. 47 only).

ventromedial orientation, forming a distinct V-shaped (angle acute) pocket between spur and posteroventral projection; spur moderately short and gradually tapered to bluntly rounded apex; gonite divided, pregonite much smaller, between base of hypandrium and postgonite, with a ventrally directed short process that bears 1 setula; postgonite with 2 processes, anterior process long, slender, and curved medially then posteriorly after basal ⅓, basal portion thickened, bearing setulae, apical portion nearly parallel sided, lacking setulae, posterior process short, not more than twice as long as wide and bearing 2 apical setulae; aedeagus (Figs. 48–49), in lateral view, enlarged basally, tapered abruptly to form a slender apex, in dorsal view, rectangular on basal ½–⅔ with margins angled medially to mostly rounded shoulders at juncture with narrow apex, apical portion abruptly narrowed, forming a slender, parallel-sided, median process; aedeagal apodeme slender, narrowly triangular to lunate in lateral view; hypandrium longer than wide, roughly rectangular, evenly and shallowly concave.

Type material.—Williston, in the original description, noted "Two specimens. St. Vincent." Sturtevant (1923) was unable to locate either after searching through collections in the BMNH, KU, and AMNH. I was likewise unsuccessful in finding any syntypes and have had to base the characterization of this species on the neotype (designated by Mathis and Edmiston, 1991: 828) that was recently collected on St. Vincent. The neotype is labeled "W.I. St.Vincent. Cumberland Bay[,] (13°16′N, 61°16′W)[,] 8–10 June 1991[,] W. N. & D. Mathis/NEOTYPE ♂ Drosophila pollinosa Williston designated by W.N.Mathis & J. Edmiston [handwritten, red]." Twenty-one neoparatypes (3 ♂, 18 ♀), which bear identical locality label data, were also designated. The neotype is double mounted (minuten in a block of plastic), is in excellent condition (some Laboubeniales on mesonotum), and is deposited in the USNM.

Other specimens examined.—Australasian/oceanian: *PITCAIRN ISLAND GROUP.* Pitcairn Island: Adamstown (25°04′S, 130°06′W), 24 May 1987, W. N. Mathis (20 ♂, 7 ♀); Down Rope (25°04′S, 130°06′W), 25 May 1987, W. N. Mathis (♂ ♀). *UNITED STATES. Hawaii.* Oahu: Ewa (seaweed on beach), 15 Mar 1946, W. W. Wirth (1 ♂); Honolulu, 15 Jan–20 Oct 1966, 1967, J. R. Vockeroth (1 ♂, 2 ♀; CNC); Kailua Beach (reared from seaweed), 28 Nov 1969, J. A. Tenorio (2 ♀). Neotropical: *PAN-*

Fig. 50. Distribution map for *Paratissa pollinosa.*

AMA. Canal Zone: Ft. Sherman, Mojinga Swamp, Jan 1953, F. S. Blanton (15 ♂, 14 ♀). Colon Province, Galeta Point, 26 Aug 1952, F. S. Blanton (1 ♂). *WEST INDIES. Dominica.* Calibishie (sea shore), 27 Feb–22 Mar 1965, 1989, W. N. Mathis, W. W. Wirth (11 ♂, 2 ♀); Layou (5 km E), 23 Mar 1989, W. N. Mathis (1 ♂); Layou River (mouth), 9 Jan 1965, W. W. Wirth (1 ♂, 2 ♀); Macoucheri (sea shore), 1 Feb 1965, W. W. Wirth (1 ♂, 1 ♀); Pagua Bay, 18 Feb 1965, W. W. Wirth (1 ♂, 1 ♀); Rosalie, 23 Mar 1989, W. N. Mathis 11 ♂, 1 ♀; USNM; St. David Bay (sea shore), 23 Jan 1965, W. W. Wirth (7 ♂, 8 ♀); Woodford Hill (sea shore), 27 Feb 1965, W. W. Wirth (2 ♂). *St. Lucia.* Cas-en-bas, 14 Feb 1978, S. A. Marshall (1 ♂, 2 ♀; CNC); Micoud (13°49′N, 60°54′W), 15 Jun 1991, D. & W. N. Mathis (3 ♂, 2 ♀); Soufrière (13°51′N, 61°04′W), 11–12 Jun 1991, D. & W. N. Mathis (5 ♂, 4 ♀). *St. Vincent.* Buccament Bay, 25–28 May 1989, W. N. Mathis (2 ♂, 1 ♀).

Distribution (Fig. 50).—Neotropical: Dominica to St. Vincent, Panama, and the Galápagos Islands. Australasian/oceanian: Hawaii (Oahu and Maui) and Pitcairn Island.

Remarks.—This species and *P. semilutea* have been confused with each other almost since they were first described (see synonymy), and externally they are virtually identical. I have been able to reliably distinguish between them only by reference to characters of the male genitalia, especially the shape of the surstylus and aedeagus. These are as follows (Fig. 26): surstylus, in posterior view, with the ventromedial angle acutely pointed, narrowly rounded in posteroventral view; the ventral spur has an oblique, ventromedial orientation, forming a distinct, U-shaped pocket (angle between spur and posteroventral projection acute) between the spur and posteroventral projection; spur gradually tapered to bluntly rounded apex; and base of aedeagus, at juncture with narrow, parallel-sided apex, with sides angulate, forming a distinct shoulder on each side.

Although previously confused with *P. semilutea,* this species is most similar to *P. neotropica,* based on characters of the male terminalia, and careful comparison of these characters, the surstylus and aedeagus in particular, is needed to distinguish between them.

The occurrence of this species on Pitcairn and Hawaiian Islands is undoubtedly adventive, probably through commerce. The species has been reared from "seaweed," a product, perhaps as packing, that could easily have been introduced to these islands along with the immatures of this species.

Paratissa semilutea (Loew)
Figs. 51–54

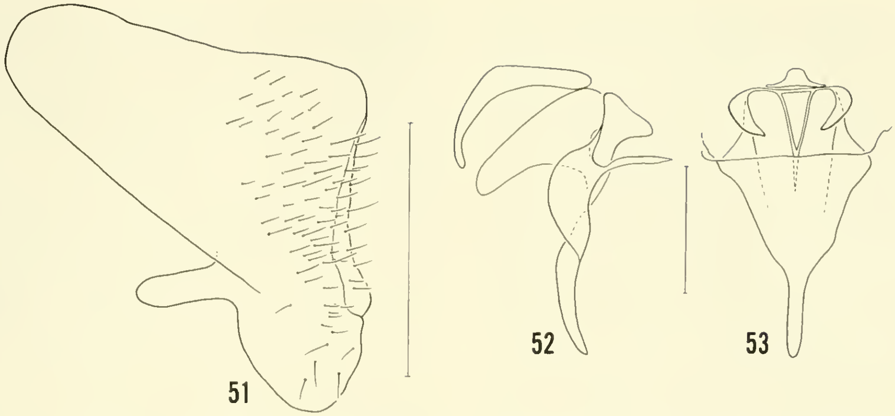
Cacoxenus semiluteus Loew, 1869: 51.

Paratissa semilutea.—Wirth, 1965: 740 [generic combination]; 1968: 9 [neotropical catalog].

Paratissa pollinosa of authors [misidentification in part].—Coquillett, 1900: 36 [list].—Sturtevant and Wheeler, 1954: 251 [review].—Wirth, 1956: 9 [list, distribution].

Description.—As in *P. neotropica* except as follows: Small to moderately small shore flies, body length 1.60 to 2.70 mm.

Thorax: Legs with femora sometimes dark colored but usually pale, yellowish; tibiae and tarsomeres mostly light reddish orange



Figs. 51–53. Male terminalia of *Paratissa semilutea*. 51, Surstylus, posteroventral view. 52, Aedeagus and aedeagal apodeme, lateral view. 53, Same, dorsal view. Scales equal 0.1 mm (larger scale is for Fig. 51 only).

to yellowish. Costal vein ratio 0.77; M vein ratio 0.61.

Abdomen: Male terminalia (Figs. 51–53) as follows: epandrium, in lateral view, more or less parallel sided, gently and shallowly curved, in posterior view broadly rounded, widest at midlevel of cercus; cercus moderately well sclerotized, roughly lunate, pointed dorsomedially; surstylus (Fig. 51), in posterior view, with ventromedial angle relatively broad, bluntly rounded, surstylar spur with oblique, ventromedial orientation, forming nearly a right angle with plane of ventromedial angle, conspicuously narrower than the latter, appearing digitiform and more or less parallel sided; gonite divided, pregonite much smaller, between base of hypandrium and postgonite, with a ventrally directed short process that bears 1 setula; postgonite with 2 processes, anterior process long, slender, and curved medially then posteriorly after basal ⅓, basal portion thickened, bearing setulae, apical portion nearly parallel sided, lacking setulae, posterior process short, not more than twice as long as wide and bearing 2 apical setulae; aedeagus (Figs. 52–53), in lateral view, enlarged basally, tapered gradually to form a slender apex, in dorsal view rectangular on basal ½–⅔ with margins gradually tapered medially to juncture with narrow apex, apical portion abruptly narrowed, forming a slender, parallel-sided, median process; aedeagal apodeme slender, narrowly triangular to lunate in lateral view; hypandrium longer than wide, roughly rectangular, evenly and shallowly concave.

Type material.—The lectotype female, here designated, is labeled "Cuba [Felipe] Poey [green on upper surface, handwritten]/ Loew Coll./semiluteus [handwritten]/Type 13453 [red, number handwritten]/LECTOTYPE ♀ Cacoxenus semiluteus Loew by W.N.Mathis [all except "LECTOTYPE" and "By" handwritten, black submargin]." The lectotype is double mounted (glued to a paper rectangle), is in poor condition (several setae of the head and the right antenna are missing), and is deposited in the Museum of Comparative Zoology (MCZ, 13453).

Other specimens examined.—Nearctic: *BERMUDA.* Devonshire Parish: Devonshire Bay (32°18′N, 64°44′W), 29 May 1991, W. N. Mathis (7 ♂, 5 ♀). Hamilton Parish: Shelly Bay Beach (32°19′N, 64°44′W), 31 May 1991, W. N. Mathis (2 ♂, 2 ♀); Walsingham Bay (32°20′N, 64°42′W), 31 May 1991, W. N. Mathis (1 ♀). Paget Parish: Grape Bay, 11 Nov 1956, P. N. Vroom (2 ♂, 2 ♀; CNC); Hungry Bay (beach, 32°17′N, 64°45′W), 2 Jun 1991, W. N. Mathis (4 ♂, 1 ♀). Pembroke Parish: Admiralty House Beach (82°18'N, 64°48'W), 2 Jun–15 Nov 1987, 1991, D. J. Hilburn, W. N. Mathis, N. E. Woodley (26 ♂, 13 ♀); Cavendish, Jan, W. S. Brooks (2 ♂; MCZ, USNM); Hamilton, 29 Jan 1934, A. L. Melander (1 ♂, 1 ♀); Spanish Point beach (32°18'N, 64°49'W), 2 Jun 1991, W. N. Mathis (5 ♂, 1 ♀). Southampton Parish: Horseshoe Bay, 12 Nov 1956, P. N. Vroom (2 ♀; CNC). St. George's Parish: Castle Island: 25 Jan 1934, A. L. Melander (6 ♂, 4 ♀); St. George: 23 Jan 1934, A. L. Melander (6 ♂, 10 ♀); Tucker's Town Bay (beach, 32°20'N, 64°41'W), 31 May 1991, W. N. Mathis (4 ♂, 2 ♀). Warwick Parish: Warwick Long Bay Beach (32°15'N, 64°48'W), 30 May 1991, W. N. Mathis (5 ♂, 5 ♀). Cooper Island: 25 Jan 1934, A. L. Melander (15 ♂, 9 ♀). *UNITED STATES. Florida.* Broward Co., Ft. Lauderdale, 26 Jan 1933, A. L. Melander (4 ♂, 2 ♀). Dade Co., Biscayne Bay, A. Slosson (3 ♂, 4 ♀; CNC, USNM); Coconut Grove, 9 Aug 1930, P. W. Oman, R. H. Beamer (2 ♀); Cutler 30 Jan 1939, A. L. Melander (11 ♂, 27 ♀); Miami (light trap), Dec, W. W. Wirth (1 ♀). Monroe Co., Bahia Honda Key (seashore), 11 Apr 1970, W. W. Wirth (4 ♀); Bahia Vaca Key, 26 Nov 1961, J. G. Chillcott (2 ♂, 2 ♀; CNC); Big Pine Key (black light trap), 27 Dec 1972, H. R. Dodge (2 ♂); Everglades National Park, 3 Apr 1958, H. V. Weems (2 ♂); Flamingo, 25 Jan–1-2 Dec 1939, 1961, J. G. Chillcott, G. Holland, A. L. Melander, E. Munroe (3 ♂, 5 ♀; CNC, USNM); Key Largo, 26 Dec 1954, C. Weems (1 ♂); Key West (on *Flaveria linearis*), 23 Jun–25 Dec 1953, 1954, 1972, H. R. Dodge, H. V. Weems, M. R. Wheeler (6 ♂, 6 ♀); Long Key, 24 Jun 1953, A. H. Sturtevant, M. R. Wheeler (8 ♂, 2 ♀); Matecumbe, 1 Feb–31 Mar 1933, 1952, A. L. Melander, J. R. Vockeroth (15 ♂, 10 ♀; CNC, USNM); Royal Palm Park, 28 Jan 1939, A. L. Melander (1 ♂). Pinellas Co., St. Petersburg, 31 Jan–26 Mar 1924–1932, E. T. Cresson, Jr., A. L. Melander (7 ♂, 5 ♀). Little Duck Key, 1 Jan 1957, D. Lindsley (2 ♂, 2 ♀). Volucia Co., 1 Aug 1956, H. A. Denmark (1 ♂). Neotropical: *BAHAMAS.* New Providence: Nassau, 5 Apr–13 Dec 1912, 1953, E. B. Hayden, F. K. Knab (8 ♂, 9 ♀). North Bimini (light trap): Feb 1968, G. M. Stokes (2 ♂, 1 ♀). San Salvador: near Cockburn Town, 18 Mar 1953, L. Giovannoli (1 ♂). South Bimini: Jul 1951, C. and P. Vaurie (1 ♂, 9 ♀). Exuma Cays: Leaf Cay of Allens Cays, 7 Jan 1953, E. B. Hayden, L. Giovannoli (2 ♂, 1 ♀). *BELIZE.* Stann Creek District: Bread and Butter Cay, Mar 1988, W. N. Mathis (2 ♂, 1 ♀); Carrie Bow Cay, 15 Jan–17 May 1984–1988, R. A. Faitoute, I. C. Feller, P. J. Spangler, W. N. Mathis (22 ♂); Coco Plum Cay, Mar–Jun 1988, 1990, C. Feller, P. J. Spangler, W. N. Mathis (22 ♂); Coco Plum Cay, Mar–Jun 1988, 1990, C. Feller, W. N. Mathis, H. B. Williams (9 ♂, 25 ♀); Man of War Cay, 2 Jun–Nov 1985, 1987, 1989, W. N. & D. Mathis, H. B. Williams (26 ♂, 17 ♀); South Water Cay, Jun 1985, W. N. Mathis (1 ♂; 5 ♀); Tobacco Range, Jul 1989, W. N. Mathis, H. B. Williams (1 ♂, 14 ♀); Twin Cays (Aanderaa Flats, dock area, east shore of East Island, south end of East Island, south end of West Island, West Bay), 18 Jan–1 Jun 1985, 1987, 1988, C. Feller, W. N. Mathis (42 ♂, 57 ♀); South Water Cay, 1 Jun 1985, W. N. Mathis (1 ♂, 3 ♀). Wee Wee Cay, 24 Jan 1987, W. N. Mathis, C. Feller (2 ♀). *MEXICO.* Quintana Roo: Allen Point, Ascension Bay, 15 Apr 1960, J. F. G. Clarke (1 ♂). *WEST INDIES. Anguilla.* Blowing Point (18°10'30"N, 63°05'50"W), 29 Mar 1992, W. E. Steiner, J. M. Swearingen (3 ♂, 2 ♀). *Antigua.* near airport, 19 Mar 1989, A. Freidberg, W. N. Mathis (5 ♂). *Cuba.* Havana Province: Jibacoa Beach (57 km E Havana), 26 Apr 1983, W. N. Mathis (11 ♂, 12 ♀). Matanzas Province: Playa Larga, 1 May 1983, W. N. Mathis (2 ♂, 2 ♀). *Jamaica.* Falmouth (bay shore), 1 Mar 1969, W. W. Wirth (6 ♂, 6 ♀). *Puerto Rico.* Guanica, 22 Jun 1952, F. S. Blanton (1 ♀). *St. Martin.* Paradise Peak, 11 Feb 1978, S. A. Marshall (3 ♂, 2 ♀; CNC). *Virgin Islands.* St. Croix: airport (at light), fall 1967, W. H. Pierce (1

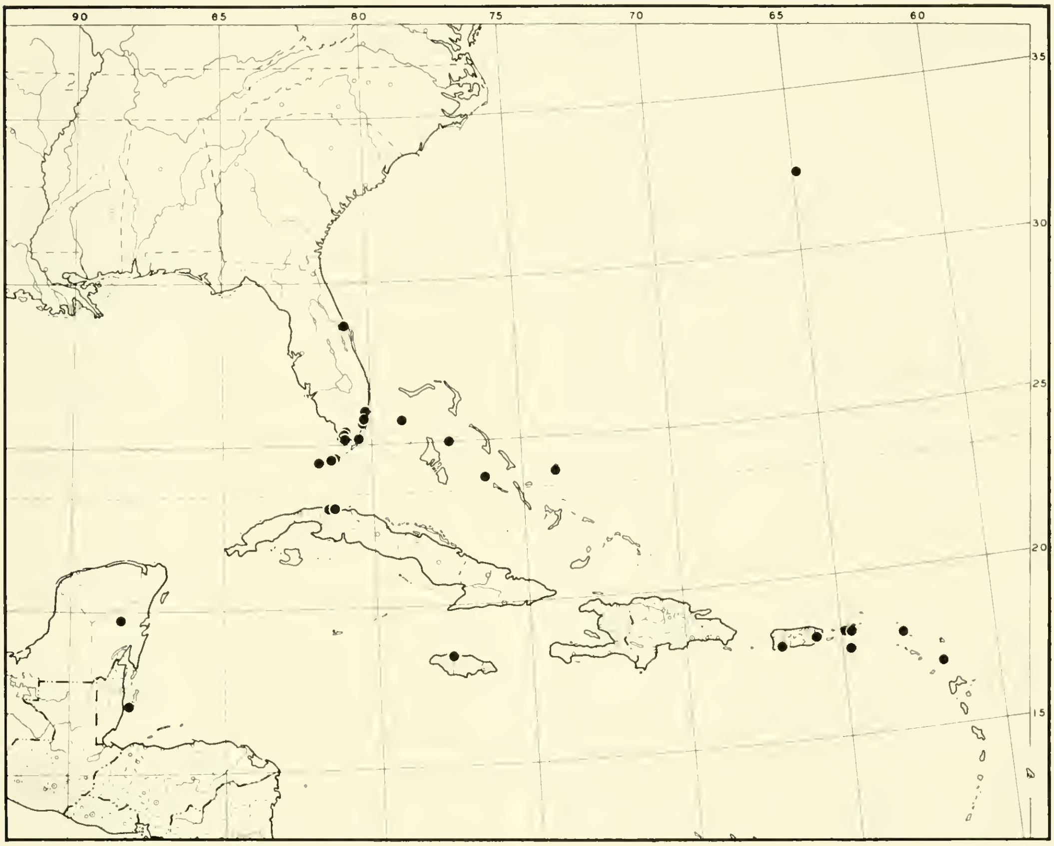


Fig. 54. Distribution map for *Paratissa semilutea.*

♂). St. John: Francis Bay (at light), 25 Mar 1958, J. F. G. Clarke (4 ♀). St. Thomas: Charlotte Amalie (3 mi from, on grass), 31 May 1917, H. Morrison (1 ♂). Pueblito del Rio (at light), 1 Aug 1963, P. J. Spangler (1 ♂).

Distribution (Fig. 54).—New World. United States (Florida) to Mexico (Quintana Roo), east to Bermuda and south to the Bahamas and West Indies (Anguilla, Antigua, Cuba, Jamaica, Puerto Rico, St. Martin, and Virgin Islands), and Belize.

Remarks.—My concept of this species is based primarily on the series, especially the males, that I collected in the province of Havana, Cuba (see specimens examined). So far as I am aware, there is only one species of *Paratissa* on Cuba, and I am assuming that the lectotype and specimens of this series are conspecific. The lectotype, which I have examined, was collected by Professor Felipe Poey, undoutedly in or near Havana, and was probably given to Baron R. Osten Sacken during the winter of 1857–58 when the latter spent five weeks in Cuba and became acquainted with Professor Poey.

ACKNOWLEDGMENTS

Although this study was based primarily on specimens in the National Museum of Natural History, numerous others were borrowed, particularly type specimens of the species previously described. To my colleagues and their institutions listed previously for the loan of specimens, I express my sincere thanks. Without their cooperation this study could not have been completed. Hollis B. Williams prepared the distribution maps, and the line illustrations were carefully rendered by Elaine R. S. Hodges. Susann Braden assisted with the preparation of the scanning electron micrographs and Victor Krantz produced the positives. For reviewing a draft of this paper I thank Robert V. Peterson, Curtis W. Sabrosky, and David A. Grimaldi. I am also grateful to David Challinor, former Assistant Secretary for Research, Smithsonian Institution, and Stanwyn G. Shetler, Deputy Director, National Museum of Natural History, for financial support to conduct field work through grants from the Research Opportunity Fund. Field work on Bermuda was supported by the Department of Agriculture, Fisheries, and Parks of Bermuda and was facilitated by Roberta Dow, Kevin Monkman, and Daniel J. Hilburn. Field work on Aldabra was supported by the Smithsonian's program to these islands, Brian Kensley coordinator.

This is contribution number 355 from the Caribbean Coral Reef Ecosystems (CCRE), Smithsonian Institution (Klaus Rützler, director, and Marsha Sitnik, administrator). Funds from CCRE, which supported the field work in Belize, are partly subsidized by a grant from the Exxon Corporation.

LITERATURE CITED

Adachi, M. S. 1952. New records and name changes in Hawaiian Ephydridae. Proceedings of the Hawaiian Entomological Society 14(3): 353–354.

Cogan, B. H. 1980. 71. Family Ephydridae, pp. 655–669. *In* Crosskey, R. W., ed., Catalogue of the Diptera of the Afrotropical Region. British Museum (Natural History), London. 1437 pp.

Cogan, B. H. and W. W. Wirth. 1977. Family Ephydridae, pp. 321–339. *In* Delfinado, M. D. and D. E. Hardy, eds., A Catalogue of the Diptera of the Oriental Region. Suborder Cyclorrhapha (Excluding Division Aschiza), Vol. 3. University Press of Hawaii, Honolulu. 854 pp.

Coquillett, D. H. 1900. New genera and species of Ephydridae. The Canadian Entomologist 32: 33–36.

Cresson, E. T., Jr. 1945. A systematic annotated arrangement of the genera and species of the Indo-Australian Ephydridae (Diptera). I. The subfamily Psilopinae. Transactions of the American Entomological Society 71: 47–75.

Hardy, D. E. 1952. Additions and corrections to Bryan's check list of the Hawaiian Diptera. Proceedings of the Hawaiian Entomological Society 14(3): 443–484.

Lamb, C. G. 1912. The Percy Sladen Trust Expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M.A. Volume IV. Number XIX. Diptera: Lonchaeidae, Sapromyzidae, Ephydridae, Chloropidae, Agromyzidae. The Transactions of the Linnean Society of London (series 2) 15: 303–348.

Loew, H. 1869. Diptera America septentrionalis indigena. Centuria Octava. Berliner Entomologische Zeitschrift 13: 1–52.

Mathis, W. N. 1977. A revision of the genus *Rhysophora* Cresson with a key to related genera (Diptera: Ephydridae). Proceedings of the Biological Society of Washington 90(4): 921–945.

———. 1986. Studies of Psilopinae (Diptera: Ephydridae), I: A revision of the shore fly genus *Placopsidella* Kertész. Smithsonian Contributions to Zoology 430: iv + 30 pp.

———. 1989a. 99. Family Ephydridae, pp. 639–649. *In* Evenhuis, N., ed., Catalog of the Diptera of the Australasian and Oceanian Regions. Bishop Mus. Press and E. J. Brill. 1155 pp.

———. 1989b. Diptera (Insecta) or true flies of the Pitcairn Group (Ducie, Henderson, Oeno, and Pitcairn Islands). Atoll Research Bulletin 327: 1–15.

Mathis, W. N. and J. F. Edmiston. 1991. S. W. Williston's species of Ephydridae (Diptera) from St. Vincent (West Indies). Proceedings of the Biological Society of Washington 104(4): 816–839.

Mathis, W. N. and Jin Zuyin. 1989. A review of the Asian species of the genus *Polytrichophora* Cresson (Diptera: Ephydridae). Proceedings of the Biological Society of Washington 102(2): 434–446.

McAlpine, J. F. 1981. Morphology and terminology—adults, pp. 9–63. *In* McAlpine, J. F., et al., eds., Manual of Nearctic Diptera, Vol. 1. Ottawa. [Volume 1 is Monograph 27 of Research Branch Agriculture Canada.]

Séguy, E. 1955. Dipteres de L'ile Tromelin. Le Naturaliste Malache 7(1): 9–12.

Sturtevant, A. H. 1923. New species and notes on synonymy and distribution of Muscidae Acalypteratae (Diptera). American Museum Novitates 76: 1–12.

Sturtevant, A. H. and M. R. Wheeler. 1954. Synopses of nearctic Ephydridae (Diptera). Transactions of the American Entomological Society 79: 151–257.

Tenorio, J. A. 1980. Family Ephydridae, pp. 251–351. *In* Hardy, D. E. and M. D. Delfinado, eds., Insects of Hawaii. Volume 13. Diptera: Cyclorrhapha III, Series Schizophora Section Acalypterae, Exclusive of Family Drosophilidae. The University Press of Hawaii, Honolulu. vii + 451 pp.

Williston, S. W. 1896. On the Diptera of St. Vincent (West Indies). The Transactions of the Entomological Society of London 1896: 253–446.

———. 1908. Manual of North American Diptera. 3rd edition. James T. Hathaway, New Haven. 405 pp.

Wirth, W. W. 1956. The Ephydridae (Diptera) of the Bahama Islands. American Museum Novitates 1817: 1–20.

———. 1965. Family Ephydridae, pp. 734–759. *In* Stone, A., et al., eds., A Catalog of Diptera of America North of Mexico. United States Department of Agriculture, Agricultural Research Service, Agriculture Handbook, 276: iv + 1696 pp.

———. 1968. 77, Family Ephydridae, pp. 1–43. *In* Papavero, N., ed., A Catalogue of the Diptera of the Americas South of the United States. Departamento de Zoologia, Secretaria da Agricultura, São Paulo.

———. 1969. New Species and Records of Galápagos Diptera. Proceedings of the California Academy of Sciences 36(20): 571–594.

Wirth, W. W. and A. Stone. 1956. Aquatic Diptera, pp. 372–482. *In* Usinger, R. L., ed., Aquatic Insects of California. University of California Press, Berkeley.

Zatwarnicki, T. 1992. A new classification of Ephydridae based on phylogenetic reconstruction (Diptera: Cyclorrhapha). Genus 3(2): 65–119.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 48–51

NAME CHANGES IN THE GENUS *TACHINA* OF THE EASTERN PALEARCTIC AND ORIENTAL REGIONS (DIPTERA: TACHINIDAE)

Chien-ming Chao and Paul H. Arnaud, Jr.

(CC) Institute of Zoology, Academia Sinica, 19 Zhongguancun Lu, Haidian, Beijing, 100080, People's Republic of China; (PHA) California Academy of Sciences, Golden Gate Park, San Francisco, California 94118. USA.

Abstract.—Eight new names are proposed for eastern Palearctic and Oriental *Tachina* to replace names that are secondary homonyms. Four of these name changes are based on new combinations as indicated: *T. iota* Chao and Arnaud for *T. minuta* (Chao, 1962), non *T. minuta* Fallén, 1810; *T. jawensis* Chao and Arnaud for *T. javana* (Malloch, 1932), present new combination, non *T. javana* Wiedemann, 1819, or *T. javana* Macquart, 1851; *T. kunmingensis* Chao and Arnaud for *T. planiforceps* (Chao, 1962), non *T. planiforceps* (Tothill, 1924); *Tachina mallochi* Chao and Arnaud for *T. atra* (Malloch, 1932), present new combination, non *T. atra* Walker (1853); *T. pingbian* Chao and Arnaud for *T. apicalis* (Chao, 1962), present new combination, non *T. apicalis* Meigen, 1824, or *T. apicalis* Walker, 1853; *T. rohdendorfiana* Chao and Arnaud for *T. rohdendorfi* (Chao, 1962), non *T. rohdendorfi* (Zimin, 1935); and *T. tienmushan* Chao and Arnaud, for *T. flavipes* (Chao, 1962), present new combination, non *T. flavipes* Meigen (1824); and *T. zaqu* Chao and Arnaud for *T. basalis* (Zimin, 1929), non *T. basalis* Walker, 1837, *T. basalis* Walker, 1849, *T. basalis* Walker, 1853, and *T. basalis* Walker, 1853.

Key Words: Insecta, Diptera, Tachinidae, *Tachina,* new names, new combinations

Recent examination of the names utilized in the genus *Tachina* in the Nearctic Region, with reports published or in press by Arnaud (1992a, b), also revealed nomenclatorial problems with names in use in the eastern Palearctic and Oriental regions.

The catalogs to the Palearctic (Herting 1984) and Oriental (Crosskey 1977) Tachinidae have formed the basis of our study, aided by other regional catalogs—Afrotropical (Crosskey 1980), Australasian and Oceanian (Cantrell and Crosskey 1989), Nearctic (Sabrosky and Arnaud 1965), and Neotropical (Guimarães 1971). Herting cited 1522 valid species of Palearctic Tachinidae, of which 42 are *Tachina* (with an additional 2086 specific names of Tachinidae cited in the synonymies, and more than 1000 additional specific names which are unfortunately not included because their status is unknown). Crosskey cited 725 valid Oriental species of Tachinidae, of which 29 are *Tachina* (as we now interpret them; formerly with 28 in *Servillia* and one in *Tachina*). We have an incomplete manuscript list of nearly 1200 names, used worldwide, in the genus *Tachina.* Four of the eight new names are proposed on the basis of new generic assignments:

***Tachina iota* Chao and Arnaud, New Name**

Servillia minuta Chao, 1962: 56.—As *Tachina* (*Servillia*) *minuta* (Chao): Herting, 1984: 87 (new combination). Preoccupied by *Tachina minuta* Fallén (1810: 274).

With the transfer of *Servillia minuta* Chao to the genus *Tachina* it becomes a secondary junior homonym. *Tachina iota* Chao and Arnaud, new name, is proposed to replace *T. minuta* (Chao), non *T. minuta* Fallén. The specific name is from the Greek *iota*—the ninth letter of the alphabet; anything very small.

Tachina jawensis Chao and Arnaud, New Name

Servillia javana Malloch, 1932: 199.—As *Tachina javana* (Malloch): Chao and Arnaud, **present new combination.** Preoccupied by *Tachina javana* Wiedemann (1819: 24, as *iavana*) and *Tachina javana* Macquart (1851: 177).

With the transfer of *Servillia javana* Malloch to the genus *Tachina* it becomes a secondary junior homonym. *Tachina jawensis* Chao and Arnaud, new name, is proposed for *T. javana* (Malloch), non *T. javana* Macquart. The specific name is a Neo-Latin adjective derived from the island of Jawa (formerly Java), Indonesia.

Tachina kunmingensis Chao and Arnaud, New Name

Servillia planiforceps Chao, 1962: 53.—As *Tachina* (*Servillia*) *planiforceps* (Chao): Herting, 1984: 87 (new combination). Preoccupied by *Tachina planiforceps* (Tothill, 1924: 261).

With the transfer of *Servillia planiforceps* Chao to the genus *Tachina* it becomes a secondary junior homonym. *Tachina kunmingensis* Chao and Arnaud, new name, is proposed to replace *T. planiforceps* (Chao), non *T. planiforceps* (Tothill). The specific name is a Neo-Latin adjective derived from Kunming, in Yunnan Province, People's Republic of China, the type locality.

Tachina mallochi Chao and Arnaud, New Name

Servillia atra Malloch, 1932: 197.—As *Tachina atra* (Malloch): Chao and Arnaud, **present new combination.** Preoccupied by *Tachina atra* Walker (1853: 273).

With the transfer of *Servillia atra* Malloch to the genus *Tachina* it becomes a secondary junior homonym. *Tachina mallochi* Chao and Arnaud, new name, is proposed to replace *T. atra* (Malloch), non *T. atra* Walker. The new name is dedicated to John Russell Malloch (1875–1963) a prodigious publisher on Diptera.

Tachina pingbian Chao and Arnaud, New Name

Servillia apicalis Chao, 1962: 58.—As *Tachina apicalis* (Chao): Chao and Arnaud, **present new combination.** Preoccupied by *Tachina apicalis* Meigen (1824: 333) and *Tachina apicalis* Walker (1853: 275).

With the transfer of *Servillia apicalis* Chao to the genus *Tachina* it becomes a secondary junior homonym. *Tachina pingbian* Chao and Arnaud, new name, is proposed to replace *T. apicalis* (Chao), non *T. apicalis* Meigen or *T. apicalis* Walker. The specific name is a noun in apposition to the generic name, based on Pingbian, the type locality in Yunnan Province, People's Republic of China.

Tachina rohdendorfiana Chao and Arnaud, New Name

Servillia rohdendorfi Chao, 1962: 51.—As *Tachina rohdendorfi* (Chao): Chao and Arnaud, **present new combination.** Preoccupied by *Tachina rohdendorfi* Zimin (1935: 556).

With the transfer of *Servillia rohdendorfi* Chao to the genus *Tachina* it becomes a secondary junior homonym. *Tachina roh-*

dendorfiana Chao and Arnaud, new name, is proposed to replace *T. rohdendorfi* (Chao), non *T. rohdendorfi* Zimin. All three names are dedicated to Boris B. Rohdendorf (1904–1977) distinguished authority on recent and fossil Diptera.

Tachina tienmushan Chao and Arnaud, New Name

Servillia flavipes Chao, 1962: 52.—As *Tachina* (*Servillia*) *flavipes* (Chao): Herting, 1984: 86 (new combination). Preoccupied by *Tachina flavipes* Meigen (1824: 280) and *Tachina flavipes* (Strobl) (1893: 94).

With the transfer of *Servillia flavipes* Chao to the genus *Tachina* it becomes a secondary junior homonym. *Tachina tienmushan* Chao and Arnaud, new name, is proposed to replace *T. flavipes* (Chao), non *T. flavipes* Meigen or *T. flavipes* (Strobl). The specific name is a noun in apposition to the generic name, based on the Tienmushan Mountains, in Zhejiang Province, People's Republic of China.

Tachina zaqu Chao and Arnaud, New Name

Servillia basalis Zimin, 1929: 214.—As *Tachina basalis* (Zimin): Herting 1984: 86 (new combination). Preoccupied by *Tachina basalis* Walker (1837: 351), *Tachina basalis* Walker (1849: 713), *Tachina basalis* Walker (1853: 281), and *Tachina basalis* Walker (1853: 285).

With the transfer of *Servillia basalis* Zimin to *Tachina* it became a secondary junior homonym. *Tachina zaqu* Chao and Arnaud, new name, is proposed to replace *T. basalis* Zimin, non *T. basalis* Walker. Named after the type locality—Zaqu, in Yushu Prefecture, Qinghai Province, People's Republic of China, a noun in apposition to the generic name.

Acknowledgment

We thank Dr. Wojciech J. Pulawski, California Academy of Sciences, San Francisco, for nomenclatural and editorial assistance.

Literature Cited

Arnaud, Jr., P. H. 1992a. Name changes in the genus *Tachina* of the Nearctic Region (Diptera: Tachinidae). Proceedings of the Entomological Society of Washington 94: 166–168.

———. 1992b. A new replacement name for a Nearctic *Tachina* (Diptera: Tachinidae). In Press.

Chao, C.-M. 1962. Descriptions of Chinese Larvaevoridae (Tachinidae). II. *Servillia*. Acta Entomologica Sinica 11, Suppl., pp. 43–65.

Cantrell, B. K. and R. W. Crosskey. 1989. Family Tachinidae, pp. 733–784. *In* Evenhuis, N. L., ed., Catalog of the Diptera of the Australasian and Oceanian Regions. Bishop Museum Special Publication 86: [1]–1155.

Crosskey, R. W. 1977. Family Tachinidae, pp. 586–697. *In* Delfinado, M. D. and D. E. Hardy, eds., A Catalog of the Diptera of the Oriental Region. Vol. 3: [i]–x, [1]–845. The University Press of Hawaii, Honolulu.

———. 1980. Family Tachinidae, pp. 822–882. *In* Crosskey, R. W., ed., Catalogue of the Diptera of the Afrotropical Region. British Museum (Natural History), London. 1437 pp.

Fallén, C. F. 1810. Försök att bestämma de i Sverige funne flugarter, som kunna föras till slägtet *Tachina*. Kongliga Vetenskaps Academiens Nya Handlingar [ser. 2] 31: 253–287.

Guimarães, J. H. 1971. Family Tachinidae (Larvaevoridae), pp. 104.1–104.333. *In* Papavero, N., ed., A Catalogue of the Diptera of the Americas South of the United States. Museu de Zoologia, Universididade de São Paulo.

Herting, B. 1984. Catalogue of Palearctic Tachinidae (Diptera). Stuttgarter Beiträge zur Naturkunde, Serie A (Biology) 369: 1–228.

Malloch, J. R. 1932. Some new species of the dipterous family Tachinidae. Stylops 1: 197–203.

Meigen, J. W. 1824. Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten. Vol. 4: xii + 428 pp., pls. 33–41. Hamm.

Strobl, G. 1893. Beiträge zur Dipterenfauna des österreichischen Littorale. Wiener Entomologische Zeitung 12: 89–108.

Tothill, J. D. 1924. A revision of the Nearctic species in the genus *Fabriciella* (Tachinidae). The Canadian Entomologist 56: 257–269.

Townsend, C. H. T. 1916. Some new North American muscoid forms. Insecutor Inscitiae Menstruus 4: 73–78.

Walker, F. 1837. Descriptions, &c. of the Diptera, pp. 331–359. *In* Curtis, J., A. H. Haliday, and F. Walker, eds., Descriptions, &c. of the Insects Collected by Captain P. P. King, R.N., F.R.S., in the Survey of the Straits of Magellan. The Transactions of the Linnean Society of London 17: 315–359.

———. 1849. List of the Specimens of Dipterous Insects in the Collection of the British Museum. Part IV, pp. 689–1172. British Museum, London.

———. 1853. Diptera. Part IV, pp. 253–414, 4 pls. *In* Insecta Saundersiana: Or Characters of Undescribed Insects in the Collection of William Wilson Saunders, Esq., F.R.S., F.L.S., etc. Vol. 1. Van Voorst, London. 474 pp.

Zimin, L. S. 1929. Kurze Uebersicht der palaearktischen Arten der Gattung *Servillia* R.—D. (Diptera). II. Revue Russe d'Entomologie 23: 210–224.

———. 1935. Sistema triby Tachinini (Diptera, Larvivoridae). Trudy Zoologicheskogo Instituta Leningrad 2: 509–636.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 52–58

TWO NEW SPECIES OF *ANASTREPHA* (DIPTERA: TEPHRITIDAE) WITH ATYPICAL WING PATTERNS

Allen L. Norrbom

Systematic Entomology Laboratory, USDA, ARS, PSI, % National Museum of Natural History, NHB 168, Washington, D.C. 20560.

Abstract.—Two species of the genus *Anastrepha* Schiner with atypical wing patterns are described: ***A. aberrans*** from Rancho Grande, Venezuela, and ***A. freidbergi*** from Pakitza, Peru. A close relationship between *A. freidbergi* and *A. doryphoros* Stone is hypothesized, and the latter species is also redescribed.

Resumen.—Se describen dos especies del género *Anastrepha* Schiner, las cuales presentan patrones alares atípicos: ***A. aberrans*** de Rancho Grande, Venezuela, y ***A. freidbergi*** de Pakitza, Peru. Se propone una hipotesis sobre la estrecha relación entre *A. freidbergi* y *A. doryphoros* Stone, y de esta última se hace también una redescripción.

Key Words: Diptera, Tephritidae, *Anastrepha,* new species, wing pattern, Peru, Venezuela

---

Anastrepha Schiner is the largest genus of Tephritidae in the New World, including almost 200 species (Norrbom and Kim 1988b), many of which are important fruit pests. Most species have a wing pattern in which three bands, termed the C-, S-, and V-bands by Stone (1942a), are at least partially represented. Two new species with atypical wing patterns are described in this paper. *Anastrepha doryphoros* Stone, to which one of the new species is closely related, also is redescribed in more detail.

Materials and Methods

I follow the morphological terminology of McAlpine (1981) and White (1988), except as noted in Norrbom and Kim (1988a). Acronyms used in the text for the depositories of specimens are as follows: National Museum of Natural History, Smithsonian Institution (USNM); Staatliches Museum für Tierkunde, Dresden (SMT).

Anastrepha aberrans **Norrbom,**
New Species

(Figs. 1A, 2C, 3A, D, G)

Type data.—Holotype ♀ (USNM), VENEZUELA: Aragua: Parque Nacional Henri Pittier, Rancho Grande, 1100 m, 1–5.XI.1966, S. S. & W. D. Duckworth.

Diagnosis.—The lack of a marginal hyaline spot or band at the apex of vein R_1 distinguishes *A. aberrans* from most species of *Anastrepha.* Other species lacking this spot include: some species of the *daciformis* group, which differ from *A. aberrans* in having only 1 orbital seta and the basal third or more of the scutellum orange to brown, distinctly darker than the apex; and *A. bezzii* Lima, species of the *grandis* group (Norrbom 1991), and some specimens of *A. cordata* Aldrich, all of which differ from *A. aberrans* in having a complete S-band that crosses cell dm. In addition to having a complete S-band, *A. castilloi* Norrbom of the *grandis* group, which might be the most

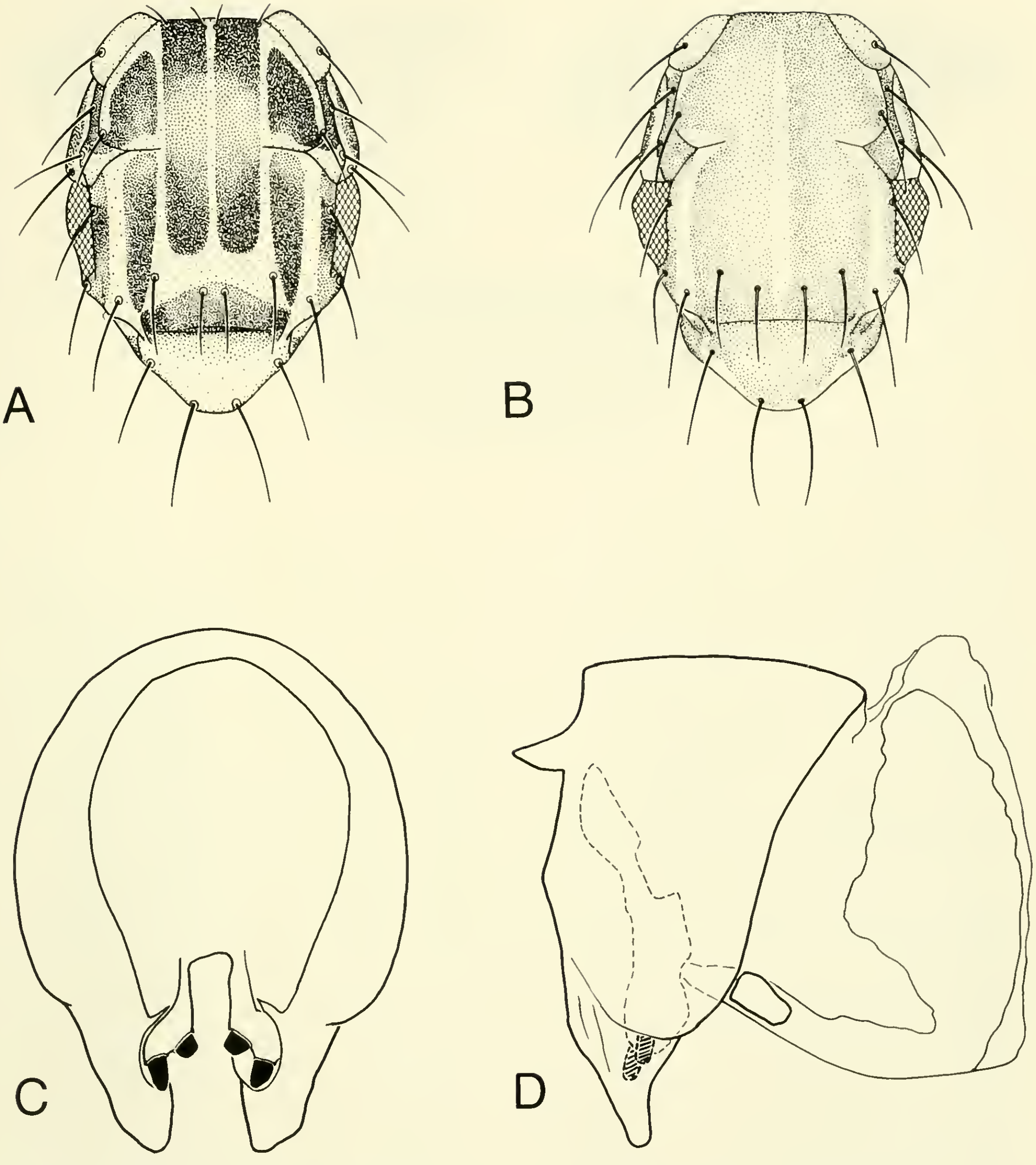


Fig. 1. A–B, Mesonotum, dorsal view; C, epandrium and surstyli, posterior view (setae omitted); D, epandrium, surstyli, and proctiger, lateral view (setae omitted); A, *A. aberrans*; B–D, *A. freidbergi*.

closely related species to *A. aberrans* (see "Remarks"), differs in terminalia length (syntergosternite 7 is 4.49–4.95 mm long, 1.21–1.35 times as long as mesonotum), in the markings of the thoracic pleuron, especially the dark greater ampulla, and in the shape of the medial yellow scutal stripe, which is more gradually expanded posteriorly. On the basis of wing pattern alone, *A. aberrans* might be mistaken as a species of *Toxotrypana* Gerstaecker, but it differs from members of that genus in having vein R_{2+3} nonsinuous, the scutum without a medial furrow, the abdomen non-petiolate, and most head and thoracic setae normal in size.

Description.—Mostly orange to dark

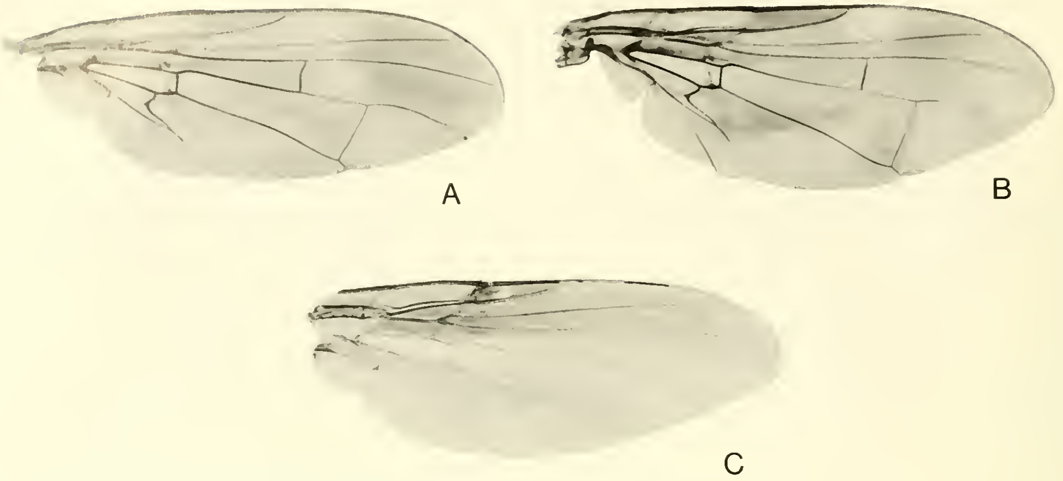


Fig. 2. Wings: A, *A. doryphoros*; B, *A. freidbergi*; C, *A. aberrans*.

brown. Setae blackish. *Head.*—Concolorous orange except ocellar tubercle dark brown and orbital plates blackish from anterior orbital seta to vertex; 2 frontal setae; 2 orbital setae, posterior one strong. Antenna extended 0.85 distance to lower facial margin. *Thorax.*—Mesonotum (Fig. 1A) 4.66 mm long. Scutum entirely microtrichose; mostly orange to dark brown; single distinct yellowish medial stripe from anterior margin to slightly posterior to acrostichal seta, abruptly broadly expanded posteriorly, extended laterally to dorsocentral seta; narrow, distinct yellowish dorsocentral stripe, fused anteriorly with yellowish area along postpronotal lobe and broadly fused posteriorly with medial stripe; distinct yellowish mark extended posteriorly from postpronotal lobe to presutural supra-alar seta; distinct yellowish sublateral stripe from transverse suture to posterior margin, across intra-alar seta; scuto-scutellar suture entirely dark brown, without distinct medial spot. Subscutellum and mediotergite orange-brown, subscutellum narrowly dark brown laterally. Pleura yellowish except oblique dark brown stripe across posterior third of anepisternum, large dark brown spot on posterior half of anepimeron, and moderate brown spot on posterior margin of laterotergite. Katepisternal seta weak, orange, subequal to postocellar seta. *Wing* (Fig. 2C).—Length 12.76 mm. Vein M moderately curved apically; section between bm-cu and r-m 2.32 times as long as section between r-m and dm-cu. Pattern faint orange, its margins diffuse, comprising: broad costal band filling cells bc, c, sc, r_1, r_{2+3}, and br and r_{4+5} anteriorly; and band filling cell bcu and extended broadly, but faintly, along veins A_1 + Cu_2, Cu_1 and dm-cu. Cell bm and anterior half of cell dm hyaline. *Abdomen.*—Tergites unicolorous yellowish brown. *Female terminalia.*—Syntergosternite 7 9.63 mm long; 2.07 times as long as mesonotum. Eversible membrane (Fig. 3A) with dorsobasal scales minute except 10 large hooklike scales in single row, separated from minute basal scales by membranous area; largest scales 0.25 mm long. Aculeus 8.81 mm long; shaft 0.08 mm wide at midpoint, sides parallel; tip (Fig. 3D) 0.51 mm long, 0.08 mm wide, non-serrate, sides slightly convex. Spermathecae (Fig. 3G) globose.

Remarks.—*A. aberrans* may be related to the *grandis* group, and particularly to *A. castilloi* Norrbom, which has a similar pattern of dorsobasal scales on the eversible membrane, with a single complete row of large scales separated from the small basal scales by a membranous area. The scutal color pat-

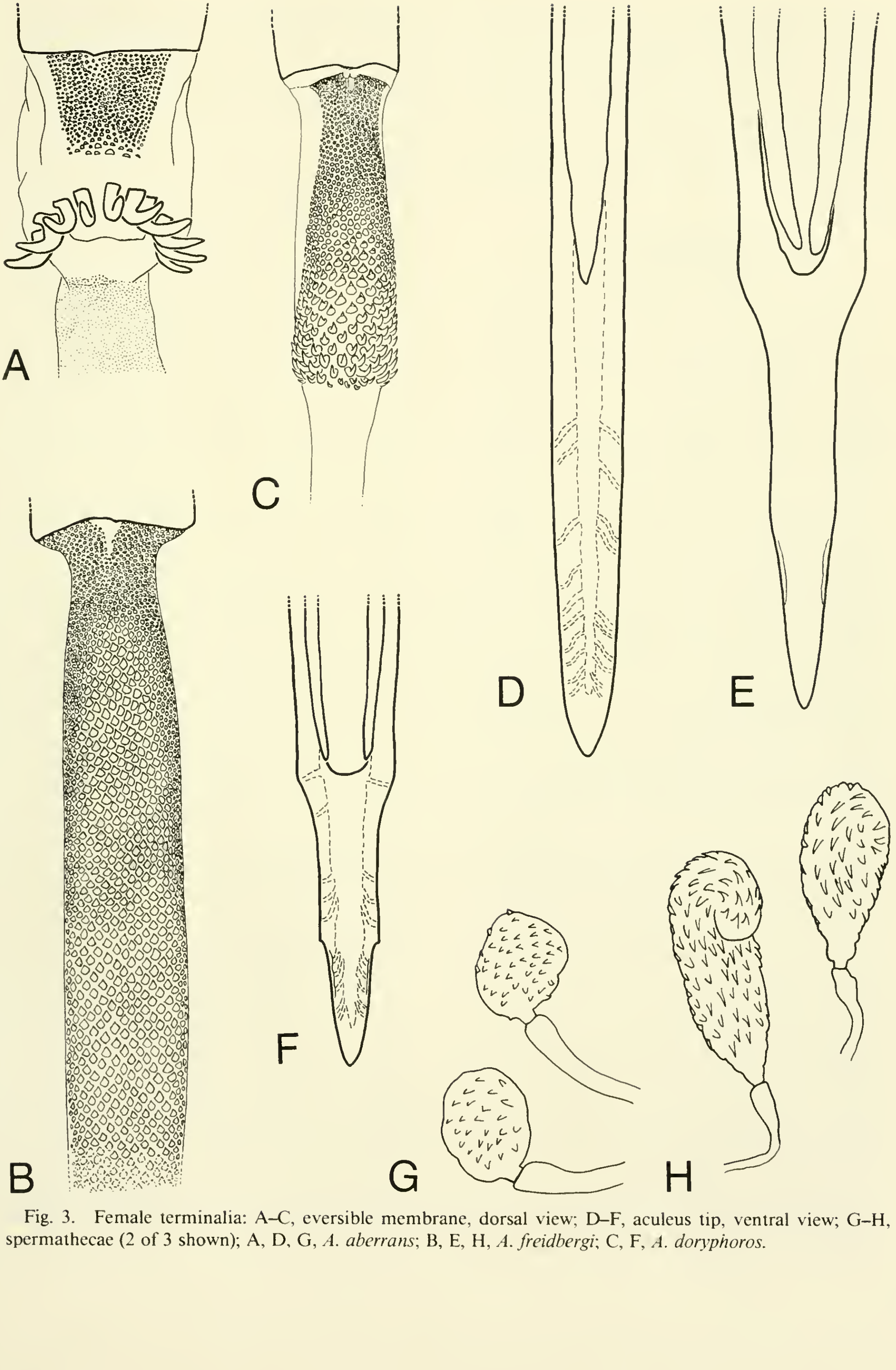


Fig. 3. Female terminalia: A–C, eversible membrane, dorsal view; D–F, aculeus tip, ventral view; G–H, spermathecae (2 of 3 shown); A, D, G, *A. aberrans*; B, E, H, *A. freidbergi*; C, F, *A. doryphoros*.

terns and the shape of the aculeus tip in these two species are also similar (see diagnosis to distinguish these species). Discovery of the male of *A. aberrans* may better clarify its relationships.

Etymology.—From the Latin aberrans (wandering), in reference to the unusual wing pattern.

Anastrepha freidbergi Norrbom, New Species

(Figs. 1B–D, 2B, 3B, E, H)

Type data.—Holotype ♀ (USNM), PERU: Madre de Dios: Manu, Rio Manu, Pakitza, 12°7′S 70°58′W, 250 m, on *Celtis* sp., 16.IX.1988, A. Freidberg. Paratypes: PERU: Madre de Dios: Manu, Rio Manu, Pakitza, 12°7′S 70°58′W, 250 m, 9–23.IX.1988, A. Freidberg, 1 ♀ (USNM). BOLIVIA: Mapiri, Sarampioni, 700 m, I–III.1903, 2 ♂ (SMT) 2 adults without abdomens (SMT, USNM); Mapiri, S. Antonio, 1000 m, 23.II.1903, 1 ♂ (USNM); Mapiri, S. Carlos, 800 m, I.1903, 1 adult without genitalia (SMT).

Diagnosis.—In Steyskal's (1977) key to the species of *Anastrepha, A. freidbergi* runs to *A. doryphoros,* from which it differs as follows: cell r_{4+5} without large subbasal hyaline area but with subapical hyaline area; hyaline spot in cell r_1 not extended to vein R_{4+5}; r-m closer to dm-cu; scutal microtrichia more extensive, submedial bare stripes shorter and more lateral bare areas absent; dorsobasal scales of eversible membrane smaller and arranged in more elongate pattern; and, aculeus tip not narrowed steplike at three-fifths its length. In the male, the posterodorsal margin of the epandrium strongly projects and there are small basal sclerotized areas on the proctiger, characters I have not observed in any other species of *Anastrepha.* They may be unique to *A. freidbergi* or may also occur in *A. doryphoros,* the male of which is unknown.

Description.—Mostly orange to redbrown. Setae redbrown to blackish. *Head.*—Concolorous except ocellar tubercle dark brown; 3–6 frontal setae; 2 orbital setae, posterior one often weak. Antenna extended 0.55–0.65 distance to lower facial margin. *Thorax.*—Mesonotum (Fig. 1B) 3.85–4.74 mm long. Scutum microtrichose except submedial bare stripe slightly lateral to acrostichal seta, narrow except at anterior margin, extended posteriorly at least to level of postsutural supra-alar seta but not beyond midpoint between transverse suture and posterior scutal margin; mostly orange-brown to redbrown; single distinct yellowish medial stripe, narrow posteriorly, not extended laterally beyond acrostichal seta; no dorsocentral stripes; small yellowish area along postpronotal lobe; distinct yellowish sublateral stripe from transverse suture to posterior margin, across intra-alar seta; scuto-scutellar suture without dark brown markings. Subscutellum and mediotergite dark redbrown to brown, usually lighter medially, but not with distinct borders as in *fraterculus* group. Pleura usually undifferentiated except yellowish dorsal anepisternal stripe and moderate brown spot on posterior margin of laterotergite. Katepisternal seta weak, yellowish, subequal to postocellar seta. *Wing* (Fig. 2B).—Length 10.40–12.18 mm. Vein M moderately curved apically; section between bm-cu and r-m 2.44–2.84 times as long as section between r-m and dm-cu. Pattern orangebrown, its margins often diffuse. Cell r_1 with broad semicircular hyaline spot apical to vein R_1 extended only to vein R_{2+3}. C-band and base of S-band broadly fused; cell r_{2+3} entirely infuscated; cell br at most with tiny hyaline area; cell bm and extreme base of cell dm hyaline. Apex of S-band and apical arm of V-bands separated only in cell r_{4+5}. Base of S-band and proximal arm of V-band separated by wedgeshaped hyaline or yellowish area in cell dm, sometimes extended slightly into cell r_{4+5}. *Abdomen.*—Tergites unicolorous orangebrown. *Male terminalia.*—Epandrium produced posterodorsally, angulate in lateral view (Fig. 1D). Outer surstylus moderately long; in posterior view (Fig. 1C), with outer margin distinctly narrowed from epandrium basally, slightly and unevenly tapered to blunt apex; mesal margin almost straight or slightly convex. Proctiger with distinct lateral fold; sclerotized parts narrowly connected; small area near base strongly sclerotized. Aedeagus 21.50–22.70 mm long; 5.00–5.71 times as long as mesonotum. Distiphallus 0.50–0.55 mm long; endophallic sclerite strong, stout and distinctly convoluted apically. *Female terminalia.*—Syntergosternite 7 13.83–14.65 mm long; 2.92–3.12 times as long as mesonotum; basal lateral lobes separated from main sclerite by membranous area. Eversible membrane (Fig. 3B) with dorsobasal scales all small, largest 0.05 mm long, triangular and projected, but not hooklike; scales extended to 5.0 mm from base of membrane, gradually decreased in size to spicules. Aculeus (dissected only in paratype) 12.34 mm long; base slightly expanded; shaft 0.15 mm wide at midpoint; tip (Fig. 3E) 0.49 mm long, 0.14 mm wide, non-serrate, tapered rapidly subbasally, then parallel sided, then gradually tapered, without step, at about three-fifths distance to apex. Spermathecae (Fig. 3H) ovoid to elongate ovoid.

Remarks.—This species and *A. doryphoros* form a monophyletic group characterized by the following synapomorphies: scutum with submedial nonmicrotrichose stripe; S- and V-bands fused basally and apically in cell r_{4+5} (occurs convergently in *A. obscura* Aldrich); dorsobasal scales of eversible membrane reduced in size but distributed in elongate pattern (a similar pattern occurs convergently in *A. bezzii*); aculeus tip tapered, parallel sided, then tapered. Their relationship among the other species groups of *Anastrepha* is unclear, except that they belong to the large group of species groups which have a distinct lateral crease in the proctiger.

The wing pattern of *A. freidbergi* is intermediate between the normal *Anastrepha* pattern and that of *A. doryphoros,* whereas the scales of the eversible membrane are less reduced in *A. doryphoros* than in *A. freidbergi.*

Etymology.—This species is named for the collector of the holotype, Dr. Amnon Freidberg.

Anastrepha doryphoros Stone
(Figs. 2A, 3C, F)

Anastrepha doryphoros Stone 1942b: 299 (description); Foote 1967: 10 (catalog); Steyskal 1977: 4 (in key); Norrbom and Kim 1988b: 5 (in classification).

Type data.—holotype ♀ (USNM), PANAMA: El Cermeño, 5.XII.1939, J. Zetek, Z-4600; USNM Type No. 56318; ovipositor mounted on slide 40.I.11a, wing on slide 40.I.11b. I added a holotype label.

Description.—Mostly light orangebrown. Setae blackish. *Head.*—Concolorous except ocellar tubercle dark brown; most head setae lost on holotype, but 3 sockets for frontal setae, 2 for orbital setae, size of socket for posterior seta indicates it was well developed. Antenna extended 0.63 distance to lower facial margin. *Thorax.*—Mesonotum 3.55 mm long. Scutum microtrichose except submedial bare stripe slightly lateral to acrostichal seta, narrow except anteriorly, extended posteriorly to level of dorsocentral seta; triangular presutural lateral bare area; and small bare stripe between dorsocentral and intra-alar setae on posterior quarter. Scutum mostly light orangebrown; single distinct yellowish medial stripe, narrow posteriorly, not extended laterally beyond acrostichal seta; no dorsocentral stripes; small yellowish area along postpronotal lobe; distinct yellowish sublateral stripe from transverse suture to posterior margin, across intra-alar seta; scuto-scutellar suture without dark brown markings. Subscutellum and mediotergite entirely light orangebrown. Pleura undifferentiated except yellowish dorsal anepisternal stripe. Katepisternal seta weak, yellowish. *Wing* (Fig. 2A).—Length 9.80 mm. Vein M moderately curved apically; section between bm-cu and r-m 1.79 times as long as section between r-m and dm-cu. Pattern orangebrown, diffuse. Cell r_1 with broad semicircular hyaline spot apical to vein R_1 extended to vein R_{4+5}. S-band not recognizable, broadly fused to C-band basally and to V-band apically and in cell dm, and almost interrupted along vein R_{4+5}; cell br, cell r_{2+3} basal to r-m, and cell dm, except extreme base, infuscated; cell r_{2+3} and r_{4+5} infuscated apically, but r_{4+5} with large subbasal hyaline spot; cell bm hyaline. *Abdomen.*—Tergites unicolorous yellowish brown. *Female terminalia.*—Syntergosternite 7 8.60 mm long; 2.42 times as long as mesonotum; basal lateral lobes small, connected normally to main sclerite. Eversible membrane (Fig. 3C) with dorsobasal scales increased in size until 1.08 mm from base, then abruptly reduced to minute spicules, largest scales 0.09 mm long, cylindrical and hooklike. Aculeus 7.50 mm long; base slightly expanded; shaft 0.12 mm wide at midpoint; tip (Fig. 3F) 0.33 mm long, 0.11 mm wide, non-serrate, tapered rapidly subbasally, then parallel sided, with distinct step at about three-fifths distance to apex, then gradually tapered. Spermathecae not examined.

Remarks.—Stone (1942b) described the aculeus tip of the holotype as having minute serrations, but his figure does not show them and I was unable to observe any using a compound microscope.

Specimens examined.—Holotype.

ACKNOWLEDGMENTS

I am grateful to U. Kallweit (SMT) for the loan of study material, and to R. A. Zucchi (Universidade de São Paulo, Piracicaba), V. Hernandez O. (Instituto de Ecologia, Xalapa), and G. J. Steck (Florida Department of Food and Agriculture) for their reviews of the manuscript. L. Lawrence drew the illustrations of the mesonota and eversible membranes of *A. freidbergi* and *A. doryphoros*, S. Shute prepared the plates, and T. B. Griswald produced the wing photographs.

LITERATURE CITED

Foote, R. H. 1967. Family Tephritidae (Trypetidae, Trupaneidae). 91 pp. *In* Vanzolini, P. E. and N. Papavero, eds., A Catalogue of the Diptera of the Americas South of the United States. Fasc. 57. Departamento de Zoologia, Secretaria da Agricultura, São Paulo.

McAlpine, J. F. 1981. Morphology and terminology—adults, pp. 9–63. *In* J. F. McAlpine, B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood (coords.), Manual of Nearctic Diptera, vol. 1. Agriculture Canada, Monograph No. 27. Ottawa.

Norrbom, A. L. 1991. The species of *Anastrepha* (Diptera: Tephritidae) with a *grandis*-type wing pattern. Proceedings of the Entomological Society of Washington 93: 101–124.

Norrbom, A. L. and K. C. Kim. 1988a. Revision of the *schausi* group of *Anastrepha* Schiner (Diptera: Tephritidae), with a discussion of the terminology of the female terminalia in the Tephritoidea. Annals of the Entomological Society of America 81: 164–173.

———. 1988b. A list of the reported host plants of the species of *Anastrepha* (Diptera: Tephritidae). U.S. Dept. Agric., Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Hyattsville, MD. 114 pp.

Steyskal, G. C. 1977. Pictorial key to species of the genus *Anastrepha* (Diptera: Tephritidae). Entomological Society of Washington, Washington, D.C. 35 pp.

Stone, A. 1942a. The fruitflies of the genus *Anastrepha.* United States Department of Agriculture, Miscellaneous Publications No. 439, 112 pp.

———. 1942b. New species of *Anastrepha* and notes on others (Diptera, Tephritidae). Journal of the Washington Academy of Sciences 32: 298–304.

White, I. M. 1988. Tephritid flies, Diptera: Tephritidae. Handbooks for the Identification of British Insects 10(5a): 1–134.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 59–69

NEW SPECIES, SUBSPECIES, AND STAGE DESCRIPTIONS OF TEXAS BAETIDAE (EPHEMEROPTERA)

W. P. McCafferty and A. V. Provonsha

Department of Entomology, Purdue University, West Lafayette, Indiana 47907.

Abstract.—***Baetodes bibranchius***, new species, is described from larvae and male and female adults. It is common in the central hill country of Texas where larvae develop in moderate currents in small to medium sized streams. ***Baetodes alleni***, new species, is described from larvae from the Guadalupe River. Congeners are discussed, and a key to the *Baetodes* species of the United States is provided. ***Procloeon texanum***, new species, is described from distinctive male adults reared from larvae from the Navasota River. It is the first nominal North American species of *Procloeon* lacking hindwings known outside northern regions of the United States and Canada. ***Callibaetis montanus punctilusus***, new subspecies, is a distinct lowland geographic variant differing in color and punctation from the primarily Mexican and Central American mountainous subspecies *C. montanus montanus* Eaton, new status. *Camelobaetidius mexicanus* (Traver and Edmunds), a relatively common Texas mayfly, is described in the adult stage for the first time based on reared adults associated with the distinctive larvae.

Key Words: Mayflies, Baetidae, Texas, new descriptions, new records

Small minnow mayflies (family Baetidae) are arguably the most taxonomically difficult and challenging group of mayflies in North America and other parts of the world due in large degree to their small size, relatively extensive adaptive radiation, and proclivity for convergent evolution with respect to reduction of size, wings, etc. Recent revisionary work (e.g. McCafferty and Waltz 1990) has begun to remedy this situation, however, considerable additional research is needed, not the least of which will be the description and documentation of species and species variability. Such descriptive works (e.g. Mayo 1972, Morihara and McCafferty 1979a, Waltz and McCafferty 1987, Lowen and Flannagan 1991) are obvious prerequisites to determining phylogenetic relationships and appropriate generic limits within the family [e.g. the progressive resolution of *Heterocloeon* (Müller-Liebenau 1974, McCafferty and Provonsha 1975, Morihara and McCafferty 1979b)].

During a recent survey of the family Baetidae in Texas, a number of new species or variants of species were discovered. In addition, we reared adults of one previously described and common species for which that stage has been unknown. Descriptions of these new taxa and the adult stage follow. With regard to the other variant populations we discovered in Texas, we defer describing them as new taxa at this time because of the possibility that they actually represent undescribed stages of previously described species. In most instances, only associations of larvae and adults through rearing will resolve whether or not these undescribed populations represent new taxa.

Baetodes bibranchius McCafferty and Provonsha, New Species
Figs. 1–5

Mature larva (in alcohol).—Body length excluding cerci: 4.2–4.6 mm; cerci 5.0 mm. *Head:* Vertex generally pale with medium brown shading in areas dorsal to antennal bases and area surrounding median ocellus. Labrum (Fig. 1) slightly narrower than inter-antennal distance, emarginate medially and with sclerotized cleft line at midpoint of apical emargination. *Thorax:* Nota pilose, pale with brown shading in some, most noticeable on pronotum. Sterna pale. Legs pale except for dark line at sclerotized and rounded apices of femora. Claws with five or more denticles. Fingerlike coxal gills double and slightly longer than median length of trochanters. Pronotum (Fig. 2) with medioposterior hump most apparent in lateral view. Mesonotum with very poorly developed posterior tubercle in form of two very small nodules. Metanotum (Fig. 2) with well-developed and erect tubercle, and reddish brown in anterior half as in abdominal terga 1–2 or 1–3. *Abdomen:* Terga (Fig. 3) generally pale, with reddish brown shading mostly in anterior half of segments 1–3, sometimes most evident in 1–2; other segments entirely pale or at most suffused with thin light brown shading anterolaterally and sometimes anteromedially. Dorsal median tubercles (Fig. 2) on segments 1–9, well developed and erect (but progressively less erect) on 1–5, well developed and moderately angled posteriorly on 6–7, well developed and strongly angled posteriorly on 8, and poorly developed and nearly flat on 9. Sterna pale but in some appearing suffused with granular pale brown, sometimes more intense anterolaterally in ganglionic areas. Gills pale. Cerci pale.

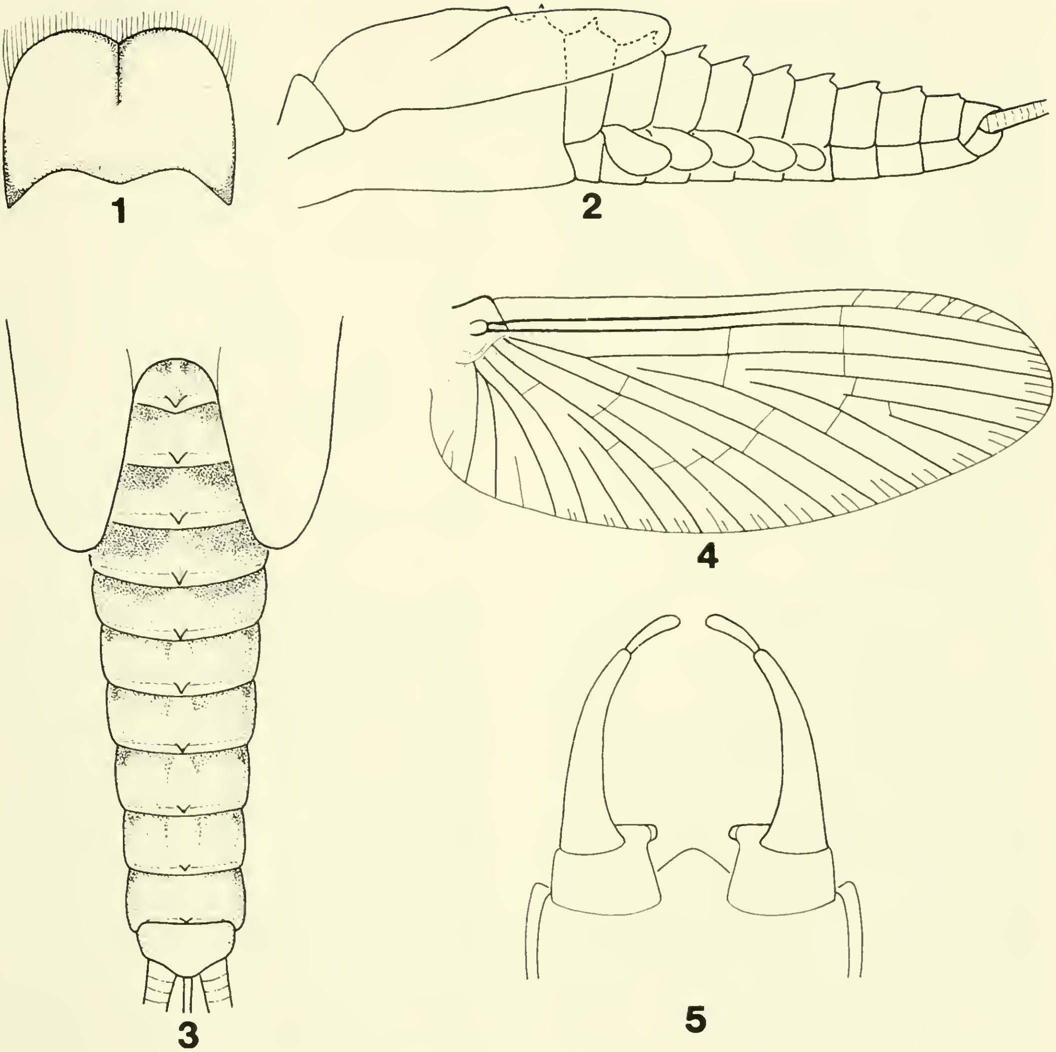
Male adult (in alcohol).—Body length: 5.0–5.5 mm; wing: 5.0 mm; cerci: unknown. *Head:* Face medium brown. Flagellum of antennae pale; scape and pedicel light brown. Compound eyes black, except turbinate portion pale. *Thorax:* Nota medium brown with few pale markings, prominent only as posterolateral and medial markings on mesonotum. Sterna medium brown, paler medially. Legs pale. Wings (Fig. 4) tinged with golden brown basally especially extreme basal posterior region of costal area; otherwise membrane and veins hyaline; venation as in Fig. 4. *Abdomen:* Terga generally pale except dark brown shading in at least anterior halves of terga 1 and 2, and light brown coloration of terga 7–10; remnants of dorsal abdominal tubercles of larva not evident. Sterna pale, slightly suffused with tan. Minute gill remnants present or not present on abdominal segments 1 and 2, absent from other segments. Genitalia as in Fig. 5, with well-developed inner lobes on basal segments of forceps and with well-developed basal convexity on subgenital plate between bases of foreceps.

Female adult (in alcohol).—Body length: 4.0 mm; wing 5.0 mm; cerci 9.0 mm. Body similar to that of male except shorter and more robust (wing length similar). Color pattern similar to male except thorax lighter shade of brown; basal tinge of wings less intense; and abdominal terga sometimes with brown segmental overlap areas, and terga 3–7 sometimes with some faint dark shading anterolaterally. Cerci pale, slightly tan at base.

Holotype.—Mature male larva, Texas, Kendall Co., Guadalupe River 1 mi S of Sisterdale at Ranch Road 1376, V-7-1977, W. P. McCafferty, A. V. Provonsha, D. Morihara, deposited in the Purdue Entomological Research Collection (PERC), West Lafayette, Indiana.

Paratypes.—One male larva and one female larva, same data and deposition as holotype.

Additional material examined.—Two larvae, Texas, Blanco Co., Blanco River 6 mi W Blanco, V-6-1977, W. P. McCafferty, A. V. Provonsha, D. Morihara, deposited in PERC; two larvae, Texas, Blanco Co., Blanco River 6 mi W Blanco, V-7-1977, W. P. McCafferty, A. V. Provonsha, D. Mori-



Figs. 1–5. *Baetodes bibranchius*: 1. Labrum, larva. 2. Lateral profile of body, larva. 3. Dorsal abdominal color pattern, larva. 4. Wing, male adult. 5. Ventral genitalia, male adult.

hara, in PERC; one immature larva, Texas, Guadalupe Co., Geronimo Creek from mi 20 N Seguin, VI-29-1988, J. R. Davis, deposited in the J. R. Davis private collection, Austin, TX; two male and six female adults, Texas, Kerr Co., Guadalupe River at Kerrville, at light, V-5-1977, W. P. McCafferty, A. V. Provonsha, D. Morihara, in PERC.

Etymology.—The specific epithet is an arbitrary combination of letters incorporating "bi" for double, and "branchius," Greek for gill. It thus alludes to the distinctive double coxal gills of the larvae.

Discussion.—This new species is evidently common in many streams in the central hill country of Texas, as would be indicated by the collecting records given above. Larvae have been found only in moderate current and often in association with somewhat silty substrates (specimens are often partially covered with silt held by the pilose thoracic nota). More precise ecological data are not available at this time. Adults, which have been associated with the larvae on the basis of the matching unique color patterns, were taken only at lights on signs adjacent to the Guadalupe River at Kerrville. Subimagos, however, were not taken.

The larvae of *B. bibranchius* are distinctive and can be compared with other known larval *Baetodes* on the basis of the published summary of Cohen and Allen (1978). A larval diagnosis is presented below via a key to the species known to occur in the United States. Unfortunately, relationships within the genus are unknown, and little can be surmised with confidence regarding the relationships of *B. bibranchius.*

Cohen and Allen (1978) indicated that details of size and mouthpart structure were of little use in the taxonomy of this group due to variability they had seen. They instead emphasized characters of tubercle placement, coloration, and, in some cases, characters of the coxal gills; they did not deal with adult characterization. On the basis of tubercle development and placement in *B. bibranchius,* the species may be related to the Central American species *B. noventus,* however, it differs in other important respects from *B. noventus.* On the basis of color patterns, *B. bibranchius* is unique but could perhaps be envisioned as having the same dorsal abdominal tendencies as the Mexican and Honduran species *B. pallidus* Cohen and Allen, but developed to a much lesser degree. It is questionable, however, if color patterns per se in mayflies are indicative of relationship. Finally, according to Cohen and Allen (1978), there are only two other species with double coxal gills. The length of such gills may be similar in *B. bibranchius* and the Mexican species *B. longus* Mayo, but the length of the double gills of the Mexican and Panamanian species *B. adustus* was not given.

Adults of *A. bibranchius* can easily be distinguished from the two other North American species of *Baetodes* that are presently known as adults (*B. edmundsi* Koss and *B. arizonensis* Koss). Key differences (see Koss 1972) are that the sterna of *A. bibranchius* are entirely pale, and no remnants of dorsal larval tubercles are present. The sterna of *B. arizonensis* are dark reddish brown in the anterior half or third, and faint posteromedian remnants of tubercles are present on some abdominal segments in *B. edmundsi,* among other differences. The most diagnostic feature of adults of *B. bibranchius* is perhaps the presence of the heavily pigmented abdominal terga 1–3, which contrast the remainder of the abdomen.

Adult generic characteristics of *Baetodes* are poorly known, the delineating characters given by Koss (1972) and Edmunds et al. (1976) being tenuous. While the number of known adults prohibits any meaningful evaluation of relationships based on this life stage, Flowers (1987) was able to correlate adults of four additional species of Neotropical species of *Baetodes.* On that basis, he was able to establish which characters might be consistent and which might be variable among species of the genus. All known adults have some degree of medial cuticular development on the basal segments of the male forceps, but the degree and kind of development appear to differ among species. In this respect the genitalia of *B. bibranchius* (Fig. 5) are much like that of the Panamanian species *B. velmae* Cohen and Allen. Flowers (1987) also pointed out that the wing shape character given by Edmunds et al. (1976) regarding the hind margin is not consistent in the genus. In any case, it has been particularly difficult for workers to interpret. The shape of the wing of *B. bibranchius* (Fig. 4) is typical of most known adults, however, having a hind margin more-or-less subparallel to the costa. We agree with Flowers (1987) that the character of the distance between marginal intercalaries (interspaces) being subequal to their length is not generic. We have found both the interspace size mentioned above and relatively smaller interspaces in a single wing of specimens of *B. bibranchius.* Therefore, the character is even of doubtful specific importance.

Baetodes alleni **McCafferty and Provonsha, NEW SPECIES**

Figs. 6–7

Mature male larva (in alcohol).—Relatively large with somewhat atypical elongate body 6.0 mm in length excluding cerci; cerci: 6.2 mm. *Head:* Vertex generally light brown, with slightly darker, faint, longitudinal stripes between compound eyes. Labrum narrow and emarginate but without sclerotized cleft line. *Thorax:* Nota with scattered and sparse, short hairs; color medium brown with pale markings prominent on mesonotum. Sterna pale but with pair of dark, sublateral lines on mesosternum. Legs generally pale except thin light brown shading along dorsal third of anterior facing surface of femora, and dark brown apices of femora. Claws with three prominent apical denticles and three or four less prominent basal denticles. Coxal gills absent. Pronotum (Fig. 6) with medioposterior elevation. Mesonotum without tubercle, but with pale median and pair of submedian longitudinal stripes. Metanotum (Fig. 6) with small tubercle. *Abdomen:* Terga (Fig. 7) light brown with darker anterior marginal areas progressively less developed in posterior segments; moderately developed tubercles on terga 1–7 (Fig. 6); tubercle on terga 8 barely discernible. Sterna pale with thin, poorly developed darker areas at segmentation margins. Gills pale. Cerci pale.

Holotype.—Mature male larva, Texas, Kendall Co., Guadalupe River 1 mi S of Sisterdale at Ranch Road 1376, V-7-1977, W. P. McCafferty, A. V. Provonsha, D. Morihara, deposited in PERC.

Etymology.—This species is named after the entomologist Richard K. Allen, in honor of his extensive contributions to our taxonomic knowledge of the mayflies of Mesoamerica and the southwestern United States.

Discussion.—We are aware of the tentative nature of any species whose description is based on limited materials. However, we decided to describe *A. alleni* at this time because it was distinct from any variations known of any other described species, and was easily distinguished from congeners, particularly those from the southwestern United States. Its diagnosis is given in the partial key below.

In terms of size, Cohen and Allen (1987) noted only four Mexican and Central American species known to be as large as *B. alleni* larvae: *B. adustus* Cohen and Allen; *B. pictus* Cohen and Allen, *B. tritus* Cohen and Allen, and *B. velmae.* In terms of coxal gills, seven species were noted to have at least some individuals devoid of such gills, as in *B. alleni*: *B. arizonensis, B. fuscipes* Cohen and Allen, *B. inermis* Cohen and Allen, *B. pallidus, B. pictus* Cohen and Allen, *B. tritus* Cohen and Allen, and *B. velmae.* In terms of dorsal tubercle distribution and development, *B. alleni* appears to be most like *B. adustus* Cohen and Allen, but *B. inermis, B. longus,* and *B. pallidus* are somewhat similar. The color pattern of *B. alleni* is difficult to relate to any others. Little, if anything, can be deduced about relationships from the above larval comparisons. This underscores the necessity of revisionary studies of this genus as was suggested by McCafferty and Waltz (1990).

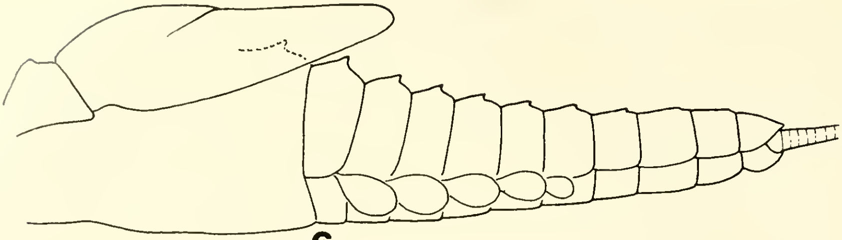
KEY TO THE UNITED STATES SPECIES OF *BAETODES*

The following larval key is an extension of the key of Cohen and Allen (1978: 255), which includes Latin American species.

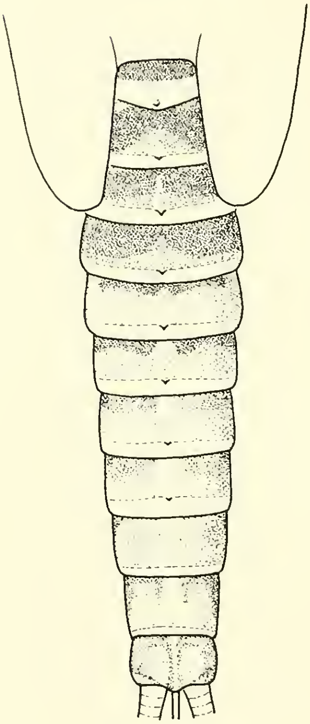
1. Coxal gills double; abdomen (Fig. 3) with terga 1–3 reddish brown in anterior halves, not markedly patterned otherwise; metanotal tubercle well developed (Fig. 2) .... *bibranchius*

– Coxal gills absent, or present and single; dorsal abdomen not patterned and colored as in Fig. 3; metanotal tubercle present or absent 2

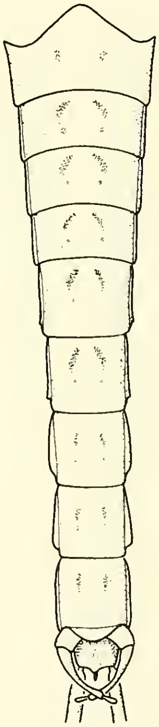
2. Abdominal tubercles present on terga 1–7; abdominal terga with dark bands anteriorly, progressively more developed medially and often



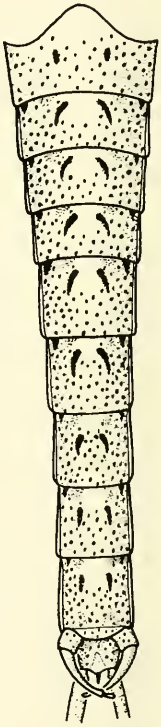
6



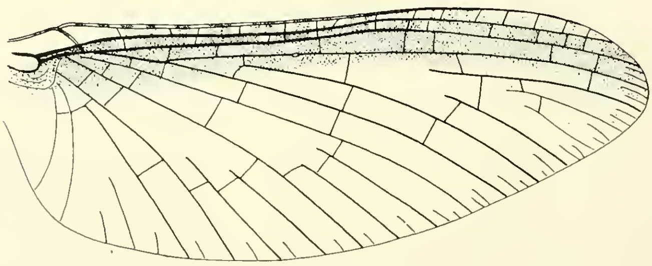
7



8



10



9

Figs. 6–10. 6–7. *Baetodes alleni* larva: 6. Lateral body profile. 7. Dorsal abdomen. 8–9. *Callibaetis montanus punctilusus* adult: 8. Ventral abdomen, male. 9. Forewing, female. 10. *Callibaetis montanus montanus* male adult abdomen.

forming broad somewhat triangular patterns in middle and posterior segments [fig. 15: Cohen and Allen (1978)]; coxal gills present and single .... *inermis*

– Abdominal tubercles present on terga 1–8 (Fig. 6) or 1–9 [e.g. fig. 12: Koss (1972)], although posterior tubercles difficult to discern in some; abdominal terga not as above [if all terga have anterior portions darkened, then darkening not more developed medially (Fig. 7) and coxal gills absent]; single coxal gills present or absent 3

3. Dorsal tubercles present on pro-, meso-, and metanotum as well as abdominal terga 1–9, well developed on thorax and abdominal terga 1–7 or 1–8 [fig. 12: Koss (1972)]; single coxal gills present .... *edmundsi*

– Dorsal tubercles present or absent on thorax [if present then not well developed and not present on all thoracic segments (e.g. pronotal hump more common)]; tubercles present on abdominal terga 1–8 and difficult to discern on 8 (Fig. 6), or present on terga 1–9 and difficult to discern on 7–9; coxal gills absent 4

4. Abdominal terga (Fig. 7) light brown with darker anterior areas up to one third or one half of tergum; sterna pale with darker lines evident; abdominal tubercles on 1–8 and difficult to discern on 8 .... *alleni*

– Abdominal terga dark reddish brown with some pale markings; abdominal sterna pale with reddish brown markings; abdominal tubercles on 1–9 and difficult to discern on 7–9 ... *arizonensis*

Callibaetis montanus punctilusus McCafferty and Provonsha,

NEW SUBSPECIES

Figs. 8–9

This new subspecies differs from typical *Callibaetis montanus* [= *Callibaetis montanus montanus* Eaton, new status] as follows:

Male adult (in alcohol).—*Head:* Entire surface of pedicel and medial surface of scape of antennae light to medium brown, contrasting pale face and flagellum. *Thorax:* Surface lacking dark and conspicuous punctate spots, with only hint of pale punctation in some, or at most sparse and relatively few punctate spots and most apparent basad of leg origins. All legs pale; all femora lacking series of punctate spots (if any spots present then indistinct). Scales of blunt claws numbering over 40 in basal area. Wings not stained with pigment, except extreme base of forewings; longitudinal veins pale except extreme base of subcosta of forewings. Forewings with costal and subcostal area hyaline (rarely in distal half of wing only); marginal intercalaries single posterior to radial triad. *Abdomen:* Terga lacking any prominent markings, punctate spots when present sparse and inconspicuous (some individuals with pale macula in extreme lateral area). Sterna (Fig. 8) without punctate spots. Median lobe of basal segment of forceps not darkened. Cerci entirely pale.

Female adult (in alcohol).—Body punctation fine (with spots small), somewhat sparse, and distinctly bright pink (specimens in 70% ETOH for 15 years). *Thorax:* Mesoscutellum usually with pair of diffuse pink patches. Forewings (Fig. 9) with vitta extending to R_2; some crossveins in small clear areas in basal half of subcostal area bright pink in some individuals, and some of these individuals with additional pink crossvein in midregion of R_1 area. Hindwings not stained. *Abdomen:* Punctate spots sparse ventrally. Cerci entirely pale.

Holotype.—Male adult, Texas, Victoria Co., Guadalupe R. at Victoria at light, V-8-1977, W. P. McCafferty, A. V. Provonsha, D. Morihara, deposited in PERC.

Paratypes.—Three male and two female adults, same data and deposition as holotype; one female adult same deposition as holotype, deposited at the United States National Museum, Washington, D.C.

Additional material examined.—One female adult and two male subimagos, same data and deposition as holotype.

Etymology.—The specific epithet is derived from "punctum," Latin for spot, and "lusus," Latin for the quality of being different. It thus is an allusion to the very different size, color, and distribution of punctate spots on the body of the adults.

Discussion.—In existing keys [e.g. Traver (1935)], this new subspecies should be identifiable as *C. montanus,* but perhaps with some difficulty because of the atypical variation it shows. As described above, the males do not exhibit the prominent maculation and punctation of *C. montanus montanus*, and the females also differ in degree with respect to color, vitta, and punctation. It remains to be seen if claw scaling differences and possible differences in marginal intercalaries are significant.

Traver (1935) gave a rather tenuous report of *C. montanus* in Texas, indicating that she had seen many males from Weslaco with typical venation but, "with wholly pale legs, the femora not at all stippled . . ." These were likely to have been *C. montanus punctilusus*. Henry (1986) reported *C. montanus* from the Concho River, with no other specific data. This material may also prove to be the new subspecies.

Callibaetis montanus has had a somewhat confused taxonomic history; it is primarily a Central American and Mexican species and many erroneous records have been based on misidentifications of *C. fluctuans* (Walsh) (G. F. Edmunds, Jr., personal communication). Therefore, in the United States, *C. montanus* appears to be restricted to extreme southwestern areas. The subspecies *C. montanus montanus* occurs in mountainous areas extending from Nicaragua to southern Arizona (Eaton 1885, 1892, Traver 1935, McCafferty and Lugo-Ortiz 1992). The subspecies *C. montanus punctilusus* is not known from mountainous regions and thus far is known only from Texas. It appears to represent a variant that has been isolated long enough to have undergone genetic change, especially with respect to coloration and punctation. If the two variants are eventually found not to be geographically isolated, the new subspecies may in fact represent a new sister species to *C. montanus*.

Camelobaetidius mexicanus
(Traver and Edmunds)
Figs. 11–12

This species has remained unknown in the adult stage since it was originally described as larvae only. We are able to provide an adult description based on male adults we reared from larvae.

Male adults (in alcohol).—Body length excluding cerci: 4.8–5.2 mm; forewings: 4.8 mm; hindwings 0.7 mm; cerci 8.8–9.0 mm. Body yellowish tan, darkest at head and thorax and slightly so at abdominal terga 7–10. *Head:* Turbinate portion of compound eyes yellow, semi-elliptical, slightly separated, and slightly divergent. *Thorax:* Pronotum with pair of brown lateral patches. Legs pale. Wing veins hyaline. Hindwing as in Fig. 11. *Abdomen:* Terga and sterna similarly pale and without maculations or color pattern. Genitalia as in Fig. 12, with forceps distinctly curved. Cerci entirely pale.

Material examined.—Four male adults and four male subimagos, all reared (with larval exuviae retained), Texas, Blanco Co., Blanco R. 6 mi W Blanco, V-6-1977, W. P. McCafferty, A. V. Provonsha, D. Morihara, deposited in PERC.

Discussion.—Traver and Edmunds (1968) originally described this species from larvae from Tamaulipas Province in Mexico. In the same paper they described adults taken from the same locality as *Dactylobaetis* sp. A, and stated that they were possibly the adults of *C. mexicanus*. Material we have reared from Texas are in partial agreement with that adult description. The male genitalia of *C. mexicanus* appear different than that described for *D.* sp. A; however, the intraspecific variation is not known with regard to this character in this genus. Perhaps more importantly, descriptions agree with regard to the pale abdomen being unmarked, and this according to Traver and Edmunds (1968) is unique for those species of the genus having pale mid abdominal segments. Except for the unicolorous abdomen, however, *C. mexicanus* appears more like *C. chiapas* (Traver and Edmunds), described from adults only from Chiapas Province, Mexico. The forceps are definitely more similar. The forewing size of *C. mexicanus* appears intermediate to what Traver and Edmunds (1968) reported for *C. chiapas* and sp A.

From the above, it is possible that *C. mexicanus* is a junior synonym of *C. chiapas* (page priority) if, indeed, the slight differences in adult coloration and wing size prove to be intraspecifically variable. We have chosen to maintain *C. mexicanus* for the time being, until additional evidence about variability in the genus *Camelobaetidius* can be garnered.

Procloeon texanum **McCafferty and Provonsha, New Species**

Figs. 13–14

Male adults (in alcohol).—Body length: 4.0 mm; wing: 3.4 mm; cerci unknown. *Head:* Face light brown. Antennae entirely pale. Turbinate portion of compound eyes entirely pale. *Thorax:* Nota light golden brown. Pleura and sterna entirely pale. Legs pale. Forewings without staining; with single marginal intercalaries beginning after R_2. *Abdomen:* All segments pale and colorless (segments 1–6 semi-hyaline, 7–10 opaque) except segments 2–7 with thin, purple, longitudinal dashes laterally in anterior half of segments (Fig. 13). Genitalia as in Fig. 14.

Holotype.—Male adult, Texas, Brazos Co., Navasota R. at Hwy. 6, VIII-10-1969, C. D. Bjork, deposited in PERC.

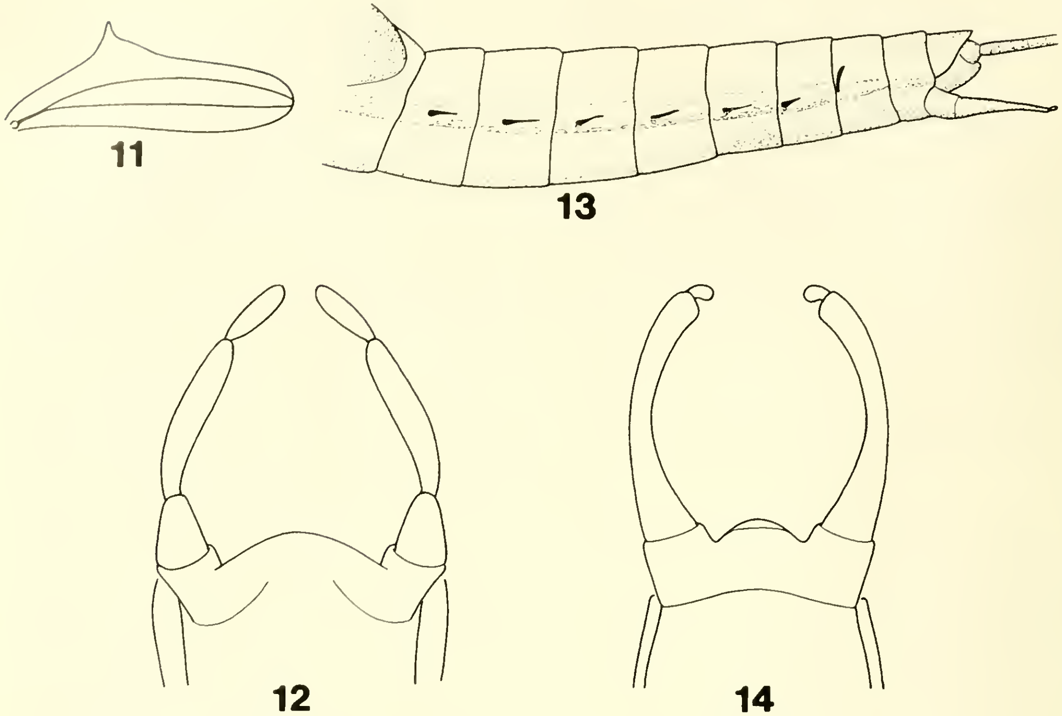
Additional material examined.—Female subimago, same data and deposition as holotype.

Discussion.—According to the labels accompanying the above specimens, they had been reared from larvae in the laboratory. It is most unfortunate, however, that the larval skins have evidently been lost.

Unlike several of the genera of Baetidae in North America, the taxonomy of this particular group of species, as defined by McCafferty and Waltz (1990) is based almost entirely on adult morphology rather than the larval stage, as, for example, in *Baetodes* and *Camelobaetidius* (treated above). For comparative descriptions of the adults in North America, see Traver's (1935) treatment of what she considered *Cloeon* at that time (essentially those baetids without hindwings and with single marginal intercalaries in the forewings). On the basis of adult morphology, this new species is distinct from any thus far known. The golden thoracic nota and the almost entirely pale abdomen with purple lateral dashes on segments 2–7 appear to be unique characteristics.

Of those *Procloeon* in North America that lack hindwings, *P. minor* (McDunnough) and *P. rubropictum* (McDunnough) are the only ones with about the same body and wing size. *Procloeon inanum* (McDunnough) and *P. minor* are known to have some lateral purplish blotches on the abdomen, but they are nothing like the thin dashes seen in *P. texanum,* and these former species have considerable coloration not shown in *P. texanum.* Like *P. texanum, P. minor* also has a more-or-less hyaline abdomen, but unlike *P. texanum, P. minor* possesses both dorsal and ventral markings on the abdomen and its head and thorax are deep blackish brown. From all of this, it is impossible at this time to determine any specific relationships of *P. texanum.*

The genus *Procloeon* generally has not been known outside the northwest and northeast regions of North America (see McCafferty and Waltz 1990). Of *Procloeon* and *Centroptilum,* a genus with which the former may be confused at this time, McCafferty and Davis (1992) have found from Texas only one species in the larval stage that lacks hindwingpads. Those larvae, which superficially appear to be related to *Centroptilum alamance* (Traver), remain undescribed because larvae of these genera are poorly known and because of the previously mentioned historical emphasis on adults. For example, there remains the possibility that these undescribed larvae (*Centroptilum* sp. 1 of McCafferty and Davis)



Figs. 11–14. 11–12. *Camelobaetidius mexicanus* male adult: 11. Hindwing. 12. Ventral genitalia. 13–14. *Procloeon texanum* male adult: 13. Lateral abdomen. 14. Ventral genitalia.

will prove to be the larvae of *P. texanum* or some other previously named species of *Procloeon* or *Centroptilum.*

ACKNOWLEDGMENTS

We thank Dennis Morihara, Pukalani, Hawaii, for his participation in our field work in Texas. We also thank Jack Davis, Austin, Texas, for providing material for examination. This paper has been published as Purdue University Experiment Station Journal No. 13390.

LITERATURE CITED

Cohen, S. D. and R. K. Allen. 1978. Generic revisions of mayfly nymphs III. *Baetodes* in North and Central America (Baetidae). Journal of the Kansas Entomological Society 51: 253–269.

Eaton, A. E. 1883–88. A revisional monograph of recent Ephemeridae or mayflies. Transactions of the Linnean Society of London 2nd Ser. Zool. 3: 1–352.

———. 1892. Biologia Centrali-Americana: Insecta, Neuroptera, Ephemeridae. Vol. 38. Bernard Quaritch, Ltd., London.

Edmunds, G. F., Jr., S. L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. University of Minnesota Press, Minneapolis.

Flowers, R. W. 1987. The adult stage of three Central American *Baetodes* (Ephemeroptera: Baetidae) with notes on the genus. Aquatic Insects 9: 1–10.

Henry, B. C., Jr. 1986. Mayflies (Ephemeroptera) of the Concho River, Texas. Southwestern Naturalist 31: 15–21.

Koss, R. W. 1972. *Baetodes*: New species and new records for North America (Ephemeroptera: Baetidae). Entomological News 83: 93–102.

Lowen, R. G. and J. F. Flannagan. 1991. Four Manitoba species of *Centroptilum* Eaton (Ephemeroptera: Baetidae) with remarks on the genus, pp. 189–206. *In* Alba-Tercedor, J. and A. Sanchez-Ortega, eds., Overview and Strategies of Ephemeroptera and Plecoptera. Sandhill Crane Press, Gainesville, Florida.

Mayo, V. K. 1972. New species of the genus *Baetodes* (Ephemeroptera: Baetidae). Pan-Pacific Entomologist 48: 226–241.

McCafferty, W. P. and J. R. Davis. 1992. New and additional records of small minnow mayflies

(Ephemeroptera: Baetidae) from Texas. Entomological News. (In press.)

McCafferty, W. P. and C. R. Lugo-Ortiz. 1992. Registros nuevos y notas sobre los Ephemeroptera de Nicaragua. Revista Nicaraguense de Entomologia 19: 1–7.

McCafferty, W. P. and A. V. Provonsha. 1975. Reinstatement and biosystematics of *Heterocloeon* McDunnough (Ephemeroptera: Baetidae). Journal of the Georgia Entomological Society 10: 123–127.

McCafferty, W. P. and R. D. Waltz. 1990. Revisionary synopsis of the Baetidae (Ephemeroptera) of North and Middle America. Transactions of the American Entomological Society 116: 769–799.

Morihara, D. K. and W. P. McCafferty. 1979a. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). Transactions of the American Entomological Society 105: 139–221.

———. 1979b. The evolution of *Heterocloeon* with the first larval description of *Heterocloeon frivolus* comb. n. (Ephemeroptera: Baetidae). Aquatic Insects 1: 225–231.

Müller-Liebenau, I. 1974. *Rheobaetis*: A new genus from Georgia (Ephemeroptera: Baetidae). Annals of the Entomological Society of America 67: 555–567.

Traver, J. R. 1935. Part II. Systematic, pp. 239–739. *In* Needham, J. G., J. R. Traver, and Y. C. Hsu, eds., The Biology of Mayflies with a Systematic Account of North American species. Comstock Publ., Ithaca, New York.

Traver, J. R. and G. F. Edmunds, Jr. 1968. A revision of the Baetidae with spatulate-clawed nymphs (Ephemeroptera). Pacific Insects 10: 629–677.

Waltz, R. D. and W. P. McCafferty. 1987. Revision of the genus *Cloeodes* Traver (Ephemeroptera: Baetidae). Annals of the Entomological Society of America 80: 191–207.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 70–73

CLASSIFICATION OF *DIPHLEPS* (HETEROPTERA: MIRIDAE: ISOMETOPINAE), WITH THE DESCRIPTION OF *D. YENLI*, A NEW SPECIES FROM DOMINICAN AMBER (LOWER OLIGOCENE-UPPER EOCENE)

Jorge A. Santiago-Blay and George O. Poinar, Jr.

(JASB and GOP) Department of Entomological Sciences, University of California, Berkeley, California 94720-0001.

Abstract.—***Diphleps yenli*** n. sp. is described from two specimens preserved in Dominican amber. A revised key to the species of *Diphleps* is provided. Initial studies suggest that species of *Diphleps* can be classified in two groups based on the magnitude of the anterior pronotal concavity angle of males: less than 140° on *D. maldonadoi* and ***D. yenli***, n. sp. which occurs in Puerto Rico and occurred in Dominican amber, respectively; equal to or greater than 140° on *D. similaris,* which inhabits Turks and Caicos as well as the Bahamas archipelagos, and *D. unica,* known from the eastern United States.

Key Words: Miridae, Isometopinae, *Diphleps, D. yenli* n. sp., key to species

There are currently eleven New World genera of Isometopinae arranged in two tribes (Henry 1980): Isometopini containing the genera *Aristotelesia* Carvalho 1947, *Brailovskiocoris* Henry 1980, *Corticoris* McAtee and Malloch 1922, *Isometocoris* Carvalho and Sailer 1954, *Lidopiella* Henry 1980, *Lidopus* Gibson 1917, *Myiomma* Puton 1872, *Myiopus* Henry 1980, *Plaumannocoris* Carvalho 1947, *Wetmorea* McAtee and Malloch 1924 and the Diphlepini with *Diphleps* Bergroth 1924. The Isometopinae have been regarded as the most ancestral mirid subfamily (Wheeler and Henry 1978).

Diphleps contains four species: *D. maldonadoi* Henry 1977 from Puerto Rico, *D. similaris* Henry 1977 from Turks and Caicos and the Bahamas archipelagos, *D. unica* Bergroth 1924 from the eastern United States, all extant, and *D. yenli* n. sp. only known from Dominican amber, the first described fossil species of the Isometopinae.

Both *D. unica* and *D. maldonadoi* occur in mature forests. *Diphleps unica,* a summer univoltine mirid common in light trap catches, has been collected among lichens on the bark of oak, *Quercus* sp. (Fagaceae), on huckelberry, *Vaccinium* sp. (Ericaceae) (Blatchley 1926), on elm, *Ulmus alata* (Ulmaceae), and on honeylocust, *Gleditsia triacanthos* (Fabaceae) (Henry 1977, Wheeler and Henry 1978). Apparently, females of *D. unica* are far more common than males (Blatchley 1926, Wheeler and Henry 1978).

Methods and Description

Most Dominican amber comes from mines located in the Cordillera Septentrional, between Santiago and Puerto Plata, in the Northern Portion of the Dominican Republic. These mines are in the Altamira facies of the El Mamey Formation (Upper Eocene), which is shale-sandstone interspersed with a conglomerate of well-rounded pebbles (Eberle et al. 1980).

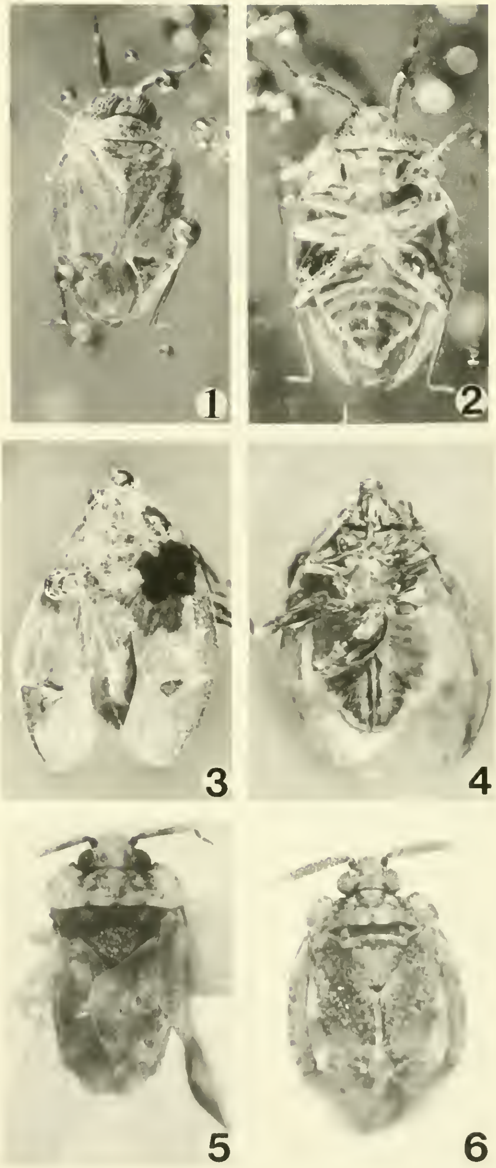
Differences in the magnitudes of absorption peaks in nuclear magnetic resonance spectra of the exo-methylene group of amber from different mines in the Dominican Republic were used to calculate the age of the various mines (Lambert et al. 1985) using the 20 million to 23 million year age of the Palo Alto mine as a standard (Baroni Urbani and Saunders 1980). The ages of the mines in that region of the country vary from 25 million to 40 million years. Amber from the La Toca mine was the oldest, some 35 million to 40 million years old (lower Oligocene to upper Eocene). These age estimates are close to the independent dating reported by Schlee (1990) who gave a range of 30 to 45 million years for the La Toca mine. Davis (1989) reported 20–30 million years as the age of Dominican amber.

Nomenclature and measurements (in mm) follow Maldonado (1969) and Henry (1977). Several pronotal angles are compatible with our grouping but the most evident one is the pronotal concavity angle (pca). Intuitively, the pca is a measure of the relative "openness" of the anterior concavities of the pronotum. Formally, the pca is the angle subtended by the segment connecting the distalmost points of the anterior pronotal concavities and the projection of the inner anterolateral aspect of the pronotum. The description refers to the male holotype, parenthetical statements refer to the female paratype, if different from holotype. The holotype (HE 4-17) is deposited in the Poinar collection of Dominican amber maintained at the Museum of Paleontology, University of California, Berkeley (acc. no. 39839). The female paratype (12535) is deposited at the National Museum of Natural History, Washington, D.C. All specimens were photographed with a Nikon stereomicroscope using Kodak 125 Plus X film.

Diphleps yenli, New Species

Santiago-Blay and Poinar

Figs. 1–4



Figs. 1–6. 1, 2. Overall views of *Diphleps yenli* n. sp. male holotype. 1, dorsal. 2, ventral. 3, 4. Overall views of *D. yenli* n. sp. female paratype. 3, dorsal. 4, ventrolateral. 5. Overall dorsal view of *D. maldonadoi* female. 6. Overall dorsal view of *D. unica* male.

Length 1.9 (2.1), maximum width 1.1 (not taken); suboval, sparsely ornamented with pale yellow, short setae; pale yellowish brown, irregularly variegated with pale brown on eyes, pronotum, scutellum, embolium, cuneus, and abdominal apex (almost uniformly pale yellowish brown). Second antennal segment with a pale brown annulus between distal half and fifth (two pale annuli, close to basal and apical thirds, excluding base and apex, respectively), third, and fourth segments pale brown. Venter pale yellowish brown except for slightly darker prosternal base and basal half of hind femora (Figs. 1–4).

Head.—Dorsally concave, pronotal anterior margin nearly three times as wide as long; tylus very reduced (small), round, width across apex 0.1; eyes relatively large, lateral margin smooth, slightly emarginated toward antennal bases (not emarginated), almost contiguous ventroposteriorly, separated ventrally by width of rostrum (0.05) (separated ventroposteriorly by slightly more than rostral width); ocelli dark brown; intraocular distance at ocelli about a third (one half) of eye dorsal width 0.02:0.06; ocelli closer to eyes than to each other (0.03:0.06). Antennal segment I, slightly thinner apically than II (0.05:0.08); II slightly curved (almost straight), with very short setae, giving granulose appearance; III and IV much smaller than second; length, maximum width of antennal segments, as follows: I 0.08:0.06; II 0.35:0.08 (0.34:0.04); III 0.09: 0.03 (0.11:0.03); IV 0.11:0.03 (0.12:0.03). Rostrum 0.66 long, reaching midlength of coxal bases II; third segment reaching prosternum, slightly expanded laterally, flaplike.

Thorax.—Pronotum 0.25 long, 0.84 wide, 3.4 times as wide as long, minutely granulate, with two small, nearly contiguous depressions on disk (not discerned in female); anterior margin bisinuous, meeting lateral margins at right (obtuse) angle, very slightly sinuous (shallowly convex); lateral sides flattened, projecting laterally and angled slightly upward; anterolateral portions strongly arched (not arched) around eyes; posterior margin shallowly and broadly concave (very slightly sinuate), with a slight mediolongitudinal ridge from midlength to posterior margin (without ridge), without keels or indentations; pca $\approx$130–140°. Mesoscutum exposed; width across anterior angles 0.69 (0.63), about half the length of scutellum; scutellum basal width across 0.59 (0.41), with shallow, median, longitudinal ridge from midlength to apex. Hemelytra suboval; embolium 0.78 (0.66) long, wide 0.14 (0.19), about twice as wide as thickness of second antennal segment; cuneus maximum width 0.44 (0.42), maximum length (perpendicular to width) 0.56 (0.59), ending near apex of membrane. Hind femora thick, 0.25 (0.27) maximum width, 0.67 (0.66) long; with fine pilosity posteriorly.

Abdomen.—Last two visible segments abruptly narrowed (evenly rounded), with broadly rounded apex, not reaching apex of cuneus. Genitalia as in Fig. 9. (Right clasper cannot be discerned).

Diagnosis.—*Diphleps yenli* n. sp. can be distinguished from *D. maldonadoi* by its relatively short tylus and males with shorter interocular/intraocular ratio (about 4.4 on *D. yenli* n. sp.; 4.7–4.9 on *D. maldonadoi*). *Diphleps yenli* n. sp. can be distinguished from *D. similaris* and *D. unica* by the magnitude of the anterior pronotal $<90°$ angle ($\geq 90°$ in *D. similaris* and in *D. unica*).

Etymology.—This species is named after Yenli Yeh, beloved wife of author JASB; name by apposition (Art. 11h(i)2 International Code of Zoological Nomenclature 1985).

KEY TO THE SPECIES OF *DIPHLEPS*

Slightly modified version of Henry's (1977) key.

1. Anterior pronotal concavity angle of males less than 140° (Figs. 1, 3, 5) 2
– Anterior pronotal concavity angle of males equal to or greater than 140° (Fig. 6) 3
2. Tylus just reaching midlength of antennal I; males with interocular/intraocular ratio about 4.4 .... *Diphleps yenli* n. sp. (Figs. 1–4)
– Tylus reaching past midlength or beyond antennal I; males interocular/intraocular ratio about 4.7–4.9 .... *D. maldonadoi* Henry 1977 (Fig. 5)
3. Mesoscutum with distal, transverse carina; adults 2.0–2.1 mm long; rostrum reaching posterior margin of metacoxae or beyond; female with inner anterolateral side of pronotum nearly touching eyes; left paramere unnotched .. .. *D. similaris* Henry 1977

– Mesoscutum without distal, transverse carina; adults 2.4–2.6 mm long; rostrum not reaching posterior margin of metacoxae; female with inner anterolateral side of pronotum removed from eyes; left paramere notched .... *D. unica* Bergroth 1924 (Fig. 6)

DISCUSSION

Species of *Diphleps* segregate in two major groups, each represented by two species, based on the morphology of the anterior pronotal concavity angle. *Diphleps maldonadoi* and *D. yenli* males have smaller (<140°) angles and, while they have well-developed eyes and reduced vertex, females have smaller eyes and larger vertex. *Diphleps yenli* male vertex is narrower and the tylus shorter than in any other described species of the genus. Conversely, *D. similaris* and *D. unica* males show a pattern reversal; they have greater (≥140°) angles.

Diphleps yenli n. sp. perhaps was a scale insect predator like some extant New World isometopines (Wheeler and Henry 1978).

ACKNOWLEDGMENTS

Dr. Jenaro Maldonado Capriles (Ponce Medical School, Puerto Rico) guided author JASB during most phases of this study. Drs. Thomas J. Henry and Richard Froeschner assisted JASB during separate visits to the Natural History Museum (Washington, D.C.) in May and August 1991. They also lent author JASB specimens of *D. unica* and *D. maldonadoi*. Dr. Henry also kindly allowed author JASB to examine the female *D. yenli* n. sp. that we designated as paratype. Dr. David Grimaldi (American Museum of Natural History, New York) lent two additional fossil *Diphleps* for examination. However, another researcher expressed the wish of further studying those exemplars, thus, we choose not to include them in this paper. Part of the travel expenses of JASB were covered by his University of California President's Post-Doctoral Fellowship. Drs. Henry and Froeschner read the typescript and suggested changes.

LITERATURE CITED

Baroni Urbani, C. and J. B. Saunders. 1980. The fauna of the Dominican Republic amber: The present status of knowledge. Proceedings of the 9th Caribbean Geological Conference August 1980. Santo Domingo, pp. 213–233.

Blatchley, W. S. 1926. Heteroptera or true bugs of Eastern North America. The Nature Publishing Co., Indianapolis, Indiana. 1116 pp.

Davis, D. R. 1989. An exceptional fossil amber collection acquired by the Smithsonian Institution. Proceedings of the Entomological Society of Washington 91: 545–550.

Eberle, W., W. Hirdes, R. Muff, and M. Pelaez. 1980. The geology of the Cordillera Septentrional. Proceedings of the 9th Caribbean Geological Conference August 1980. Santo Domingo, pp. 619–632.

Henry, T. J. 1977. *Teratodia* Bergroth, new synonym of *Diphleps* Bergroth with descriptions of two new species (Heteroptera: Miridae: Isometopinae). Florida Entomologist 60: 201–210.

———. 1980. Review of *Lidopus* Gibson and *Wetmorea* McAtee and Malloch, descriptions of three new genera and two new species, and key to New World genera (Hemiptera: Miridae: Isometopinae). Proceedings of the Entomological Society of Washington 82: 178–194.

Lambert, J. B., J. S. Frye, and G. O. Poinar, Jr. 1985. Amber from the Dominican Republic: Analysis by nuclear magnetic resonance spectroscopy. Archaeometry 27: 43–51.

Maldonado Capriles, J. 1969. The Miridae of Puerto Rico (Insecta, Hemiptera). Tech. Pap. 45. University of Puerto Rico (Mayagüez Campus). Agricultural Experiment Station (Río Piedras). 133 pp.

Schlee, D. 1990. Das Bernstein-Kabinett. Stuttgarter Beitrager für Naturkunde, Ser. C., No. 28, pp. 1–100.

Wheeler, A. G., Jr. and T. J. Henry. 1978. Isometopinae (Hemiptera: Miridae) in Pennsylvania: Biology and descriptions of fifth instars, with observations of predation on obscure scale. Annals of the Entomological Society of America 71: 607–614.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 74–78

CURICTAN COPULATION AND WATERSCORPION HIGHER CLASSIFICATION (HETEROPTERA: NEPIDAE)

S. L. Keffer and J. E. McPherson

(SLK) Department of Entomology, National Museum of Natural History, Washington, D.C. 20560; (JEM) Department of Zoology, Southern Illinois University at Carbondale, Carbondale, Illinois 62901.

Abstract.—The copulatory posture of *Curicta howardi* is described in detail. One aspect of curictan copulation, the grasping of the female's head by the male protibia, is tentatively identified as unique to the genus and therefore diagnostic. We relate our observations and those of previously studied waterscorpions to the currently accepted higher classification of the Nepidae (Lansbury 1974) and conclude that copulatory posture may be of subfamilial significance, thereby lending support to the inclusion of *Curicta* in the subfamily Nepinae. However, copulation has not been studied in two key genera, the Australian endemics *Austronepa* and *Goondnomdanepa*. Both of these genera are currently placed in the subfamily Ranatrinae but also possess certain of the tribal characteristics of *Curicta* and the other Nepinae genera. Thus, if they are found to copulate in a nepine/curictine manner, then copulatory posture as a suprageneric character would contribute to the tribal, rather than the subfamilial, classification of the family.

Key Words: *Curicta howardi* Montandon, waterscorpion copulation, Nepidae higher classification, Heteroptera

Little is known about copulatory behavior in waterscorpions. Thus far, information is available only for *Curicta howardi* Montandon (Wiley 1922, 1924), *Laccotrephes fabricii* Stål (Mattei 1965), *Nepa cinerea* L. (Poisson 1924, Larsén 1938), and *Ranatra linearis* L. (Larsén 1938). This paper presents further information on copulation in *Curicta howardi* and relates our observations to the currently accepted higher classification of the Nepidae (Lansbury 1974).

Methods and Materials

In July of 1988, two populations of *C. howardi* were collected from the Coastal Plain region of Texas and returned to the laboratory at Southern Illinois University at Carbondale, Illinois. The first population was taken from Skull Creek, ca. 2 km west of Altair at Route 90, Colorado County. The second population was collected from San Fernando Creek at Route 44, 1 km east of Alice, Jim Wells County. The specimens were maintained in 5 gallon aquaria with a sloping sand beach at one end and approximately 1 inch of deionized water at the other end. The aquaria were kept in incubators under identical rearing conditions approximating the May–July photoperiod and temperatures in the collection area, i.e. 14L:10D photoperiod and 27.5–28.9°C. Small pieces of plastic aquarium plants were placed in the water to provide a perch for the adults. Aquaria were cleaned weekly or more often if they became fouled. Specimens were fed a variety of foods, primarily Corixidae and small *Bueno* sp. (Notonectidae), approximately 1.5 food items/day.

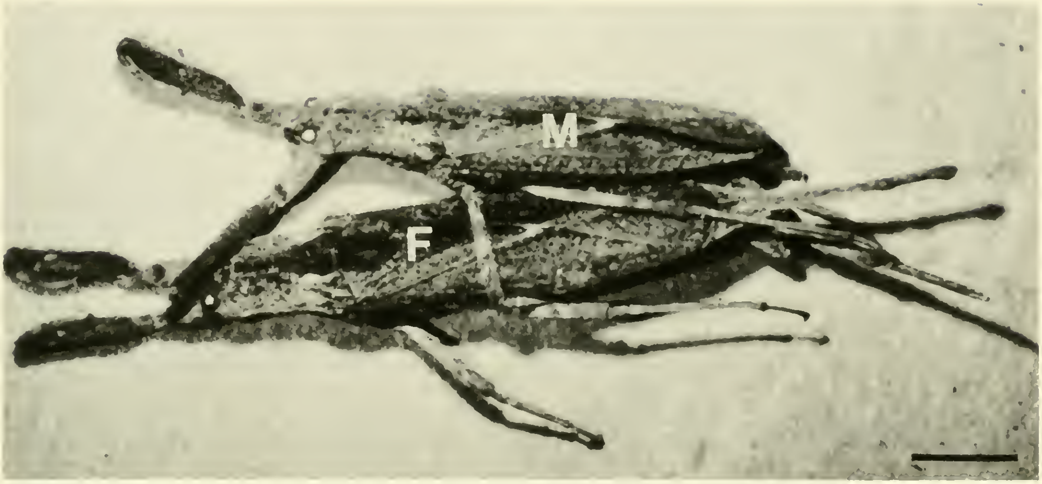


Fig. 1. Male and female *C. howardi* in copula, dorsolateral view (bar scale = 3 mm). M = male; F = female; OP = male operculum.

The aquaria were checked irregularly throughout both the incubator's day and night cycle for copulating pairs which, when discovered, were preserved for study by spraying with ethyl chloride followed by freezer storage. Photographs were taken on Kodak Panatomic-X film with a 35 mm Contax camera adapted to a Zeiss SR Stereo microscope.

RESULTS

Copulation was observed in the laboratory on a daily basis but only during the night cycle of the incubator. Duration of copulation events varied from about 5 minutes to 8 hours. (It is possible that the short copulations were not completed even though the male had assumed the copulatory posture outlined below.) Lengthy copulations were not unexpected because two of the adults used in this study were collected in copula in the field and remained thus for about eight more hours. No apparent courtship behavior was detected prior to copulation.

At the onset of copulation, a male would approach a female, usually from her right side, and grasp her with his three adjacent legs (Fig. 1). In this grasp, his protibia was hooked over her head between the eye and the adjacent paraclypeus. His mesofemur was thrown over the dorsum of her abdomen posterior to the scutellum, and his mesotibia was flexed ventrally under her abdomen. His metathoracic leg extended posteroobliquely over her abdominal dorsum; his metatibia was not flexed underneath. In preparation for copulation, the male twisted the distal half of his abdomen ventrally under the female. This manuever considerably deformed the male's abdomen and placed his last abdominal tergum obliquely underneath the female's genital operculum (Fig. 2). The two plates of the male's last abdominal tergum separated medially and he extended the genital capsule anterodorsally, effectively placing the capsule upside down relative to its usual orientation in his body and pointing anteriorly; at rest the capsule and enclosed phallus point posteriorly. During copulation the male's parameres hooked onto the female's first gonapophyses.

DISCUSSION

Wiley (1922) observed *C. howardi* specimens copulating shortly after they had been taken from the field and placed in a common container. She noted that "the male takes a position to one side of the female,

Fig. 2. Male and female *C. howardi* in copula, terminal abdominal segments, ventral view (bar scale = 2 mm). M = male; F = female; OP = male operculum.

and usually to the right. If to the right, he hooks his left anterior tarsus over her head; if to the left, the right fore tarsus is used" (p. 507). She observed that mating occurred almost daily from early spring through late summer (Wiley, 1924: 327) and that the duration of copulation often lasted several hours. Our results confirm Wiley's observations regarding both the male preference for grasping the female from her right and the often long duration of the copulations. In one respect, however, our results differ. In our laboratory cultures males always hooked their protibia, not just the protarsus, over the female's head. Interestingly, the use of the protibia/tarsus to grasp the female's head during copulation appears to be unique to the genus (see below). Thus, this trait can tentatively be considered diagnostic for *Curicta.*

Copulatory posture in two of the three other waterscorpion species studied resembles that observed for *Curicta howardi.* In *L. fabricii* (Mattei, 1965: 75, fig. 8C) and *N. cinerea* (Poisson, 1924: plate 5, fig. 15; Larsén, 1938: 58, fig. 19), the male lies to one side and partially above the female as in *Curicta* but does not hook his protibia over the female's head. The protibia of the *L. fabricii* male grasps the female by the anterior half of the pronotum while the mesothoracic leg clasps her at the junction of her pronotum and abdomen. The protibia of the *N. cinerea* male grasps the female by the posterior part of the pronotum while the mesothoracic leg grasps the distal half of her abdomen. The metathoracic leg of both *L. fabricii* and *N. cinerea* extends postero-obliquely over the female abdominal dorsum as occurs in *C. howardi.* Mattei (1965) neither illustrated nor described the placement of the male abdomen of *L. fabricii* underneath the female other than to say on page 78, "le mâle glisse son extrémité abdominale au-dessous de l'abdomen de la femelle." However, his dorsal illustration of a copulating pair (p. 75, fig. 8C) shows the male respiratory siphons at about a 45° angle to the female's siphons. This siphon configuration is similar to that illustrated and discussed for *N. cinerea* by Larsén (1938) suggesting that the same abdominal deformation occurs in *L. fabricii.* During copulation in *R. linearis,* the male does not deform the abdomen (see below) and the male's siphons diverge from the female's siphons at approximately 15°. As in *C. howardi,* the male *N. cinerea* deforms his abdomen to place the dorsum of his last abdominal segment under the female's operculum (Larsén 1938: p. 60, figs. 20–22) and the phallus is inserted upside down and backwards relative to its resting position.

The male of *R. linearis* assumes a somewhat different copulatory posture (Larsén 1938: p. 80, fig. 37). Instead of lying immediately adjacent to and partially on top of the female as occurs with *Curicta, Laccotrephes,* and *Nepa,* the male *Ranatra* angles the anterior part of his body away from the female while still hooking his profemur and tibia midway over her pronotum and his mesofemur and tibia over her abdomen just anterior to the inner angle of the hemelytral membranes. By angling away from the female, the male is able to place his last abdominal segment under her operculum without deforming his abdomen as in *Curicta, Laccotrephes,* and *Nepa.* During copulation, *Ranatra linearis* inserts an upside-down, backward phallus (p. 82, figs. 38–39) as do *Curicta, Nepa,* and presumably *Laccotrephes.*

The Nepidae are currently divided by Lansbury (1974) into two subfamilies (Nepinae, Ranatrinae) and five tribes (Nepini, Curictini, Goondnomdanepini, Austronepini, Ranatrini). According to this higher classification, *Curicta* (Curictini) is one of three "transitional" (pp. 222–223) genera, along with two Australian endemics, *Austronepa* (Austronepini) and *Goondnomdanepa* (Goondnomdanepini), between the genera of the tribe Nepini with their broad, dorsoventrally flattened bodies and the narrow, tubular-shaped genera of the Ranatrini. Ten morphological characters are used in the Lansbury classification: four are weighted as subfamilial and six as tribal. *Curicta* is assigned to the subfamily Nepinae because it has the same four subfamilial characters as the genera of the Nepini. However, at the tribal level, *Curicta* is congruent with the Nepini for only 2 characters and with the Ranatrini for the remaining 4 characters. Similarly, *Austronepa* and *Goondnomdanepa* are assigned to the subfamily Ranatrinae because they possess the same subfamilial characters as the genera of the Ranatrini but at the tribal level, *Austronepa* and *Goondnomdanepa* are congruent with only four of six and one of six Ranatrini characters, respectively, while agreeing with the Nepini on the remaining characters. Hence, these three genera are each accorded their own tribe and are understood as "transitional" because they each possess a mix of Nepini and Ranatrini character states.

Laccotrephes and *Nepa* belong to the Nepinae-Nepini and *Ranatra* belongs to the Ranatrinae-Ranatrini. The deformation of the male abdomen during copulation found in *Curicta, Laccotrephes,* and *Nepa* further aligns *Curicta* with the Nepinae. Unfortunately, nothing is currently known about the copulatory postures of the other two transitional waterscorpion genera, *Austronepa* and *Goondnomdanepa.* The Nepinae, including *Curicta,* all have visible abdominal parasterna, whereas the Ranatrinae, including the transitional Australian genera, have the parasterna infolded (Menke and Stange 1964, Lansbury 1974). Could it be that this parasternal infolding structurally prevents the male Ranatrinae abdomen from twisting under the female's abdomen during copulation? If it is found that males of all the Ranatrinae genera do not deform their abdomens during copulation, then this aspect of waterscorpion copulatory posture will constitute an additional character in support of Lansbury's subfamilial classification. If, however, males of *Austronepa* and/or *Goondnomdanepa* are observed to twist their abdomens under the female in the Nepini/Curictini manner, then copulatory posture will constitute a tribal character in the Lansbury classification thus further contributing to the mixing of Nepini and Ranatrini characters in the three transitional genera.

Acknowledgments

We are indebted to Dr. Peter P. Korch of Barnesboro, PA for help collecting the specimens of *C. howardi.* We also would like to thank Dr. David G. King of the Department of Anatomy and Steve Taylor of the Department of Zoology, Southern Illinois University, for taking the photomicrographs and suggesting the use of ethyl chloride respectively.

Literature Cited

Lansbury, I. 1974. A new genus of Nepidae from Australia with a revised classification of the family (Hemiptera-Heteroptera). Journal of the Australian Entomological Society 13: 219–227.

Larsén, O. 1938. Untersuchungen über den geschlechtsapparat der aquatilen wanzen. Opuscula Entomologica (Suppl.) 1: 1–388.

Mattei, C. 1965. Morphologie et biologie de *Laccotrephes fabricii* Stål, 1868 (Insecte Hétéroptère, Hydrocorise, Nepidae). Annales de la Faculté des Sciences, Université de Dakar 18: 59–94.

Menke, A. S. and Stange, L. A. 1964. A new genus of Nepidae from Australia with notes on the higher classification of the family. Proceedings of the Royal Society of Queensland 75: 67–72.

Poisson, R. 1924. Contribution a l'étude des Hémiptères aquatiques. Bulletin Biologique de la France et de la Belgique 58: 51–305.

Wiley, G. O. 1922. Some notes on the biology of *Curicta* from Texas. Kansas University Science Bulletin 14(20): 507–511.

———. 1924. On the biology of *Curicta drakei* Hungerford (Heteroptera, Nepidae). Entomological News 35: 324–331.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 79–98

THE WHITE PEACH SCALE, *PSEUDAULACASPIS PENTAGONA* (TARGIONI-TOZZETTI) (HOMOPTERA: DIASPIDIDAE): LIFE HISTORY IN MARYLAND, HOST PLANTS, AND NATURAL ENEMIES

Lawrence M. Hanks and Robert F. Denno

(LMH) Post-doctoral Fellow, Department of Entomology, University of California, Riverside, California 92521; (RFD) Professor, Department of Entomology, University of Maryland, College Park, Maryland 20742.

Abstract.—The white peach scale, *Pseudaulacaspis pentagona* (Targioni Tozzetti), is a severe pest of woody ornamentals and fruit trees throughout the world. In this paper we review information on the life history, host plant relationships, and natural enemies of *P. pentagona.* Also, we present new data on the life history (fecundity and primary sex ratio), population biology (seasonal development, dispersal, dispersion and host plant range), and natural enemies (parasitoids, hyperparasitoids and predators) of *P. pentagona.*

Key Words: Biological control, host plants, natural history, natural enemies, *Pseudaulacaspis pentagona* (Targioni Tozzetti), white peach scale

The white peach scale, *Pseudaulacaspis pentagona* (Targioni Tozzetti), is one of the most damaging armored scale pests of woody ornamentals and fruit trees in the world (Beardsley and Gonzalez 1975, DeBach and Rosen 1976, Johnson and Lyon 1988, Miller and Davidson 1990). By killing mulberry trees, *P. pentagona* threatened the Italian silk industry (Howard 1916), and the widespread ornamental oleander was nearly eradicated from Bermuda (Simmonds 1958, Bennett and Hughes 1959). *P. pentagona* was first recorded in the United States in Florida in the early 1900s (Gossard 1902) where it devastated the peach industry (Gossard 1902, Van Duyn 1967) and continues to be a severe pest throughout the southeastern United States (Johnson and Lyon 1988).

P. pentagona is native to China (Gossard 1902, Howard 1916, Murikami 1970), but is presently distributed throughout western Europe, Asia, Australia, Africa, the Caribbean and Pacific Islands, and the Americas where it feeds on a tremendous diversity of host plants (Davidson et al. 1983). In the United States, it occurs from Florida west to Texas and north to Maryland and Tennessee (Davidson et al. 1983).

P. pentagona has long been confused with its sibling congener, the white prunicola scale, *P. prunicola* (Maskell). Both species are broadly sympatric, share many host plant species and occur abundantly throughout Maryland and Virginia (Davidson et al. 1983, Rhoades et al. 1985). Despite the confusion of these two taxa in the early literature, they can be easily separated by taxonomic characters and also the color of their eggs (Davidson et al. 1983). Because eggs of *P. pentagona* are conspicuously white or coral in color, while those of *P. prunicola* are pink, the species can be identified where this characteristic is reported (Davidson et al. 1983). Also, differences in host plant utilization exist between these two armored

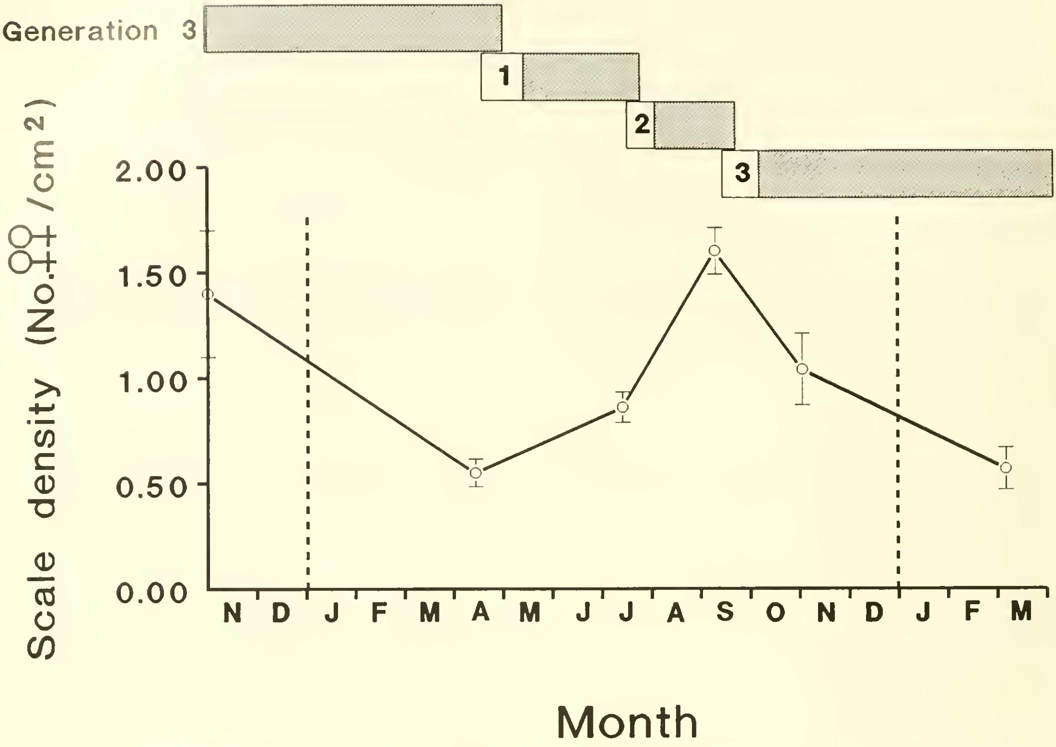


Fig. 1. Average density (±SE) of female *P. pentagona* (No./cm²) on mulberry trees in the urban landscape of College Park, MD. Means are based on 20 samples (cuttings) taken from 5 field trees in April, July, September and November 1986, and March 1987. Samples taken during the first, second, and third scale generations were when most females were second instars (see Hanks 1991 for detailed methods). Bars at the top indicate the 3 annual generations. The occurrence of the crawler stage (unshaded bars) and the second instar + adult stage (shaded bars) are shown for each generation.

scales. *P. pentagona* can be readily cultured on potatoes, while *P. prunicola* survives poorly on this host (LMH unpublished data).

In this paper we review information on the life history, host plant relationships, and natural enemies of *P. pentagona.* We also present new data on the life history (fecundity and primary sex ratio), population biology (season development, dispsersal, dispersion and host plant range), and natural enemies (parasitoids, hyperparasitoids and predators) of this important economic pest.

Life History

Seasonal development

In the equatorial climate of Trinidad, *P. pentagona* reproduces year round (Bennett 1956), while at more temperate latitudes, 2 to 5 discrete generations per year occur depending on the regional climate (Bennett and Brown 1958, Yonce and Jacklin 1974, Kozarzevskaja and Mihajlovic 1983, Davidson et al. 1983). In Maryland, there are three generations per year with highest densities of adults in August–October (Fig. 1). Successful overwintering takes place only as fertilized adult females (Bennett and Brown 1958, Kuitert 1967, Bobb et al. 1973, pers. obs.). Some females deposit eggs prior to the onset of winter, but these eggs usually fail to survive (Yonce and Jacklin 1974, Nalepa and Meyer 1990, pers. obs.). Development time from egg through adult ranges from 35 to 90 days (Bennett and Brown 1958, Hughes 1960, Van Duyn 1967, Kuitert 1967, Kozarzevskaja and Mihajlovic 1983). Development time for the spring and summer generations in Maryland is 60 and 50 days respectively and is inversely temperature dependent (LMH unpublished data).

Mating, Sex Determination, Oviposition and Fecundity

Males begin searching for mates immediately after emergence from the pupal case (LMH pers. obs.). Males locate mates in response to a pheromone emitted by females (Heath et al. 1979, Einhorn et al. 1983). Both sexes commonly mate with several individuals and during mating the male stands on top of the female's cover (Van Duyn and Murphey 1971, pers. obs.).

Sex determination in *P. pentagona* as well as other armored scales is haplodiploid (Bennett and Brown 1958). The chromosome number for *P. pentagona* females (2N = 16) and males (N = 8) is twice that of most other diaspidids suggesting a tetraploid origin (Brown and Bennett 1957, but see Nur 1990). In male eggs, paternal chromosomes become condensed during mitotic development and all functional chromosomes are maternal in origin, while female eggs contain functional chromosomes from both parents (Bennett and Brown 1958). Yeast-like symbionts are transmitted transovarially and may play a role in scale nutrition (Brown and Bennett 1957, Miller and Kosztarab 1979, Tremblay 1990).

Adult females usually deposit eggs for periods less than 10 days, but oviposition may be extended in warmer climates (Kuitert 1967, Yonce and Jacklin 1974). The eggs and first instar crawlers of *P. pentagona* are both sexually dichronic and dimorphic (Bennett and Brown 1958). First-deposited eggs are female and are coral in color, which are followed by white male eggs. Generally, the primary sex ratio is 1:1 (Brown and Bennett 1957, Van Duyn and Murphey 1971) and average lifetime fecundity ranges from 50 to 200 eggs per female (Bennett and Brown 1958, Kuitert 1967, Van Duyn and Murphey 1971, Bobb et al. 1973, Ball 1980, Yasuda 1983a). Unmated females do not produce eggs, but can live as long as 60–75 days (Bennett and Brown 1958, Van Duyn and Murphey 1971, LMH unpublished data).

We estimated the fecundity and primary sex ratio of *P. pentagona* from 110 infested cuttings taken from 25 mulberry trees in College Park, MD in February 1986 (see Hanks 1991 for detailed methods). Each cutting was placed in a petri dish and ringed with Vaseline®, and all dishes were maintained in an incubator at 26°C and 70% RH. Average fecundity and sex ratio were estimated at 76.7 and 0.96:1 (M:F) by counting and sexing (by color) the emerging crawlers entrapped in the vaseline and dividing the count for each cutting by the number of adult females/cutting.

Fecundity can be increased by raising *P. pentagona* under warm temperature conditions (Yasuda 1983a) or on preferred host plant species (Hughes 1960, Kozarzevskaja and Mihajlovic 1983). Host plant condition can also influence fecundity. For example, we examined the effect of host plant water deficit on the fecundity and survivorship of *P. pentagona* by raising them on mulberry trees subjected to low water and high water treatments (see Hanks 1991 for methods). Fecundity was significantly lower on drought-stressed trees (26.4 ± 4.8 eggs/female) than on watered trees (36.5 ± 2.3) (ANOVA, $F_{1,18} = 12.01$, $P = 0.003$). Similarly, scale survivorship was significantly lower on drought-stressed trees (69 ± 8%) compared to well-watered trees (84 ± 4%) (ANOVA, $F_{1,18} = 5.88$, $P = 0.02$).

While the primary sex ratio averages 1:1 in most populations (Brown and Bennett 1957, Van Duyn and Murphey 1971), it can be altered by a variety of factors. Delayed fertilization of females may result in a strong male bias in the eggs (Brown and Bennett 1957). A female-biased sex ratio results when scales are raised on fertilized host plants or under warm rearing conditions (Yasuda 1983a, b).

Some females of *P. pentagona* produce only male eggs under certain conditions

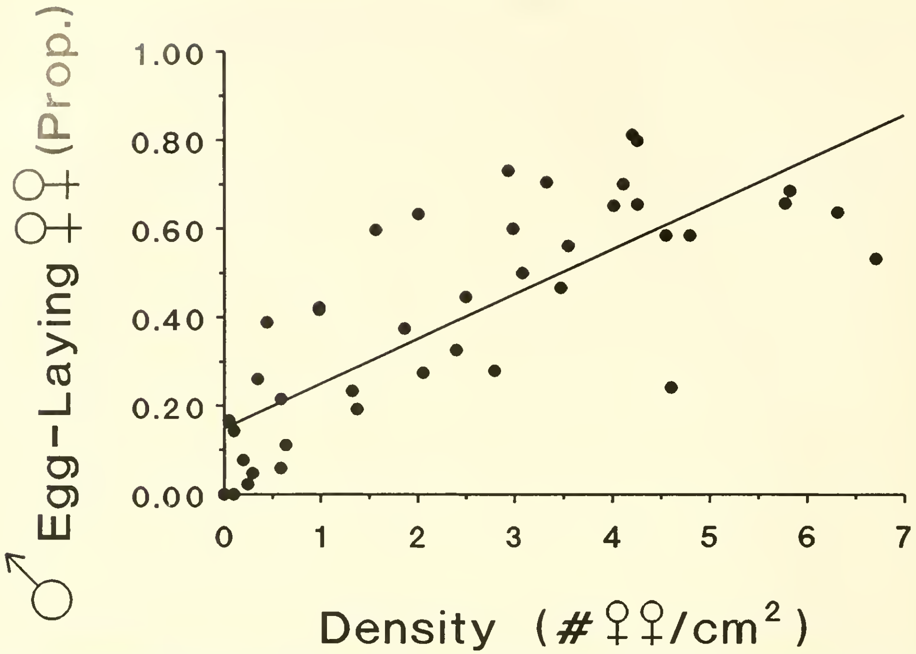


Fig. 2. Relationship between the proportion of female *P. pentagona* laying only male eggs and the density of female scales on mulberry trees. Mulberry trees (34 2-year-old clones in the greenhouse) were artificially infested with scale eggs yielding a range of adult densities from 0.2 to 7.0 adult females/cm^2). Subsequently, the number of females producing only male eggs as well as those producing eggs of both sexes was determined by removing scale covers and sexing the offspring (see Hanks 1991 for methods). Best fit regression: Y = 0.093X + 0.18, $r^2 = 0.55$, $P < 0.001$.

(Hughes 1960, Bennett and Brown 1958). In Maryland populations of *P. pentagona*, there was a positive relationship between the proportion of females laying only male eggs and the density of female scales on the trees (Fig. 2). Male bias in the offspring at high population densities may have resulted from mate availability and delayed fertilization (Brown and Bennett 1957), because in heavy infestations male pupal cases form a dense mat over females which interferes with mate location and mating (LMH pers. obs.). Also, high concentrations of female pheromones are known to disrupt the searching behavior of the males (Heath et al. 1979).

Dispersal Behavior of Crawlers

Eggs of both sexes hatch 3 to 5 days after oviposition (Fig. 3). The colonization of new host plants occurs primarily by the aerial dispersal of crawlers, while intraplant dispersal results from both aerial displacement and walking (Hanks and Denno 1992a). Following dispersal, crawlers of armored scales in general must settle on the host plant relatively soon or survivorship is drastically decreased (Beardsley and Gonzalez 1975). Crawlers of *P. pentagona* actively move about for up to 12 hours before settling to feed (Hughes 1960, Van Duyn and Murphey 1971). Female crawlers wander further from the parent female before settling than do male crawlers. This behavior results in the spread of the population throughout the host plant; male crawlers usually settle in aggregations not far from the maternal cover (Bennett and Brown 1958, Bénassy 1961, Van Duyn 1967). The longevity of male crawlers in glass containers (21.6 ± 1.6 hours, n = 20) was significantly higher than the longevity of female crawlers (15.8 ± 1.5

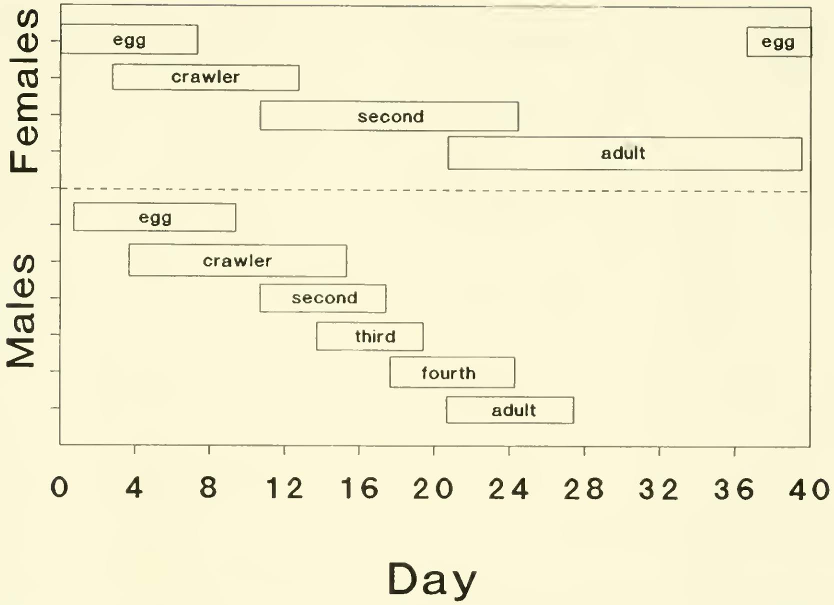


Fig. 3. Phenology of the life stages of the males and females of *P. pentagona* raised on potatoes in the laboratory at 26°C. Bars represent the duration of each life stage.

hours, n = 20) (ANOVA, $F_{1,18} = 6.03$, $P = 0.03$), suggesting the restricted dispersal of males is not attributable to reduced longevity.

Crawlers of some scale insect species exhibit behaviors (rearing up on their hind legs) in wind currents which increase their chances for aerial transport (Washburn and Washburn 1984). We observed no such behavior in the crawlers of *P. pentagona.* Placed in a directed air flow, crawlers of both sexes taken from high-density cultures clung tenaciously to the substrate. These observations suggest that crawlers do not readily disperse, even though aerial dispersal does occur and is necessary for the colonization of new host plants (Van Duyn 1967).

Crawlers of *P. pentagona* exhibit negative geotaxis, positive phototaxis and thigmotaxis, and tend to settle in cracks and other irregularities in the bark (Bennett and Brown 1958, Hughes 1960, Bénassy 1961, Yonce and Jacklin 1974, Van Duyn and Murphey 1971). Both sexes settle on old bark and rarely colonize new growth (Hughes 1960, Kuitert 1967). Furthermore, it is quite common for crawlers to settle under existing female covers (Van Duyn and Murphey 1971). For example, in a sample of recently settled crawlers on 3 mulberry trees, 24.7% of female crawlers (N = 81) and 11.8% of male crawlers (N = 85) settled under the covers of adult females from the previous generation. The repeated settling of crawlers under persisting female covers results in an accumulation of scale covers which can encrust the bark of the host (Kuitert 1967).

Growth and Development

After settling, crawlers insert their stylets into the host plant and begin to feed (Beardsley and Gonzalez 1975). To determine the specific mulberry tissues in which *P. pentagona* feeds, we dissected scale-infested cuttings and followed the stylets of 30 adult female scales to their termination. In all cases, the stylets of females terminated in tissues in and around the cambium (primary and secondary xylem). Similarly, Yasuda (1979) reported cambial feeding in *P. pentagona.*

Females molt once into 2nd instars before molting again into sexually mature adults (Fig. 3). Females (2nd instars and adults) form their covers by rotating around their inserted stylets and secreting wax from glands on the pygidium (Van Duyn 1967). Secreted wax is troweled with the pygidium into a whitish, nearly circular cover, which in the adult is 2.0–2.5 mm in diameter (Stoetzel 1976). Both the first and second instar exuviae are incorporated into the cover during construction as are bark fragments which appear to camouflage the cover (LMH pers. obs.). The scale covers of all settled female life stages are tightly appressed to the bark.

Unmated females construct an aberrant cover which extends to one side of the original cover and is loose and cottony in consistency (Bénassy 1958, Bennett and Brown 1958). Unfertilized females partially extend themselves from beneath the extended cover, and may even emerge entirely (Bennett and Brown 1958, pers. obs.). This behavior, also exhibited by other diaspidids (Ezzat 1957, Gentile and Summers 1958), may render females more accessible to males and/or enhance pheromone distribution (Bennett and Brown 1958, Beardsley and Gonzalez 1975).

Males pass through 4 instars (crawlers + 2nd–4th instars) before molting to adults (Fig. 3). As second instars, males begin constructing their distinctive, tubular, white cover (1.5 mm in length for 4th instars). Simultaneously, copious quantities of loose waxy threads are produced which extend beyond the cover (Van Duyn 1967). Adult male emergence is crepuscular (McLaughlin and Ashley 1977). Adult males measure 0.7 mm in length with a 1.4 mm wingspan (Van Duyn 1967). Most males live <1 day and are capable of mating immediately after eclosion (Bennett and Brown 1958, Van Duyn and Murphey 1971). Like males of other diaspidids, *P. pentagona* males are very weak fliers and are incapable of upwind flight in even slight breezes (Rice and Moreno 1970, Moreno et al. 1972).

HOST PLANT UTILIZATION

Host plant range

P. pentagona has been recorded feeding on 121 genera of host plants world wide (Borchsenius 1966) and 115 plant genera in Florida alone (Dekle 1977). However, due to the taxonomic confusion between *P. pentagona* and *P. prunicola,* it is not possible to associate the above-referenced host plants with either *Pseudaulacaspis* species. We compiled a list of host plants for *P. pentagona* from references in which 1) the distinction between the two congeners was made (Rhoades et al. 1985 and Davidson and Miller unpublished data), and 2) *P. pentagona* could be identified from reported egg color (Hughes 1960, Van Duyn and Murphey 1971, Brown and Bennett 1957). From our survey, 98 genera in 55 families were verified as hosts (Table 1), attesting to the polyphagous nature of this pest. Of those hosts reported, most were angiosperms (not Araucariaceae) and were woody shrubs or trees. However, monocots (e.g. Araceae and Orchidaceae) and primitive (Magnoliaceae) and derived dicot families (Fabaceae) are all recorded hosts.

The most commonly reported hosts in the United States are mulberry (*Morus alba* L.), peach (*Prunus persica* L.), persimmon (*Diospyros* spp.), chinaberry (*Melia azedarach* L.), and *Callicarpa* spp. (Davidson et al. 1983). In Maryland, *P. pentagona* occurs most abundantly on *M. alba,* but is found less commonly on *Catalpa* and rarely on *Cornus* and *Juglans* (LMH unpublished data). Our observed pattern of host utilization in Maryland was largely confirmed by extracting host plant records for *P. pentagona* from the museum collection of scale insects at the USDA Systematic Entomology Laboratory, Beltsville, Maryland as well as host species records listed by Rhoades et al. (1985). Records from 7 reported host species showed that *P. pentagona* was collected primarily from *M. alba* (≈30% of samples), *Catalpa speciosa* Warder (≈30% of samples), and *Salix nigra* L. (≈20% of

Table 1. Genera and Families of the host plants of *Pseudaulacaspis pentagona*. Genera are from Davidson and Miller (unpublished data) except when marked by (1) Rhoades et al. (1985), (2) Hughes (1960), (3) Van Duyn and Murphey (1971), and (4) Brown and Bennett (1957). Genera marked with "*" are shared with *P. prunicola*.

Acanthaceae:	*Acanthus*
	Crossandra
Actinidiaceae:	*Actinidia*
Amaranthaceae:	*Gomphrena*
Anacardiaceae:	*Mangifera*
	Rhus
	Schinus
	Spondias
Apocynaceae:	*Allamanda*
	*Nerium**
	Plumeria
Aquifoliaceae:	*Ilex**
Araceae:	Philodendron
Araliaceae:	Aralia
	Hedera
Araucariaceae:	Dombeya
Berberidaceae:	Mohonia
Bignonaceae:	*Catalpa**
	Tecoma
Brassicaceae:	*Iberis*
Buddleiaceae:	*Buddleia*
Buxaceae:	*Buxus*[1]
Caricaceae:	*Carica*
Celastraceae:	*Euonymus*
Convolvulaceae:	*Ipomoea*
Cornaceae:	*Cornus*
Crassulaceae:	*Bryophylum*
	Kalanchoe
	Sedum
Cucurbitaceae:	*Cucurbita*
Cycadaceae:	*Cycas*
Ebenaceae:	*Diospyros*
Ericaceae:	*Rhododendron*[1]
Euphorbiaceae:	*Croton**
	Euphorbia
	Jatrophya
	Manihot
	Ricinus
Fabaceae:	*Acacia*
	Crotolaria
	Glycine[1]
	Pueraria[3]
Fagaceae:	*Castanea*
Geraniaceae:	*Geranium*
	Perlargonium
Grossulariceae:	*Ribes*
Hydrangeaceae:	*Hydrangea*
Juglandaceae:	*Carya*[1]
	Juglans
Lauraceae:	Sassafras
Lythraceae:	Lagerstroemia[1]
Magnoliaceae:	*Magnolia**
Malvaceae:	*Gossypium*
	Hibiscus
	Malachra
Meliaceae:	*Cedrela*
	Melia
Moraceae:	*Broussonetia*
	Castilla
	Ficus
	Morus
Oleaceae:	*Fraxinus**
	Jasminium
	*Ligustrum**
	*Osmanthus**
	Syringa[1]*
Orchidaceae:	orchid spp.
	Stanhopea
Passifloraceae:	*Passiflora*
Piperaceae:	*Piper*
Pittosporaceae:	*Pittosporum*
Ranunculaceae:	*Clematis*
Rhamnaceae:	*Rhamnus*
	Ziziphus
Rosaceae:	*Cydonia*
	Persica
	*Prunus**
Rubiaceae:	*Cinchona*
	Palicourea
Rutaceae:	*Citrus*
Salicaceae:	*Salix**
	*Populus**
Sapindaceae:	*Koelreuteria*[2]
Solanaceae:	*Solanum*
	Capsicum
Sterculiaceae:	*Firmiana*
	Sterculia
	Theobroma
Theaceae:	*Camellia*
Ulmaceae:	*Trema*
	Ulmus[3]
Urticaceae:	*Boehmeria*
Verbenaceae:	*Castoria*
	Callicarpa
	Lantana
	Stachytarpheta[4]
Vitidaceae:	*Vitis*

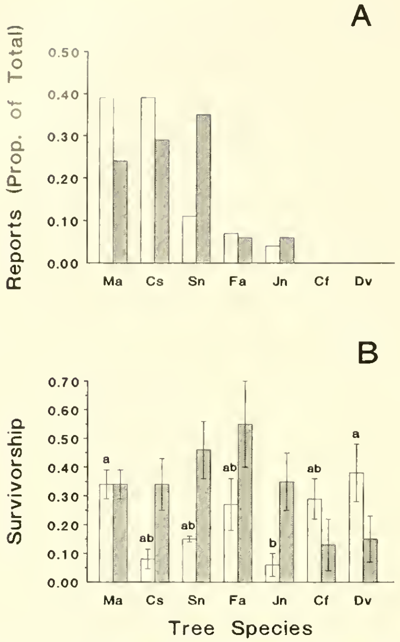


Fig. 4. (A). Number of host plant records (proportion of total) of *P. pentagona* feeding on *Morus alba* (Ma), *Catalpa speciosa* (Ca), *Salix nigra* (Sa), *Fraxinus americana* (Fa), *Juglans nigra* (Jn), *Cornus florida* (Cf), and *Diospyros virginiana* (Dv). Maryland and Virginia records were taken respectively from: 1) the museum collection of scale insects at the USDA Systematic Entomology Laboratory, Beltsville, Maryland (unshaded bars), and 2) Rhoades et al. (1985) (shaded bars). (B) Crawler (unshaded bars) and postcrawler survivorship (shaded bars) of *P. pentagona* raised on the above seven host plant species. Survivorship was determined by transferring 6 cohorts of 15 female eggs to 3 trees of each plant species and raising the eggs to adulthood (see Hanks 1991 for detailed methods). All cohorts were caged so that host plant effects were not confounded by the actions of natural enemies. Eggs for all transfers were collected on scale-infested cuttings taken from one mulberry tree in College Park, MD. There was no significant host plant effect on postcrawler survivorship. Means for crawler survivorship (±SE) marked with different letters were significantly different (ANOVA, Bonferroni *t*-test, $P < 0.05$).

samples) followed by *Fraxinus americana* L. (≈5%), and *Juglans nigra* L. (≈5%) (Fig. 4A). Despite their abundance in the Maryland area, there were no records of *P. pentagona* on *Cornus florida* L. or *Diospyros virginiana* L. *M. alba* was probably underrepresented in museum records because the occurrence of *P. pentagona* on this host is common knowledge and does not often require verification.

We examined the ability of *P. pentagona* to survive on these 7 common tree species by transferring cohorts of female eggs to each plant species and raising the eggs to adulthood (Fig. 4B). Crawler (egg to settled crawler), but not postcrawler survivorship (settled crawler to mature adult) differed significantly among plant species (ANOVA$_{\text{crawler}}$, $F_{1,14} = 3.67$, $P = 0.012$; ANOVA$_{\text{postcrawler}}$, $F_{1,14} = 1.55$, $P = 0.220$; Fig. 4B). The significant host species effect resulted from the reduced survivorship of crawlers on *J. nigra*. However, survivorship did not differ significantly on 5 tree species (*M. alba, C. speciosa, S. nigra, F. americana, C. florida,* and *D. virginiana*) suggesting that *P. pentagona* can colonize and survive on a variety of unrelated host plant species. *P. pentagona* showed high survivorship on some host species which it rarely infests (ash, dogwood, persimmon), suggesting that factors other than the direct effects of the host plant on performance are responsible for the rarity of infestations on these hosts in the field. Despite the evidence for polyphagy, *P. pentagona* does show variation in performance among some host plant species (Simmonds 1958, Hughes 1960), and even among individual mulberry trees (Hanks 1991).

Spatial Distribution of Scales on Mulberry Trees

Scale insects commonly show patchy distributions on their hosts, and it is not uncommon for heavily infested trees to neighbor scale-free trees (Edmunds and Alstad 1978, Miller and Kosztarab 1979, Wainhouse and Howell 1983). Populations of *P. pentagona* also show contagious distributions on their host plants in Bermuda and Florida (Simmonds 1958, Van Duyn 1967). We examined the dispersion of *P. pentagona* in the urban landscape of Maryland by estimating the densities of populations (No. adult females/cm^2 determined by vi-

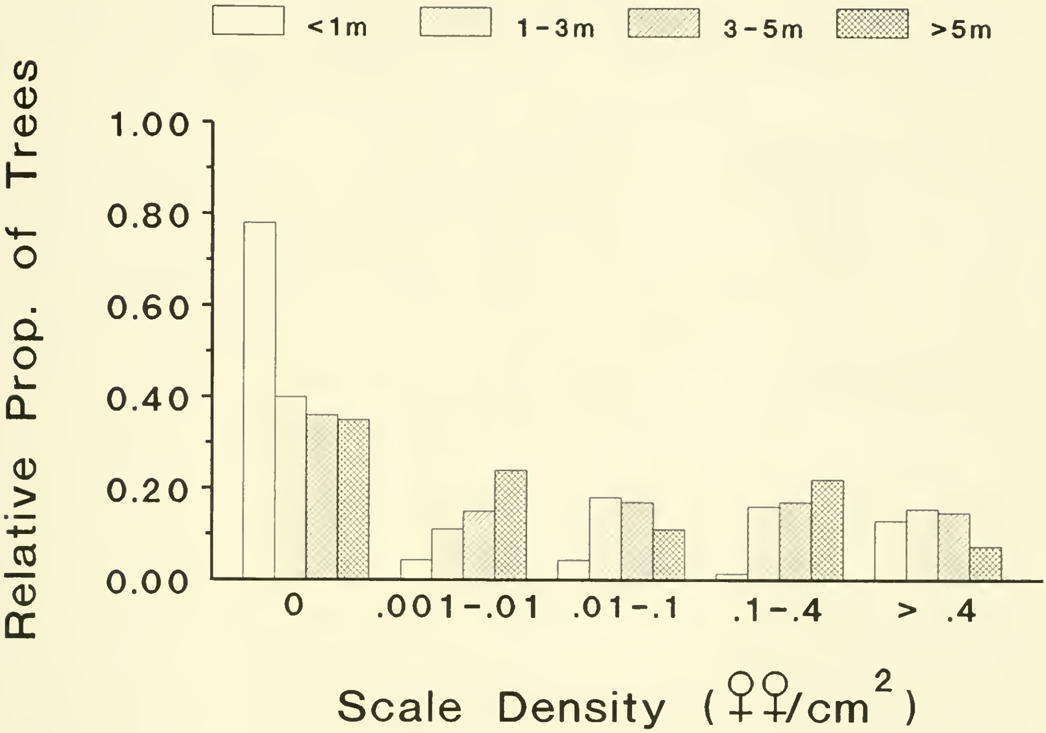


Fig. 5. Relative proportion of 4 sizes of mulberry trees (<1 m, 1–3 m, 3–5 m, and >5 m in height) in 5 density classes of *P. pentagona* (0, 0.001–0.01, 0.01–0.1, 0.1–0.4, and >0.4 adult females/cm²).

sual counts) on 100 randomly-selected mulberry trees. Dispersion of *P. pentagona* populations was assessed by calculating k-values of the negative binomial model (Southwood 1966). Large values of k (>8) indicate a uniform dispersion of populations across trees, while contagiously distributed populations are indicated by small k values (Southwood 1966). The k value for populations of *P. pentagona* was 0.07, indicating a highly clumped distribution on mulberry trees in Maryland. The contagious distribution of *P. pentagona* in Maryland results from a combination of water-stress and natural enemy attack which relegates scale populations to trees in the urban landscape not suffering from moisture deficit (Hanks and Denno 1992b). Adaptation of *P. pentagona* to individual trees was weak and failed to account for the discrepant infestations which can occur on neighboring trees (Hanks 1991).

We also examined the relative abundance of *P. pentagona* on mulberry trees of differing size. The height and density of scale infestations were determined for 300 randomly-selected mulberry trees in the urban landscape. Trees were segregated by height into 4 classes (<1 m, 1–3 m, 3–5 m, and >5 m) and by scale density into 5 density classes (0, 0.001–0.01, 0.01–0.1, 0.1–0.4, and >0.4 adult females/cm²). Trees in the four size classes differed significantly in their scale densities (Kruskal-Wallis test, $P = 0.0001$; Fig. 5). Of the 300 field trees, 46% were entirely free of scales and 16% carried heavy infestations (>0.4 adult females/cm²). Most trees in the smallest size class were scale-free (78%) while most trees in larger size classes were infested to some extent (>50%) (Fig. 5). Simmonds (1958) also reported that *P. pentagona* was much less abundant on young hosts (oleanders) than older shrubs. The poor dispersal and colo-

Table 2. Parasitoids associated with *Pseudaulacaspis pentagona.* (Some species may be hyperparasites.)

Parasitoid species	Location	Reference
Encyrtidae		
Ablerus americanus (Girault)	USA	1
Ablerus clisiocampae (Ashmead)	Czech., USA, Europe	1, 2, 3, 4, 5, 6
Ablerus molestus Blanchard	Brazil	7
Ablerus perspeciosus Girault	Czech., Europe, Japan, USA	2, 3, 5, 8
Ablerus peruviana Girault	Brazil	7
Adelencyrtus sp.	India	9
Adelencyrtus aulacaspidis (Brethes)	Czech., Europe, Japan	2, 3, 8, 10
Anicetus sp.	Japan	21
Aphycus flavidulus (Brethes)	Brazil	7, 11
Aphytis chilensis Howard	Brazil	4
Aphytis diaspidis (Howard) (= *fuscipennis*)	Africa, Argentina, Europe, Japan, Italy, New Guinea, Taiwan, Trinidad	2, 5, 12, 13, 10, 14, 15, 16
Aphytis lingnanensis Comp.	China, USA	14
Aphytis proclia (Walker)	Czech., Bermuda, Burma, France, Italy, Switz., USA	1, 3, 5, 12, 5, 13, 14
Aphytis vandenboschi DeBach and Rosen	Japan	12
Apterencyrtus microphagus (Mayr)	Europe, Japan	2, 7, 10
Archenomus bicolor Howard	Czech.	3
Archenomus orientalis Silvestri	Europe, Italy, Japan, USA	2, 10, 23
Arrhenophagus albitibiae Girault	Samoa	17
Arrhenophagus chionaspidis Aurivillius	Europe, France, Japan, India, Taiwan, USA	2, 9, 10, 16, 18, 19, 20
Aspidiotiphagus citrinus (Craw.)	Argentina, Bermuda, Colombia, Czech., Europe, Japan, Trinidad, USA	1, 3, 13, 21, 2, 22, 5, 4, 23, 5, 24
Aspidiotiphagus lounsburyi (Berlese and Paoli)	Bermuda, Principe, Sao Tome, USA	1, 2, 13
Azotus capensis (Howard)	Europe, Japan	2, 8
Azotus marchali Howard	USA	6
Azotus platensis (Brethes)	Argentina, Brazil	7, 25
Cales noacki Howard	Argentina, Brazil, Europe, Czech.	2, 3, 7, 25
Cheiloneurus sp.	India	9
Coccobius (= *Physicus*) sp.	India	9
Coccophagioides kuwanae (Silvestri)	Europe, Japan, Italy	2, 8, 9, 10
Comperiella bifasciata Howard	Orient, USA	14
Encarsia sp.	India	9
Encarsia aurantii (Howard)	Brazil, Europe	2, 7, 11
Encarsia (= *Prospaltella*) *berlesei* Howard	Arg., Bermuda, Colombia, France, Hungary, Iran, Italy, Japan, Turkey, USA, USSR,† Yugo.	1, 3, 6, 26, 27, 4, 5, 10, 14, 24, 14, 22, 28, 29, 30
Encarsia citrina (Craw.)	USA	14
Encarsia (= *Prospaltella*) *diaspidicola* (Silvestri)	Africa, Bermuda, Europe, France, Japan, Italy, Taiwan	2, 4, 13, 14, 20, 10, 16
Encarsia lounsburyi (Berlese and Paoli)	Bermuda, New Guinea, Trinidad, USA	1, 5, 13, 23
Encarsia murtfeldtae (Howard)	Argentina, Europe, Italy, USA	2, 5, 23
Encarsia perniciosi (Tower)	China	14
Epitetracnemus sp.	India	9
Epitetracnemus (= *Anabrolepis*) *comis* Nois and Hui	China	31

Table 2. Continued.

Parasitoid species	Location	Reference
Epitetracnemus lindingaspis (Tachikawa)	Japan	21
Marietta sp.	Samoa, USA	17, 27
Marietta carnesi (Howard)	USA	1
Marietta javensis (Howard)	India	9
Marietta mexicana (Howard)	Europe	2
Marietta pulchella (Howard)	USA	5, 32
Metaphyscus sp.	USA	6
Prospaltella diaspidis (= *niigata*) Nakagama	Europe, Japan	2, 13
Physcus varicornis (Howard)	USA	6
Pteroptrix dimidiatus Westw.	Europe	2
Thysanus flavopalliatus (Ashmead)	USA	1, 4, 22, 27
Eulophidae		
Tetrasticus pupureus (Cameron)	India	9
Ceraphronidae		
Aphanogmus n. sp.	USA	1
Ceraphron sp.	USA	6
Megaspilidae		
Dendrocerus sp.	USA	6
Megaspilus prob. *fuscipennis* (Ashmead)	USA	6
Platygasteridae		
Amitus sp.	USA	6
Amitus spiniferus (Brethes)	Brazil	7
Signiphoridae		
Chartocerus pulcher (Girault)	USA	5
Signiphora aspidioti Ashmead	Europe	2
Signiphora bifasciatus Ashmead	Brazil	4, 11
Signiphora caridei Brethes	Brazil, Europe	2, 4, 11
Signiphora endophragmata Blanchard	Argentina	25
Signiphora flavopalliatus Ashmead	USA	4, 27
Signiphora platensis Brethes	Brazil, Europe	2, 7

References: 1) Collins and Whitcomb (1975), 2) Kosztarab and Kozár (1988), 3) Kozarzevskaja and Mihajlovic (1983), 4) Hughes (1960), 5) Peck 1963, 6) Nalepa and Meyer (1990), 7) Silva et al. (1968), 8) Murakami (and references therein, 1970), 9) Sankaran (1984), 10) Yasumatsu and Watanabe (1965), 11) Davidson and Miller (in prep.), 12) Rosen and DeBach (1979), 13) Simmonds (1958), 14) Cock (1985), 15) Mercet (1932), 16) Yen (1973), 17) Liebregts and Sands (1989), 18) Ball and Stange (1979), 19) Tachikawa (1959), 20) Quilici et al. (1987), 21) Yasuda (1981), 22) Kuitert (1967), 23) Clausen (1978), 24) Posada and Garcia (1976), 25) DeSantis (1941), 26) Darvas and Zsellér (1985), 27) Van Duyn and Murphey (1971), 28) Habibian (1981), 29) Kózar et al. (1982), 30) Howard (1912), 31) Noyes and Hui (1987), 32) Present study.

† Locations cited as USSR indicate territories encompassed by former USSR.

nizing ability of armored scales (Beardsley and Gonzalez 1975) probably contributes to their rarity on young and/or small hosts.

NATURAL HISTORY

Parasitoids and hyperparasitoids

A total of 60 species of parasitoids and hyperparasitoids have been associated with *P. pentagona* world wide (Table 2), although some of these records are probably confounded with the enemies of *P. prunicola*. Approximately 75% of the parasitoids were wasps in the family Aphelinidae. Similarly, 6 species of aphelinid wasps dominated the community of parasitoids attacking populations of *P. pentagona* at our study site in College Park, MD. The aphelinids included

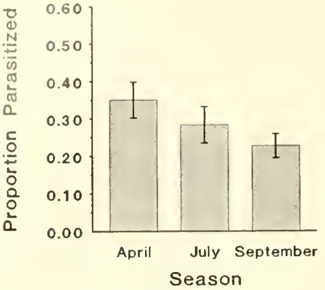


Fig. 6. Proportion of *P. pentagona* females parasitized by *E. berlesei, A. proclia*, and *A. bicolor* on mulberry trees in the urban landscape of College Park, MD. Parasitoids were sampled by taking scale-infested cuttings from mulberry trees during the first, second, and third scale generations when most females were second instars. Twenty cuttings were collected from 5 field trees in April, July and September 1986. Cuttings were returned to the laboratory, placed in plastic bags and stored in an incubator (21–24°C). The emerging parasitoids were identified to species and counted. Rates of parasitism for each cutting were determined by dividing the number of parasitized females by the total number of female scales (see Hanks 1991 for detailed methods).

3 primary parasites, *Encarsia berlesei* (Howard), *Archenomus bicolor* Howard (Gordh), and *Aphytis proclia* (Walker) and 3 hyperparasitoids, *Ablerus clisiocampae* (Ashmead), *A. perspeciosus* Girault and *Marietta pulchella* (Howard) also emerged from scales on the cuttings. Only female scales were attacked and males remained free of parasitoids.

E. berlesei is a parthenogenetic endoparasitoid which attacks only two other host species, *P. prunicola* and *Melanaspis obscura* (Comstock), in the United States (Howard 1912, Krombein et al. 1979, Stimmel 1982). The parthenogenetic ectoparasitoid, *A. proclia*, is polyphagous attacking a variety of armored scales in the United States (Krombein et al. 1979, but see Rosen and DeBach 1979 for possible taxonomic confusion). *A. bicolor* is a bisexual endoparasitoid which attacks only *P. pentagona* and an *Aspidiotus* species in the United States (Krombein et al. 1979). Multiple parasitism is unknown in *E. berlesei* and *A. bicolor*, but *P. pentagona* is occasionally multiply parasitized by *A. proclia* (at most 2 parasitoids/host) (LMH unpublished data).

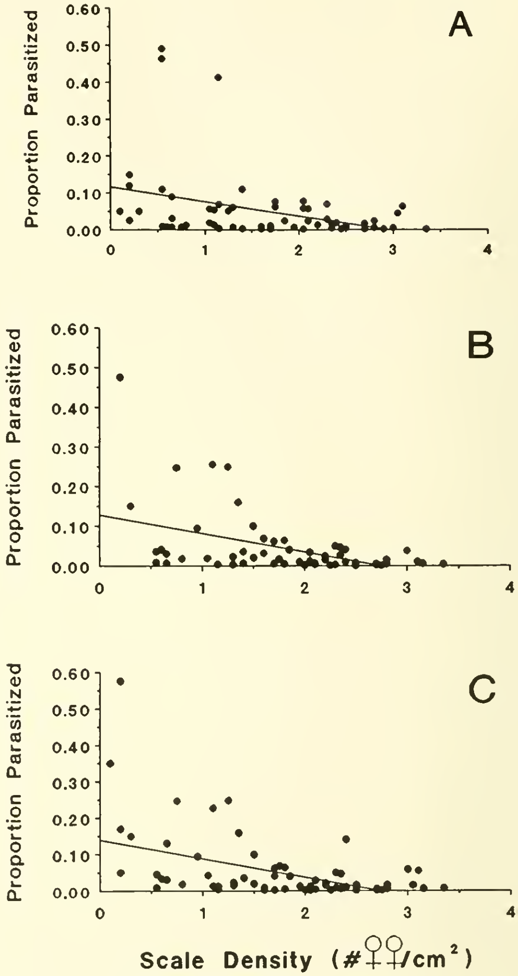


Fig. 7. Relationship between parasitism rate (proportion of scales parasitized by *E. berlesei* [A], *A. proclia* [B], and *A. bicolor* [C]) and the density of *P. pentagona* (No. adult females/cm²) on 50 mulberry trees in the urban landscape of College Park, MD (see Hanks 1991 for detailed methods).

Parasitism rate (combined mortality from all three primary parasitoid species) declined gradually over the course of the season dropping from 35% in the spring to 25% in the fall generation of scales (Fig. 6). The seasonal decrease in parasitism rate occurred despite a threefold increase in scale population size from spring to fall (Fig. 1). This pattern is strongly suggestive of temporally inverse density-dependent parasitism (Hanks 1991). Also, spatial patterns of inverse density-dependent parasitism by *A. proclia, E. berlesei,* and *A. bicolor* were observed among populations of *P. pentagona* on different mulberry trees (Fig. 7). Thus, patterns of inverse density-dependent parasitism in the parasitoids of *P. pentagona* are evident at both temporal and spatial scales (Hanks 1991). Explanations for inverse density-dependent parasitism include parasitoid egg depletion, interference among parasitoids at high host densities, and failure of parasitoids to aggregate in patches of high host density (Hanks 1991).

The three primary parasitoids differed in their proportional contribution to total parasitism from one scale generation to the next (Fig. 8). *A. proclia* was the most abundant species emerging from scales in the third (April) and first (July) generations, while *E. berlesei* was the most prolific parasitoid attacking second generation scales in fall.

Also, the three primary parasitoid species showed marked differences in their patterns of spring emergence within one scale generation (overwintering females) (Fig. 9). *E. berlesei* and *A. proclia* were the first parasitoids to emerge in spring followed one week later by *A. bicolor.* Both *E. berlesei* and *A. proclia* showed a distinct second peak of emergence, as has been observed for these two parasitoids of *P. pentagona* in Japan (Yasuda 1981). Similarly, Simmonds (1958) observed a double peak of emergence for an *Aphytis* species attacking *P. pentagona* in Bermuda. These data suggest that by emerging earlier in the scale generation, *E. berlesei* and *A. proclia* can complete two generations, while *A. bicolor* by emerging late is restricted to a single generation. That *E. berlesei* and *A. proclia* can complete 2 generations on a single generation of *P. pentagona* may explain why these two species are the most abundant parasitoids in the system. The proportion of total parasitism attributable to *A. proclia, E. berlesei,* and *A. bicolor* was 41, 35, and 24% respectively.

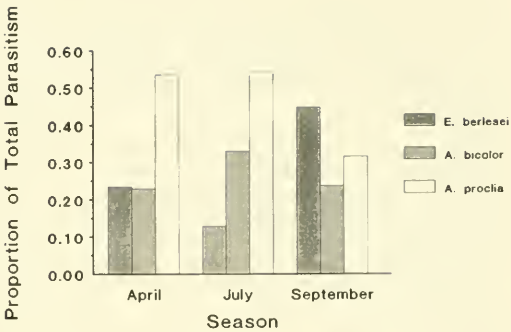


Fig. 8. Relative proportion of total parasitism of *P. pentagona* attributable to *E. berlesei, A. proclia,* and *A. bicolor* during the first, second and third scale generations (see Fig. 6 caption for methods).

Even though parasitized females of *P. pentagona* were invariably killed, they occasionally managed to deposit a fraction of their eggs. For example, 9.7% of female *P. pentagona* (n = 396) that were parasitized by *A. proclia* succeeded in laying 28 ± 14 eggs, while 9.2% (n = 131) of the scales were parasitized by the endoparasites *E. berlesei,* and *A. bicolor* deposited 25 ± 9.9 eggs. In Maryland populations of *P. pentagona,* the hyperparasitoids *A. clisiocampae, A. perspeciosus,* and *M. pulchella* were not common and accounted for 1.2, 0.7, and 0.1%

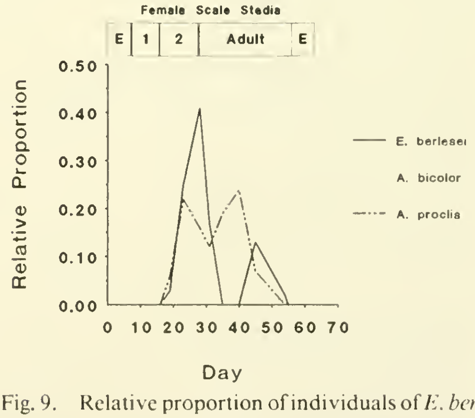


Fig. 9. Relative proportion of individuals of *E. berlesei, A. proclia,* and *A. bicolor* (expressed as a proportion of the total number of conspecifics collected) emerging each day from overwintering females of *P. pentagona* on mulberry cuttings (see Fig. 6 caption for methods). Bar illustrates the phenology of the life history stages of *P. pentagona* (egg, first instar crawlers, second instars and adults).

Table 3. Predators of *Pseudaulacaspis pentagona.*

Predator species	Locations	Reference
Arachnida:		
Acarina		
Hemisarcoptes malus (Shimer)	Principe, Sao Tome, USA	1, 13, 32
Hemicheyletia scutellata (DeLeon) 1	USA	1
Hemicheyletia wellsi Baker	USA	1
Lasioseius sp.	Principe, Sao Tome	13
Lorryia nr. *cobremani* (Baker) 1	USA	1
Tydeus sp.	Bermuda	13
Insecta:		
Orthoptera		
Periplaneta americana L.	Bermuda	13
Periplaneta australasiae (Fabr.)	Bermuda	13
Thysanoptera		
Karnyothrips flavipes (Jones) 1	USA	1
Halothrips nr. *americanus* (Hood) 1	USA	4
Coleoptera		
Coccinellidae		
Callicaria superba Mulsant	Europe, Japan, Taiwan	2, 8, 10, 16, 30
Chilocorus bipustulatus L.	Europe, Italy	2, 11, 13, 20, 33
Chilocorus bivulnerus Mulsant	USA	35
Chilocorus cacti L.	Cuba, Puerto Rico, Trinidad	13, 14, 38
Chilocorus circumdatus (Gylh.)	Ceylon, India	14, 33
Chilocorus kuwanae Silvestri	China, Europe, Japan, USA	2, 8, 10, 13, 14, 30, 33
Chilocorus nigritus (Fabricius)	Mauritius, Reunion	34, 36
Chilocorus politus Mulsant	Mauritius, Reunion	34, 36
Chilocorus rubidus Hope	Europe, Japan	2, 8, 10
Chilocorus similis (Rossi)	Japan	33
Chilocorus stigma (Say)	USA	1, 4, 27, 32
Coccidophilus cariba Breth.	Antigua, Montserrat	14
Coccidophilus citricola Brethes	Argentina, Colombia, Trinidad	14, 24, 33
Cryptognatha gemellata (= *simillima*) Mulsant	Trinidad	14
Cryptognatha nodiceps Marshall	Principe, Sao Tome, Trinidad	13, 37
Cryptolaemus montrouzieri Mulsant	USA, Reunion	4, 36
Endochilus styx Sic.	Sao Tome, Principe	13
Exochomus childreni Mulsant	USA	4
Exochomus quadripustulastus (L.)	Europe	2, 11
Hyperaspis japonica Crotch	Europe, Japan	2, 9, 10, 30
Lindorus (= *Rhyzobius*) *lophanthae* (Blaisdell)	Argentina, Australia, Bermuda, Brazil, Europe, Italy, USA	1, 2, 4, 7, 13, 14, 20, 32, 33
Microweisea coccidivora (Ashmead)	USA	1
Neaporia nr. *grahami* Brethes	Bermuda	13
Nephus phosphorus Lewis	Japan	21
Orculus sp.	Principe, Sao Tome	13
Pentilia insidiosa Mulsant	Puerto Rico, Trinidad	13, 14
Pharosymnus sp.	Bermuda	11
Pharosymnus horni Gorh.	India	9
Prodilis nr. *gorhami* (Brethes)	Trinidad	14
Pseudoscymnus hareja Weise	Europe, Japan	2, 10, 14, 30
Rodalia cardinalis (Mulsant)	Brazil	7
Rodalia concolor Lewis	Europe, Japan	2, 8, 10, 30

Table 3. Continued.

Predator species	Locations	Reference
Rodalia limbata Motschulsky	Japan	21
Scymnomorphus sp.	Mauritius	34
Scymnus hareja Weise	Japan	13
Scymnus hilaris Motschulsky	Japan	21
Serangium japonicum Chapin	Japan	21
Stethorus spp.	Japan	21
Stethorus japonicus Kamiya	Europe, Japan	2, 8, 10, 30
Sticholotis gomyi Chazeau	Reunion	36
Sticholotis madagassa Weise	Reunion	36
Sticholotis punctata Crotch	Europe, Japan	2, 8, 30
Sticholotis quadrisignata Weise	Samoa	17
Sukunahikona japonica H. Kamiya	Japan	21
Telsimia nigra (Weise)	Europe, Japan	2, 13, 14, 30
Telsimia nitida Chapin 1	Samoa	17
Nitidulidae		
Cybocephalus sp.	Bermuda, India, Trinidad, USA	1, 9, 14
Cybocephalus binotatus Gouvelle	Reunion	36
Cybocephalus foderi (= *luteipes*) Endrody-Youga	Hungary	26
Cybocephalus gibbulus Erichson	Europe, Japan, USA	2, 13, 30
Cybocephalus nipponicus Endrody-Younga	Japan	21
Cybocephalus pullus Endrody-Younga	Reunion	36
Cybocephalus rufifrons Reitter	Europe, Italy	2, 20, 22
Neuroptera		
Chrysopidae		
Chrysopa sp.	USA	4, 27
Chrysoperla rufilabris (Burmeister)	USA	1
Mallada boninensis (Okamoto)	Europe, Japan, Taiwan	2, 10, 16, 30
Coniopterygidae		
Heteroconis picticornis (Banks)	China	14
Lepidoptera		
Arctiidae		
Eilema griseola (Hubner)	Europe, Japan	2, 8, 39
Lithosia quadradives Butler	Europe, Japan	2, 8, 10, 30
Cosmopterigidae		
Pyroderces rileyi (= *stigmatophora*) (Walsingham) 2	USA	4, 8, 27
Noctuidae		
Eublemma sp.	Africa	8
Stathmopodidae		
Stathmopoda sp. 2	Samoa	17
Diptera		
Dentifibula sp.	Japan	21
Dentifibula viburni (Felt)	USA	1
Lestodiplosis sp.	Japan	21
Cecidomyiidae		
spp.?	India	9
Anthrocnodax diaspidis Kieff.	Italy	33

Table 3. Continued.

Predator species	Locations	Reference
Anthrocnodax moricola Kieff.	Africa	33
Silvestrina silvestrii Kieff.	Africa, Brazil	33
Tricontrarinia ciliatipennis Kieff.	Japan	33
Syrphidae		
Salpingogaster nigriventris Bigot	Argentina, USA	33

References as in Table 2 with the addition of: 33) Thompson and Simmonds (1964), 34) Moutia and Mamet (1947), 35) Gossard (1902), 36) Guyot and Quilici (1987), 37) Bennett (1956), 38) Wolcott (1960), 39) Strickland (1947).

mortality of the primary parasitoids. Our sampling and rearing methods (see caption for Fig. 6) did not allow for the association of hyperparasitoids with specific host species. Hyperparasites were also uncommon in populations of *P. pentagona* elsewhere (Williams 1970, Collins and Whitcomb 1975, Yasuda 1981).

Predators

A total of 80 species of predators have been reported attacking *P. pentagona* throughout the world, most of which (58%) are coccinellid beetles (Table 3). In Maryland, the coccinellids *Lindorus lophanthae* (Blaisdell) and *Chilocorus stigma* Say commonly feed on *P. pentagona.* Adults and larvae of both *C. stigma* and *L. lophanthae* entirely consume first instar scale insects, but when feeding on second instars and adults chew characteristic oblong holes into scale covers (Hanks 1991).

In Maryland populations of *P. pentagona,* coccinellid larvae (*L. lophanthae* and *C. stigma* combined) were scarce during spring and summer, but increased dramatically in density by the end of the summer generation of scales in September (Fig. 10A). Predator density was therefore high when scales began to oviposit in September. Predation rate by the two coccinellids remained low ($<5\%$) through spring and summer, but increased substantially in late fall to 30% (Fig. 10B). Even though these coccinellids aggregated on mulberry trees with high scale densities, their impact on scale populations was relatively low due to their appearance late in the season (Hanks 1991).

Biological Control and Management of *P. pentagona*

P. pentagona is one of 18 diaspidid species which has been successfully controlled using biological agents (DeBach and Rosen 1976). *E. berlesei* is a widely distributed parasite (Table 1.2) that has provided effective control of *P. pentagona* in several areas (Howard 1916, DeBach and Rosen 1976, Greathead 1976, Clausen 1978). The coccinellids *L. lophanthae* and *C. stigma* are polyphagous predators which have proven successful in controlling scale insects (Clausen 1978).

Nevertheless, these enemies failed to suppress populations of *P. pentagona* in the disturbed urban landscape of Maryland where scale populations frequently outbreak and occasionally even kill their mulberry hosts. Reasons for this failure include 1) inverse density-dependent parasitism exhibited by *E. berlesei, A. proclia,* and *A. bicolor* (scale insects escape their parasitoids (Hanks 1991)), 2) partial oviposition by female scales despite being parasitized, and 3) the rarity of predaceous coccinellids through summer when *P. pentagona* populations are growing rapidly (Hanks 1991). However, in forest habitats, generalized predators (earwigs, tree crickets, harvestmen) which are less abundant in landscape settings maintain populations of *P. pentagona* at very low densities (Hanks and Den-

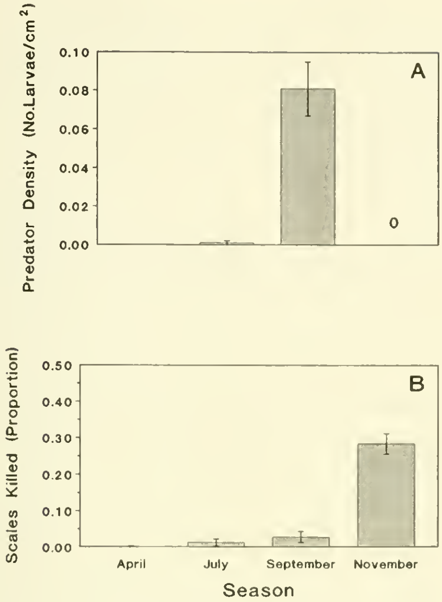


Fig. 10. (A) Density of coccinellid larvae (*L. lophanthae* and *C. stigma* combined) in populations of *P. pentagona* on mulberry trees in the urban landscape of College Park, MD. Predators were sampled by taking 20 scale-infested cuttings from 5 mulberry trees during the first, second, and third scale generations and in the late fall, 1986 (see Fig. 3 for sampling dates and *P. pentagona* phenology, and Hanks 1991 for sampling details). Cuttings were returned to the laboratory and the number of coccinellid larvae and the number of predator-damaged and undamaged adult female scales were counted. (B) Seasonal change in predation rate (proportion of *P. pentagona* killed which showed characteristic feeding damage by *L. lophanthae* and *C. stigma*).

no 1992b). Similarly, hymenopterous parasitoids were reported to suppress densities of *P. pentagona* in undisturbed habitats in Florida (Collins and Whitcome 1975). From a pest management perspective, dense and diverse plantings of ornamental trees encourage generalist predators and provide a better setting for natural control of armored scale pests (Hanks and Denno 1992b).

ACKNOWLEDGMENTS

John Davidson, Irwin Forseth, and Michael Raupp reviewed earlier drafts of this report. James Stimmel and an anonymous reviewer contributed to the final draft. We appreciate their constructive comments. We also thank J. Davidson and D. R. Miller for providing unpublished host plant records for *P. pentagona.* Partial support for this research was provided by the Gahan Regents Fellowship to LMH. This is Scientific Article Number A6321, Contribution Number 8497 of the Maryland Agricultural Experiment Station, Department of Entomology.

LITERATURE CITED

Ball, J. C. 1980. Development and fecundity of the white peach scale at two constant temperatures. Florida Entomologist 63(1): 188–194.

Ball, J. C. and L. A. Stange. 1979. Report of *Arrhenophagus chionaspidis* on *Pseudaulacaspis pentagona* in Florida. Forida Entomologist 62(4): 414.

Beardsley, J. W., Jr. and R. H. Gonzalez. 1975. The biology and ecology of armored scales. Annual Review of Entomology 20: 47–73.

Bénassy, C. 1958. Influence of coupling and fertilization on the differentiation of the sexes and the formation of the protective shield in *Pseudaulacaspis pentagona* Targ. (Homoptera, Diaspididae). Comptes Rendus de l'Académie des Sciences, Paris 264(4).

———. 1961. Contribution a l'étude de l'influence de quelquer facteurs écologiques sur la limitation des pullulations de cochenilles-diaspines. Institut National de la Recherche Agronomique Series A, No. 3742.

Bennett, F. D. 1956. Some parasites and predators of *Pseudaulacaspis pentagona* in Trinidad, B.W.I. Canadian Entomologist 88: 704–705.

Bennett, F. D. and S. W. Brown. 1958. Life history and sex determination in the diaspine scale, *Pseudaulacaspis pentagona* Targ. (Coccoidea). Canadian Entomologist 90: 317–324.

Bennett, F. D. and I. W. Hughes. 1959. Biological control of insect pests in Bermuda. Bulletin of Entomological Research 50: 423–436.

Bobb, M. L., J. A. Weidhaas, Jr., and L. F. Ponton. 1973. White peach scale: Life history and control studies. Journal of Economic Entomology 66(6): 1290–1292.

Borchsenius, N. S. 1966. A catalogue of the armoured scale insects of the world. Akademiia Nauk SSSR, Zoologicheskii Institut, Leningrad.

Brown, S. W. and F. D. Bennett. 1957. On sex determination in the diaspine scale *Pseudaulacaspis pentagona* (Targ.) (Coccoidea). Genetics 42: 511–523.

Clausen, C. P. 1978. Introduced Parasites and Predators of Arthropod Pests on Weeds: A World Review. U.S.D.A. Handbook 480.

Cock, M. J. W. 1985. A review of biological control of pests in the commonwealth caribbean and Bermuda up to 1982. Commonwealth Institute of Biological Control Technical Communication 9.

Collins, F. A. and W. H. Whitcomb. 1975. Natural enemies of the white peach scale, *Pseudaulacaspis pentagona* (Homoptera: Coccidae) in Florida. Florida Entomologist 58(1): 15–21.

Darvas, B. and H. I. Zsellér. 1985. Effectiveness of some juvenoids and anti-ecdysones against the mulberry scale, *Pseudaulacaspis pentagona* (Homoptera: Diaspididae). Phytopathologia Academiae Scientarum Hungaricae 20(3–4): 341–346.

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. Proceedings of the Entomological Society of Washington 85: 753–761.

DeBach, P. and D. Rosen. 1976. Armoured scale insects, pp. 139–178. *In* DeLucchi, V. L., ed., Studies in Biological Control. International Biological Programme 9. Cambridge University Press.

Dekle, G. W. 1977. Florida Armored Scale Insects. Arthropods of Florida and Neighboring Land Areas, Vol. 3.

DeSantis, L. 1941. List de himenopteros parasitos y predatores de los insectos de la Republica Argentina. Sociedade Brasileiri de Agronomia Boletin 4: 1–60.

Edmunds, G. F. and D. N. Alstad. 1978. Coevolution in insect herbivores and conifers. Science 199: 941–945.

Einhorn, J., H. Bianchi, and C. Bénassy. 1983. Combined effects of two pheromonal components on the male sexual behavior of a diaspine coccid, *Pseudaulacaspis pentagona* Targ. (Homoptera, Diaspididae). Comptes Rendus de l'Académie des Sciences, Paris, t. 296, Serie III: 861–863.

Ezzat, Y. M. 1957. Biological studies on the olive scale (*Parlatoria oleae* Colvee). Bulletin de la Societé Entomologique d'Egypte 41: 351–363.

Gentile, A. G. and F. M. Summers. 1958. The biology of the San Jose scale on peaches with special reference to the behavior of males and juveniles. Hilgardia 27: 269–285.

Gossard, H. A. 1902. Two peach scales. Florida Agricultural Experimental Station Bulletin 61: 492–498.

Greathead, D. J. 1976. A review of biological control in western and southern Europe. Commonwealth Institute of Biological Control Technical Communication 7.

Guyot, J. and S. Quilici. 1987. Etude bio-écologique de la cochenille diaspine *Pseudaulacaspis pentagona* Targioni-Tozzetti et de ses ennemis naturels à la Réunion. Fruit 42(10): 583–592.

Habibian, A. 1981. Some studies on *Pseudaulacaspis pentagona* Targ. and its newly imported parasite (*Prospaltella berlesei*) in Guilan province. Entomologie et Phytopathologie Appliqueés 49(1): 65–72.

Hanks, L. M. 1991. Factors influencing the distribution and abundance of the white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Homoptera: Diaspididae): Host plants and natural enemies. Dissertation, The University of Maryland, College Park, Maryland, USA.

Hanks, L. M. and R. F. Denno. 1992a. The importance of demic adaptation in colonization and spread of scale insect populations. *In:* Kim, C., ed., Evolution of Insect Pests: The Patterns of Variations. John Wiley and Sons, Inc. Publications, New York. (In press.)

———. 1992b. Natural enemies and plant water relations influence the distribution of the armored scale insect *Pseudaulacaspis pentagona* (Homoptera: Diaspididae). Ecology (*in press*).

Heath, R. R., J. R. McLaughlin, J. H. Tumlinson, T. R. Ashley, and R. E. Doolittle. 1979. Identification of the white peach scale sex pheromone. Journal of Chemical Ecology 5(6): 941–953.

Howard, L. O. 1912. The activity of *Prospaltella berlesei* Howard against *Diaspis pentagona* Targ. in Italy. Journal of Economic Entomology 5: 325–328.

———. 1916. Further notes on *Prospaltella berlesei.* Journal of Economic Entomology 9: 179–188.

Hughes, I. W. 1960. Host relationships and natural enemies of the white peach scale, *Pseudaulacaspis pentagona* (Targ.), (Homoptera, Coccoidea). Thesis, University of Florida, Gainsville, Florida, USA.

Johnson, W. T. and H. H. Lyon. 1988. Insects that Feed on Trees and Shrubs, Cornell Univ. Press, Ithaca.

Kosztarab, M. and F. Kozár. 1988. Scale Insects of Central Europe. W. Junk, Publishers, Boston, USA.

Kozár, F., V. A. Jasnosh, and G. M. Konstantinova. 1982. Comparative evaluation of the distribution of scale-insects (Hom. Coccoidea) and their parasites in Georgia (USSR) and in Turkey. Zeitschrift fuer Angewandte Entomologie 93: 333–338.

Kozarzevskaja, E. and L. Mihajlovic. 1983. Biological data of mulberry scale (*Pseudaulacaspis pentagona* Targ.-Tozz.) and its parasites (Chalcidoidea) in Belgrade. Zastita bilja 34(1), br. 163: 59–75.

Krombein, K. V., P. D. Hurd, and D. R. Smith. 1979. Catalog of Hymenoptera in America North of Mexico. Smithsonian Inst. Press, Washington, D.C.

Kuitert, L. C. 1967. Observations on the biology, bionomics, and control of white peach scale *Pseu-*

daulacaspis pentagona (Targ.). Florida State Horticultural Society 1969: 376–381.

Liebregts, W. J. M. M. and D. P. A. Sands. 1989. Population studies and biological control of *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Hemiptera: Diaspididae) on passion fruit in Western Samoa. Bulletin of Entomological Research 79: 163–171.

McLaughlin, J. R. and T. R. Ashley. 1977. Photoperiod and temperature modulation of male eclosion time in the white peach scale, *Pseudaulacaspis pentagona*. Physiological Entomology 2: 209–212.

Mercet, R. G. 1932. Notas sobre afelinidos (6th note). Eos 8: 352–325.

Miller, D. R. and J. A. Davidson. 1990. A list of the armored scale insect pests, pp. 299–306. *In* Rosen, D., ed., The Armored Scale Insects. Their Biology, Natural Enemies and Control. Vol. B. Elsevier Science Publishers B.V., Amsterdam, The Netherlands.

Miller, D. R. and M. Kosztarab. 1979. Recent advances in the study of scale insects. Annual Review of Entomology 24: 1–27.

Moreno, D. S., G. E. Carman, R. E. Rice, J. G. Shaw, and N. S. Bain. 1972. Demonstration of a sex pheromone of the yellow scale, *Aonidiella citrina*. Annals of the Entomological Society of America 65: 443–446.

Moutia, L. A. and R. Mamet. 1947. An annotated list of insects and Acarina of economic importance in Mauritius. Mauritius Department of Agricultural Science Serial Bulletin 29.

Murikami, Y. 1970. A review of biology and ecology of diaspine scales in Japan (Homoptera, Coccoidea). Mushi 43: 65–114.

Nalepa, C. A. and J. R. Meyer. 1990. The seasonal history of the white peach scale (Homoptera: Diaspididae) and its hymenoptera natural enemies in North Carolina. Journal of Entomological Science 25: 303–310.

Noyes, J. S. and R. Hui. 1987. Two new species of Encyrtidae (Hymenoptera) reared from diaspidid scale insects (Homoptera: Diaspididae) in China. Entomotaxonomia 9(3): 167–174.

Nur, U. 1990. Chromosome, sex ratios, and sex determination, pp. 179–190. *In* Rosen, D., ed., The Armored Scale Insects. Their Biology, Natural Enemies and Control. Vol. B. Elsevier Science Publishers B. V., Amsterdam, The Netherlands.

Peck, O. 1963. A catalogue of the nearctic Chalcidoidea. Canadian Entomologist Supplement 30, 1092 pp.

Posada, O. L. and F. R. Garcia. 1976. Lista de predatores, parasitos y patogenos de insectos registrados en Colombia. Ministerio de Agricultura, Instituto de Colombia Agopec. Boletin Tecnical 41.

Quilici, S., B. Trahais, and R. Manikom. 1987. Institut de Recherches sur les fruits et Argrumes. Rapport Annuel 1987.

Rhoades, M. H., M. Kosztarab, and E. G. Rajotte. 1985. Identification, hosts and distribution of *Pseudaulacaspis pentagona* (Targioni-Tozzetti) and *P. prunicola* (Maskell) in Virginia (Homoptera: Diaspididae). Proceedings of the Entomological Society of Washington 87(3): 545–553.

Rosen, D. and P. DeBach. 1979. Species of *Aphytis* of the World. W. Junk B.V. Publishers, The Hague.

Rice, R. E. and D. S. Moreno. 1970. Flight of male California red scale. Annals of the Entomological Society of America 63: 91–96.

Sankaran, T. 1984. Survey of natural enemies of diaspine scale insects in south India. Commonwealth Institute of Biological Control 87(2): 38–52.

Silva, A. G. d'a., C. R. Goncalves, D. M. Galcao, A. J. L. Goncalves, J. Gomes, M. N. Silva, and L. Simoni. 1968. Quarto catálogo dos insetos que viven nos plantas do Brasil seus parasitos e predadores. Parte II. Ministerio da Agrecultura Laboratorio Central Patologia Vegetal 1: 1–622.

Simmonds, F. J. 1958. The oleander scale, *Pseudaulacaspis pentagona* Targ. (Homoptera: Coccoidea) in Bermuda. Bermuda Department of Agriculture Bulletin 31.

Southwood, T. R. E. 1966. Ecological Methods. John Wiley and Sons, New York, USA.

Stimmel, J. F. 1982. Seasonal history of the white peach scale, *Pseudaulacaspis pentagona* (Targ.-Tozz.) (Homoptera:Diaspididae) in northeastern Pennsylvania. Proceedings of the Entomological Society of Washington 84: 128–133.

Stoetzel, M. B. 1976. Scale-cover formation in the Diaspididae (Homoptera: Coccoidea). Proceedings of the Entomological Society of Washington 78(3): 323–331.

Strickland, A. H. 1947. Coccids attacking cacao (*Theobroma cacao* L.) in West Africa, with descriptions of 5 new species. Bulletin of Entomological Research 38: 497–523.

Tachikawa, T. 1959. Studies on the natural history enemies of *Pseudaulacaspis pentagona* Targioni (2). Plant Protection 13: 75–82.

Thompson, W. R. and F. J. Simmonds. 1964. A catalogue of the parasites and predators of insect pests. Commonwealth Institute of Biological Control Section 3. Predator host catalogue.

Tremblay, E. 1990. Endosymbionts, pp. 275–284. *In* Rosen, D., ed., The Armored Scale Insects. Their Biology, Natural Enemies and Control. Vol. A. Elsevier Science Publishers B.V., Amsterdam, The Netherlands.

Van Duyn, J. W. 1967. Observations on the life history and studies on control of white peach scale, *Pseudaulacaspis pentagona* (Targioni) (Homoptera, Coccoidea). M.S. Thesis, University of Florida, Gainsville, Florida, USA.

Van Duyn, J. W. and M. Murphey. 1971. Life history and control of white peach scale. *Pseudaulacaspis pentagona* (Homoptera: Coccoidea). Florida Entomologist 54: 91–95.

Wainhouse, D. and R. S. Howell. 1983. Distribution of attack by beech scale *Cryptococcus fagisuga* in beech progeny trials. Proceedings of the International Union of Forestry Research Organizations (I.U.F.R.O.): Beech Bark Disease Working Party Conference, 1983, USDA Forest Service, pp. 33–37.

Washburn, J. O. and L. Washburn. 1984. Active aerial dispersal of minute wingless arthropods: Exploitation of boundary-layer velocity gradients. Science 223: 1088–1089.

Williams, J. R. 1970. Studies on the biology, ecology and economic importance of the sugar-cane scale insect, *Aulacaspis tegalensis* (Zhnt.) (Diaspididae), in Mauritius. Bulletin of Entomological Research 60: 61–95.

Wolcott, G. N. 1960. Efficiency of ladybeetles in insect control. Journal of Agriculture, University of Puerto Rico 44: 166–172.

Yasuda, S. 1979. Microscopic observations on the external morphology of *Pseudaulacaspis pentagona* Targioni and on the portion of mulberry tissues inserted with the stylet. Japanese Journal of Applied Entomology and Zoology 23: 61–68.

———. 1981. Natural enemies of *Pseudaulacaspis pentagona* Targioni (Hemiptera: Diaspididae) and their seasonal abundance. Japanese Journal of Applied Entomology and Zoology 25: 236–241.

———. 1983a. Effects of thermal conditions on the sex ratio of *Pseudaulacaspis pentagona* (Targioni) (Hemiptera: Diaspididae), at the early stage of ovogenesis and egg batch size. Journal of Sericultural Science of Japan 52(2): 106–109.

———. 1983b. Effect of fertilization in mulberry plants on the sex ratio of eggs of the mulberry scale, *Pseudaulacaspis pentagona* (Targioni). Journal of Sericultural Science of Japan 52(1): 9–12.

Yasumatsu, K. and C. Watanabe. 1965. A tentative catalogue of insect natural enemies of injurious insects in Japan. Part 2. Host parasite-predator catalogue. Entomological Laboratory, Kyushu University. Hakozaki, Fukuoka, Japan.

Yen, D. F. 1973. A natural enemy list of insects of Taiwan. Department of Plant Pathology and Entomology, National Taiwan University. Taipei, Taiwan.

Yonce, C. E. and S. W. Jacklin. 1974. Life history of the white peach scale in central Georgia. Journal of the Georgia Entomological Society 9(4): 213–216.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 99–106

CALOPHYA TRIOZOMIMA SCHWARZ, A SUMAC-FEEDING PSYLLID NEW TO THE EASTERN UNITED STATES (HOMOPTERA: PSYLLOIDEA: CALOPHYIDAE)

A. G. Wheeler, Jr. and John E. Rawlins

(AGW) Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania 17110; (JER) Section of Invertebrate Zoology, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania 15213.

Abstract.—*Calophya triozomima* Schwarz, known previously from Alberta, Arizona, California, Colorado, Idaho, Missouri, and Utah, is reported from the eastern United States. It was collected on native and ornamental fragrant sumac (*Rhus aromatica* Ait.) in Connecticut, Kentucky, Indiana, Maryland, Michigan, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin. Eastern records are listed and mapped, observations on seasonal history and habits are summarized, and recognition features and illustrations of adult habitus and wing venation are provided. Although eastern populations could be adventive, this psyllid is considered indigenous in the eastern United States.

Key Words: Psyllids, distribution, faunal origin, *Rhus aromatica*, pest potential

---

The genus *Calophya* Löw (Calophyidae) is a large, predominantly North Temperate group of psyllids feeding primarily on plants in the family Anacardiaceae (Hodkinson 1980). It is placed in the nominotypical subfamily Calophyinae, a lineage considered monophyletic by White and Hodkinson (1985). The Calophyinae contain five genera of which *Calophya* is the largest with species in the Holarctic and Neotropical regions. Most hosts of *Calophya* are in the Rutales (Burseraceae, Rutaceae, and Anacardiaceae), but species have been reported from *Phoradendron* (Loranthaceae, Santalales) and *Idria* (Fouquieriaceae, Violales) (Hodkinson and White 1981). *Calophya* currently contains five South American and 14 North American species (Hodkinson and White 1981, Hodkinson 1988). Four species have been previously reported from the eastern United States, but only *C. flavida* Schwarz and *C. nigripennis* Riley have been collected east of Illinois and north of Florida (*C. pallidula* McAtee was described from Illinois, and *C. arcuata* Caldwell is found in Florida).

Like most psylloids, species of *Calophya* are narrowly host specific, with the Holarctic species specializing on sumac, *Rhus* (Anacardiaceae) (Hodkinson 1974). *Calophya flavida* feeds on smooth sumac (*R. glabra* L.) and *C. nigripennis* is found on dwarf sumac (*R. copallina* L.) (Crawford 1914, McAtee 1918). Most species of *Calophya* from the western United States have hosts in *Rhus* subgenus *Lobadium* (which contains *R. aromatica* Ait.), including *C. aurea* Tuthill, *C. californica* Schwarz, *C. dubia* Crawford, *C. nigrella* Jensen, and western populations of *C. triozomima* Schwarz.

Our recent collecting has produced the first records of *C. triozomima* from the eastern United States. Herein we list new records, map the known eastern distribution,

Fig. 1. Distribution of *Calophya triozomima* in the eastern United States. Dots = new records; circle = previous easternmost record.

and give notes on its habits and seasonal history on fragrant sumac (*R. aromatica*). Recognition features and illustrations of adult habitus and wing venation are provided. Neither *C. flavida* nor *C. nigripennis* were collected from *R. aromatica* during the course of this study.

Distribution

Schwarz (1904) described *C. triozomima* from southern Arizona and Los Angeles Co., California. Paratypes from Arizona (Oracle and Santa Rita Mountains, as cited by Crawford [1914]) were collected on *R. trilobata* (Nutt.) Gray (for discussion of the status of *R. trilobata*, see "The Host Plant"). Crawford (1914) recorded *C. triozomima* from Colorado and described the new variety *claripennis* from Arizona and Colorado. Subsequent records have been west of the Mississippi River: Idaho (Klyver 1932), Alberta (Strickland 1939), Utah (Jensen and Knowlton 1951), and Missouri (Craig 1973). The host for the Columbia, Missouri, collection was *R. aromatica*.

The following records, all from *R. aromatica*, document the presence of *C. triozomima* in the eastern states (Fig. 1). Voucher specimens from our field work have been deposited in the collections of the Carnegie Museum of Natural History, Pittsburgh (CMNH); Cornell University, Ithaca, New York (CUIC); and Pennsylvania Department of Agriculture, Harrisburg (PDA). The Wisconsin record is based on a specimen in the Entomological Collections of the Natural History Museum (USNM), Beltsville, Maryland.

CONNECTICUT: *Middlesex Co.*, Wesleyan University, Middletown, 15 July 1989, A. G. Wheeler, Jr. (AGW). **INDIANA:** *Tippecanoe Co.*, Purdue University, West Lafayette, 6 July 1986, T. J. Henry and AGW. **KENTUCKY:** *Jessamine Co.*, Camp Nelson, Boone's Bluff, 20 April 1991, AGW. **MARYLAND:** *Allegany Co.*, Fifteen Mile

Creek Road, Green Ridge State Forest, 30 June 1991, AGW; N. of Flintstone, 19 Aug. 1991, AGW. **MICHIGAN:** *Chippewa Co.,* Maxton Plains, Drummond Island, 20 July 1991, AGW. **NEW YORK:** *Tompkins Co.,* Cornell University, Ithaca, 12, 24 & 27 May 1990 and 17 March & 4 Aug. 1991, AGW. **OHIO:** *Ottawa Co.,* Marblehead Peninsula, near Lakeside, 8 Aug. 1992, AGW. **PENNSYLVANIA:** *Bedford Co.,* Shawnee State Park, S. of Schellsburg, 9 & 17 May, 13 June 1990, 10 Aug. 1991, AGW; *Cumberland Co.,* Cave Hill, Carlisle, 29 July 1990, 5 & 13 May and 18 Aug. 1991, AGW; *Fulton Co.,* shale barren E. of Harrisonville, 29 July 1990, AGW; *Huntingdon Co.,* Hawns Bridge shale barren, S. of Huntingdon, 16 May 1989, J. E. Rawlins and AGW (Host Voucher in Carnegie Herbarium, Thompson No. 8370); *Juniata Co.,* limestone glade S. of McAlisterville, 10 May & 21 June 1990, 20 May 1991, AGW. **TENNESSEE:** *Davidson Co.,* Long Hunter State Recreation Area, 19 April 1991, AGW. **VIRGINIA:** *Frederick Co.,* Highway I-81 at junction with Route 672 near Clear Brook, 11 May & 16 Aug. 1991, AGW; *Pulaski Co.,* Route 100 at junction with Highway I-81 S. of Dublin, 5 May, 10 & 27 June 1991, AGW; *Shenandoah Co.,* shale barren, base of Short Mountain, SE of Mount Jackson, 11 May 1991 & 4 Sept. 1992, AGW. **WEST VIRGINIA:** *Berkeley Co.,* Yankauer Nature Preserve, c. 6 mi. NE of Martinsburg, 30 April 1990, AGW. **WISCONSIN:** *Jefferson Co.,* Waterloo, 14 July 1961, W. E. Simmons.

THE HOST PLANT

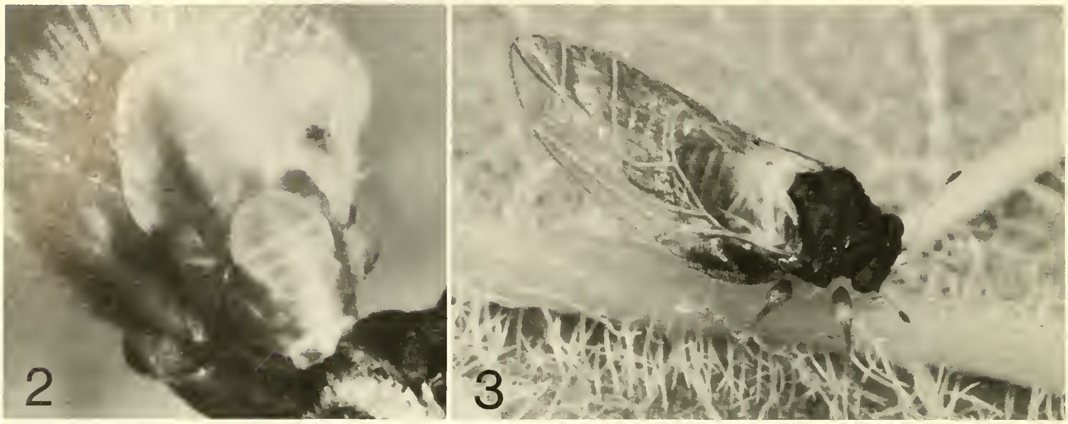
Rhus aromatica is a straggling or upright shrub that grows to a height of about 2 m. It often forms thickets and has ascending lower branches. Leaves are trifoliate and resemble those of poison ivy, *Toxicodendron radicans* (L.) Kuntze. They are coarsely toothed and usually glossy on the upper surface. Flowers are polygamous or dioecious, yellow, catkinlike before opening, and appear in March or April before the leaves unfold. The bright red fruits are densely pubescent. Ranging from southern Ontario and Quebec south to Florida and west through the Great Lakes region, Alberta, and Oregon south to California, Texas, and Mexico, this highly variable plant grows in dry rocky or sandy soils (Fernald 1950, Gleason and Cronquist 1991).

Rhus aromatica and *R. trilobata* were placed in *Rhus* subgenus *Lobadium* section *Lobadium* by Barkley in his classic monograph of North American sumacs (Barkley 1937). Young (1978), using morphological features, wood anatomy, and flavonoid chemistry, grouped the *R. aromatica-R. trilobata* complex with the other deciduous species in the subgenus *Lobadium*: *R. allophylloides* Stanley, *R. schmideloides* Schlecht, and *R. microphylla* Engelm. ex A. Gray. Kartesz and Kartesz (1980) listed *R. aromatica* and *R. trilobata* as distinct species, but we note that the latter has been treated recently as one of several western varieties of *R. aromatica* (e.g. McGregor 1986, Looman and Best 1987, Welsh et al. 1987; see also Gleason and Cronquist 1991). The distribution given above includes that of varieties formerly referred to *R. trilobata.*

Rhus aromatica is used as an ornamental plant for its dense, glossy foliage that turns orange or scarlet in fall; several cultivars have been developed. It is useful for providing quick growing cover, especially on sunny slopes (Dirr 1975, Everett 1982).

HABITATS

We encountered *C. triozomima* in several specialized habitats. At the Hawns Bridge Barrens Natural Area in Huntingdon Co., Pennsylvania, it was found on fragrant sumac growing on sheer cliffs overlooking Raystown Lake. This is a small barren of southwest-facing slope and thin soil overlying Devonian bedrock. Lying at the northern limit of the mid-Appalachian shale barrens, it lacks most of the endemic plants characteristic of shale barrens in southwestern Virginia and adjacent West Virgin-



Figs. 2–3. *Calophya triozomima* feeding on fragrant sumac, *Rhus aromatica.* 2. Overwintering nymph. 3. Adult in late spring.

ia (Keener 1983). The collections in Fulton Co., Pennsylvania, Allegany Co., Maryland, and Shenandoah Co., Virginia, are also from shale barrens. In other native stands of fragrant sumac in Pennsylvania, *C. triozomima* was taken in a small limestone glade in Juniata Co. and on limestone bluffs overlooking the Conodoguinet Creek in Cumberland Co. The psyllid also was found at the edge of a cedar (or limestone) glade in Central Tennessee, in a remote natural area on Drummond Island in Michigan, from an old quarry in what formerly was limestone prairie in Ohio, and from native plants growing above Fall Creek Gorge on the Cornell University Campus in Central New York.

In landscape plantings, the psyllid was collected on the campuses of Purdue University in Indiana, Wesleyan University in Connecticut, and along two major highways in Virginia. Its abundance on cultivated fragrant sumac appeared greater than in most populations in the wild, possibly because the dense ornamental plantings offer a more abundant food resource than the generally sparse native stands.

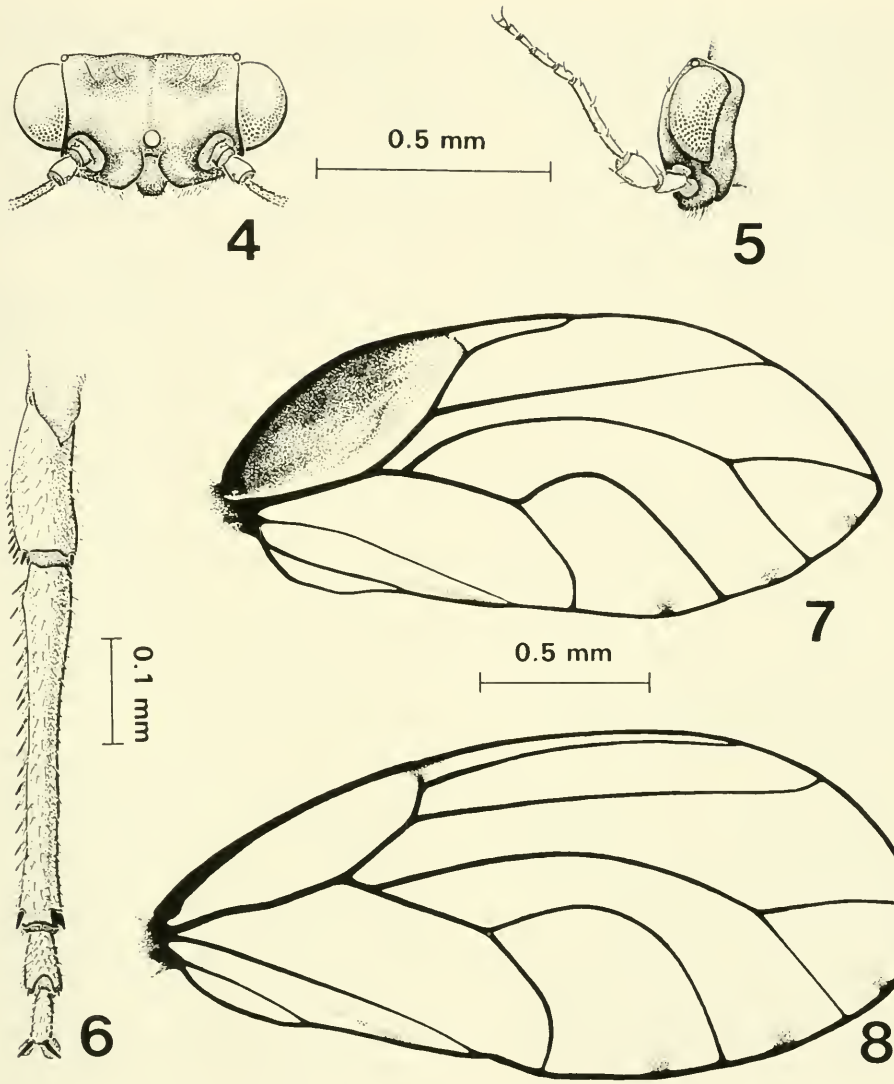
Seasonal History and Habits

These notes on habits and seasonality represent a composite of observations made at several localities. The seasonality profile was inferred by contrasting intervals when adults were observed (usually during periods of peak abundance) with those when no adults could be collected. Regular sampling of a population throughout the season is needed to obtain a better understanding of its life history.

Overwintering occurs as late-instar nymphs appressed to stems at the axil of a leaf bud and twig, the base of buds, and on bracts of the aments or catkins (Fig. 2). As temperatures warm in spring, they are found on leaf buds and catkins. Adults were present by late April in Kentucky and Tennessee, and teneral adults were collected in late April in West Virginia's eastern panhandle and in early May in Pennsylvania. At Ithaca, New York, only nymphs were found on 12 and 24 May 1990, but adults were present by 27 May.

Adults were observed on leaves and stems and also clustered around buds (Fig. 3). Overwintered adults had disappeared by late May in more southern populations, and first generation adults were present by late June. At most sites, they persisted through July. The large numbers of adults observed during the first half of August apparently represented a second generation.

The bivoltine life cycle of *C. triozomima* contrasts with the univoltinism of *C. nigri-*



Figs. 4–8. Adult structures of *Calophya*. 4. *C. triozomima*, anteroventral view of head. 5. *C. triozomima*, lateral view of head. 6. *C. triozomima*, metathoracic leg showing absence of darkened spines at apex of basal tarsomere. 7. Left forewing of *C. triozomima*. 8. Left forewing of *C. flavida*.

pennis on dwarf sumac. Like *C. triozomima,* it overwinters as nymphs, and adults begin to appear in spring (mid-May in southern New Jersey). However, eggs do not hatch until mid- to late June, and each of the first three nymphal stages lasts about a month. Development in *C. nigripennis* therefore has been characterized as "very slow" (Weiss 1918, Weiss and Nicolay 1918).

RECOGNITION CHARACTERS

Species of *Calophya* in the eastern United States may be recognized by the rounded vertex that is neither flattened nor extended anteriorly (Fig. 4), by the absence of dark, modified spines at the distal end of the basal tarsal segment of the hind legs (a feature characteristic of several other northeastern psylloids) (Fig. 6), by forewing venation with the medial and cubital veins stalked and not arising at the same point as the radial vein (Figs. 7, 8), and by moderately developed genal cones that do not (or barely) cover the frons on the midline (Fig. 5).

Adults of the typical morph of *C. triozomima* are easily distinguished from sympatric congeners in the East by their transparent forewings bearing a diffuse, darkened spot on the anterior basal cell (Fig. 7), and their brown to black thoraces (Fig. 3). The forewings are entirely darkened in *C. nigripennis,* and the body is light yellow to orange throughout in *C. flavida.* Pale yellow individuals of *C. triozomima* (variety *claripennis* Crawford) lack the dark spot at the base of the forewing, and may be distinguished from *C. flavida* by the apex of the forewing, which is subacute in *C. triozomima* (Fig. 7) and broadly rounded or slightly angled in *C. nigripennis* and *C. flavida* (Fig. 8). Adult psylloids with dark thoraces and transparent wings on fragrant sumac in the eastern United States are most likely *C. triozomima.* Specimens referable to the *claripennis* phenotype are apparently rare in the eastern United States as only a few females taken in Huntingdon Co., Pennsylvania, match the varietal description.

A second, possibly undescribed (and univoltine) species of the genus often co-occurs with *C. triozomima* on fragrant sumac in the East. We are attempting to determine the identity of this small, pale yellow *Calophya,* one that will be misidentified as *C. flavida* using available literature.

Last-instar nymphs of *C. triozomima* are best identified by association with adults, but can be recognized as calophyine by the following combination of characters: antennae less than half the length of the forewing pads; scales or enlarged, bladelike setae (sectasetae) absent on the margins of the abdomen and forewing pads; sectasetae present on the antennae (White and Hodkinson 1985).

Discussion

That *C. triozomima* has long been known only from western North America suggests it is not native in the East. Its recent detection on the Cornell University campus where the insect fauna has been reasonably well studied for more than a century supports such a conclusion. Its presence on ornamental fragrant sumac on college campuses and along highways could indicate an introduction with nursery stock.

But *C. triozomima* could well be indigenous in the East. It develops on a relatively inconspicuous shrub that entomologists could easily overlook. Or potential collectors might avoid this plant because its foliage looks so much like that of poison ivy. In addition, fragrant sumac often grows on steep slopes that limit accessibility to collectors. Indeed, the occurrence of psyllids in several remote, undisturbed areas points to an indigenous status in eastern North America. We acknowledge, however, that some vagile immigrants disperse rapidly and are able to colonize habitats well removed from their area of entry.

We consider this psyllid native to the eastern states because of its association with a host plant unlikely to draw attention from entomologists, because the Psylloidea in general have not been well collected, and because certain Lepidoptera taken with the psyllid at the Hawns Bridge shale barren are mainly western species that also are poorly known or have gone unnoticed in the East (J. E. Rawlins, unpublished data).

The pest potential of *C. triozomima* is uncertain. Johnson and Lyon (1988) mentioned *C. californica* Schwarz as a pest of *Rhus ovata* S. Wats. in California. The Neotropical *C. schini* Tuthill, discovered in California in 1984, has become a pest of California pepper tree, *Schinus molle* L. Nymphs develop within pits they induce on pepper tree leaflets and cause foliar pitting, discoloration, and distortion. Cessation of growth and loss of foliage also are possible (Downer et al. 1988, Johnson and Lyon 1988). Although *C. triozomima* appears not to cause such noticeable injury, we have observed some leaflet distortion on fragrant sumac. Dwarf sumac heavily infested with

C. nigripennis shows discoloration of foliage and disfiguration of upper leaf surfaces (Weiss 1918, Weiss and Nicolay 1918). We conclude that large populations of *C. triozomima* sometimes developing on cultivars of *R. aromatica* in landscape plantings should be considered potentially injurious.

ACKNOWLEDGMENTS

We are grateful to W. C. Forrey (Bureau of State Parks, Pennsylvania Department of Environmental Resources) for permission to collect at Shawnee State Park, R. S. Jensen (Natural Resources, Tennessee Department of Conservation) for permission to collect at Long Hunter State Recreation Area, L. M. Russell (USDA, Systematic Entomology Laboratory, Beltsville, MD) for the Wisconsin record, P. Jones (Ohio Department of Natural Resources, Columbus) for information on the Ohio site, and J. F. Stimmel (PDA, BPI, Harrisburg) for the photograph used in Fig. 2. For helping us locate populations of *Rhus aromatica* we thank C. Bell (Shepherd College, Shepherdstown, WV), J. Campbell (The Nature Conservancy, Lexington, KY), C. S. Keener (Pennsylvania State University, University Park, PA), L. H. Klotz (Shippensburg University, Shippensburg, PA), A. F. Rhoads (Morris Arboretum of the University of Pennsylvania, Philadelphia, PA), T. L. Smith (Virginia Division of Natural Heritage, Richmond), P. S. Somers (Tennessee Department of Conservation, Nashville), S. A. Thompson (Carnegie Museum of Natural History, Pittsburgh, PA), and D. Young (Shawnee State Park, Schellsburg, PA). We thank M. A. Klingler for the line drawings, and M. A. Daman for assistance in manuscript preparation.

LITERATURE CITED

Barkley, F. A. 1937. A monographic study of *Rhus* and its immediate allies in North and Central America, including the West Indies. Annals of the Missouri Botanical Garden 24: 265–500.

Craig, W. S. 1973. A psyllid (*Calophya triozomima*). United States Department of Agriculture, Cooperative Economic Insect Report 23(38): 656.

Crawford, D. L. 1914. A monograph of the jumping plant-lice or Psyllidae of the New World. United States National Museum, Bulletin 85. 186 pp.

Dirr, M. A. 1975. Manual of woody landscape plants: Their identification, ornamental characteristics, culture, propagation and uses, 3rd ed. Stipes Publishing Company, Champaign, Ill. 826 pp.

Downer, J. A., P. Svihra, R. H. Molinar, J. B. Fraser, and C. S. Koehler. 1988. New psyllid pest of California pepper tree. California Agriculture 42(2): 30–32.

Everett, T. H. 1982. The New York Botanical Garden Illustrated Encyclopedia of Horticulture. Vol. 9. Garland Publishing, New York, pp. 2863–3224.

Fernald, M. L. 1950. Gray's Manual of Botany, 8th ed. American Book Company, New York. 1632 pp.

Gleason, H. A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. New York Botanical Garden, Bronx, New York. 910 pp.

Hodkinson, I. D. 1974. The biology of the Psylloidea (Homoptera): A review. Bulletin of Entomological Research 64: 325–339.

———. 1980. Present-day distribution patterns of the holarctic Psylloidea (Homoptera: Insecta) with particular reference to the origin of the nearctic fauna. Journal of Biogeography 7: 127–146.

———. 1988. The Nearctic Psylloidea (Insecta: Homoptera): An annotated check list. Journal of Natural History 22: 1179–1243.

Hodkinson, I. D. and I. M. White. 1981. The Neotropical Psylloidea (Homoptera: Insecta): An annotated check list. Journal of Natural History 15: 491–523.

Jensen, D. D. and G. F. Knowlton. 1951. The Psyllidae of Utah. Utah Agricultural Experiment Station, Mimeograph Series 308. 5 pp.

Johnson, W. T. and H. H. Lyon. 1988. Insects that Feed on Trees and Shrubs, 2nd ed. Cornell University Press, Ithaca, N.Y. 556 pp.

Kartesz, J. T. and R. Kartesz. 1980. A Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland. Vol. II. The Biota of North America. University of North Carolina Press, Chapel Hill. 498 pp.

Keener, C. S. 1983. Distribution and biohistory of the endemic flora of the mid-Appalachian shale barrens. Botanical Review 49: 65–115.

Klyver, F. D. 1932. Biological notes and new records of North American Chermidae (Homoptera). Entomological News 43: 7–12, 33–40, 70–75.

Looman, J. and K. F. Best. 1987. Budd's Flora of the Canadian Prairie Provinces. Research Branch, Agriculture Canada Publication 1662. 863 pp.

McAtee, W. L. 1918. Psyllidae of the vicinity of Washington, D.C., with description of a new species of *Aphalara* (Hom.). Entomological News 29: 220–224.

McGregor, R. L. 1986. Anacardiaceae, pp. 571–575. *In* Great Plains Flora Association. Flora of the Great Plains. University Press of Kansas, Lawrence.

Schwarz, E. A. 1904. Notes on North American Psyllidae. Part I. Proceedings of the Entomological Society of Washington 6: 234–245.

Strickland, E. H. 1939. Further notes on Psyllidae taken in Alberta (Homoptera). Canadian Entomologist 71: 212–215.

Weiss, H. B. 1918. Unusual nursery insects. New Jersey Department of Agriculture, Bureau of Statistics and Inspection Circular 24. 13 pp.

Weiss, H. B. and A. S. Nicolay. 1918. The life history and early stages of *Calophya nigripennis* Riley. Journal of Economic Entomology 11: 467–471.

Welsh, S. L., N. D. Atwood, S. Goodrich, and L. C. Higgins, eds. 1987. A Utah flora. Great Basin Naturalist Memoirs 9: 1–894.

White, I. M. and I. D. Hodkinson. 1985. Nymphal taxonomy and systematics of the Psylloidea (Homoptera). Bulletin of the British Museum of Natural History (Entomology) 50: 153–301.

Young, D. A. 1978. Reevaluation of the sections of *Rhus* L. subgenus *Lobadium* (Raf.) T. & G. (Anacardiaceae). Brittonia 30: 411–415.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 107–112

NOMADA ANNULATA SMITH (HYMENOPTERA: ANTHOPHORIDAE), A CONFIRMED CLEPTOPARASITE OF *ANDRENA MACRA* MITCHELL (HYMENOPTERA: ANDRENIDAE) AND OTHER *NOMADA-ANDRENA* ASSOCIATIONS

ERIC W. RIDDICK

Howard University, Department of Zoology, Washington, D.C. 20059. Present address: Division of Biological Control, University of California, 1050 San Pablo Avenue, Albany, California 94706.

Abstract.—*Nomada annulata* Smith is a cleptoparasite in the nests of *Andrena macra* Mitchell. This relationship was confirmed when *N. annulata* adults were found inside *A. macra* brood cells in winter, *N. annulata* prepupae were found inside brood cells in summer, and prepupae were reared to the adult stage by the fall season. Other *Nomada-Andrena* associations, reported in North America north of Mexico, are discussed.

Key Words: *Nomada*, cleptoparasites, *Andrena*, bees

Nomada is the largest genus of Nomadinae in North America north of Mexico and contains approximately 300 species (Hurd 1979). Less than 15% of the North American species have any aspect of their biology reported. *Nomada* are cleptoparasites in the nests of other bees, mainly *Andrena*. Other Andrenidae (*Nomadopsis, Panurgus*), Anthophoridae, Halictidae, and Melittidae also contain members utilized as hosts (Bohart 1970, Eickwort and Abrams 1980).

An earlier study of *Nomada annulata* Smith reported the identification of a sex-specific compound in the cephalic secretions of males (Duffield et al. 1990). It was in this study that *Andrena macra* Mitchell was implicated as the host of *N. annulata*. This current paper outlines the research that confirmed the *N. annulata-A. macra* association.

The definitive and putative *Nomada-Andrena* associations, reported in America north of Mexico, are tabulated and discussed. The methodology presented herein can be used to accurately associate *Nomada* species with *Andrena* hosts, in future investigations.

MATERIALS AND METHODS

Nesting sites were found on the United States Marine Corps Reservation at Quantico, Virginia, by walking alongside roadways and noting bee and cleptoparasite flight activity, in May 1983. All sites were on sun-exposed roadsides, had soil of a clay-like consistency, and had sparse amounts of grasses in them. The approximate distance between nesting sites ranged from 1 mile, between sites I and III, to 5 miles, between sites I and IV.

Andrena macra are solitary, univoltine bees that conduct nesting activities from early May until the middle of June, in Virginia. Their nests display an aggregated or clumped distribution within each site. A typical *A. macra* nest contains an entrance, tumulus, main vertical shaft, lateral shafts, and 4–12 brood cells (Riddick 1992).

Winter dormant bees were excavated from nests at nesting site I from March to May

1984. A trench was dug in front of a m^2 area of the site, where *A. macra* nest entrances were aggregated on the surface in the previous nesting season. Soil particles were then removed from the wall of the trench with a microspatula. Brood cell depth was approximately 30–70 cm beneath the surface of site I. A cell is an oval to urn-shaped chamber in which an immature bee is reared. Each is composed of two walls: an outer wall of compacted soil and a thin, shiny inner lining of a wax-like composition. Cells were located and checked for prepupae and adult bees, which became visible when the cell wall was broken with a microspatula. No attempt was made to distinguish cells of a nest from those of another.

Adult *N. annulata* and *A. macra* were collected while they flew over the surface of nesting sites in May 1984, in order to estimate their relative abundance. Standardized trapping of bees occurred with a sweep net, while traversing the sites. The time and temperature were recorded for each session.

Prepupae involved in the rearing trials were excavated from nesting sites II and III from July to August 1984; and site II in June 1985. Brood cell depth beneath the surface of these sites ranged from 30–70 cm. Each prepupa, with most of its brood cell, was carved out of the ground with the microspatula and placed in a 4-dram glass shell vial. Vials were transported to the laboratory inside an ice chest on the same day.

In the first rearing trial, 71 prepupae were collected then stored at 3.0°C for two to three months, because it was assumed that prepupae would normally overwinter as prepupae, and therefore required months of cold exposure in the laboratory before development could resume. Rearing at room temperature (24–27°C) began on 29 October and ended on 21 December 1984, when all prepupae had metamorphosed into adults or died. The rearing chamber consisted of a plastic container (26 × 36 × 14 cm) covered with a dark trash can liner. Each shell vial was examined at least once a week to notice whether prepupae had died and if brood cells were dry. Water droplets were added directly to the outer cell wall as needed, to maintain moisture within individual vials.

The second rearing trial involved 47 prepupae excavated from nesting site II between 22–29 June 1985. The second trial began on 30 June, without any prior cold exposure, and ended by 24 October. The rearing chamber was a styrofoam ice chest (14 × 30.5 × 14 cm) which had a strip of plastic between the body and lid. This chamber was designed to keep moisture inside. Maintenance procedures were the same as those used in the first trial.

Reared adults were sacrificed, preserved, and stored in the Insect Collection, Department of Zoology, at Howard University.

RESULTS

Nomada annulata overwintered inside *A. macra* brood cells. Thirteen brood cells (3.37%) contained a *N. annulata* adult, all alive, in winter 1984. Live *A. macra* were found in 121 cells; 72 (18.65%) contained a prepupa, 49 (12.69%) contained an adult. Dead *A. macra* were found in 36 cells; 04 (1.03%) contained a prepupa, 32 (8.29%) contained an adult. Notice that 216 cells (55.96%) contained fungus, covering the contents. Empty cells (195) were also present, but not included in the calculation of percentages.

Nomada annulata were first observed at the surface of *A. macra* nesting site I on 10 May 1984, days after *A. macra* major emergence. Within a 32 min collecting session at site I, a single male *N. annulata* and 26 *A. macra* (males > females) were captured as they flew above the surface. Air temperatures ranged from 29–34°C. Male *N. annulata* were apparently searching for females to mate with.

By 15 May, *N. annulata* were more abundant at the nesting sites. Forty *N. annulata* (males and females) were captured, with 11

A. macra (males < females), in 41 min at site I. Air temperature was at least 21°C. On 19 May, 24 *N. annulata* were captured, with 8 *A. macra* females, in 38 min (temp. 29–30°C) at site I; 23 *N. annulata*, with 4 *A. macra* females, in 35 min (temp. 30–40°C) at site II; 22 *N. annulata*, with 11 *A. macra* females, in 37 min (temp. 48–49°C) at site IV; and 14 *N. annulata*, with 16 *A. macra* females, in 21 min (temp. 38–39°C) at site V.

When investigating *A. macra* nests, female *N. annulata* flew above the surface at a height of 5–8 cm, under sunny to partly sunny skies, if air temperatures were at least 20°C. Each cleptoparasite landed on the nest tumulus, vibrated the distal portion of its antennae down into the opening, entered it, but usually retreated at once. The maternal host bees sometimes appeared at their entrances soon thereafter. At other instances, *N. annulata* entered nests and remained within them for a minute or more.

Bee prepupae were present within *A. macra* brood cells, in the summer. Of a total of 71 cells containing live bees, excavated in July and August 1984, 1 cell (1.4%) contained a *N. annulata* prepupa and 70 cells (98.6%) contained an *A. macra* prepupa. Of 47 cells containing live bees, excavated from 22–29 July 1985, 7 cells (14.89%) contained a *N. annulata* prepupa and 40 cells (85.11%) contained an *A. macra* prepupa.

The first rearing trial began on 29 October 1984, proceeding a period of cold exposure. One *N. annulata* (male) prepupa metamorphosed into a pupa by 21 November, and then into an adult, with expanded wings and complete pigmentation, by 10 December. Six *A. macra* (2 males : 4 females) were reared to mature adults, by 21 December.

The second rearing trial began on 30 June 1985, without prior cold exposure. Two *N. annulata* prepupae metamorphosed into pupae by 26 September, and metamorphosed into adults, with expanded wings and complete pigmentation, by 29 October. Eighteen *A. macra* (10 males : 8 females) were reared successfully by 29 October as well.

Four *N. annulata* failed to develop to the mature adult stage for several reasons. A parasitoid (mutillid wasp) egg was attached to the cuticle of one; the mutillid immature died several days later in the laboratory, and the paralyzed *N. annulata* prepupa soon succumbed. Another *N. annulata* prepupa was found covered with an unidentified fungus. Another had died for no apparent reason. One *N. annulata* female developed to the premature adult stage, but failed to expand its wings.

Discussion

Nomada annulata overwintered as adults within *A. macra* nests. Other *Nomada* overwinter as prepupae or as adults inside host nests. Rozen (1977) indicated that members of Nomadinae typically pass the winter as prepupae in the nests of their hosts, and then resume development in the spring season. However, Eickwort and Abrams (1980) have determined that this pattern is variable. They found *Nomada* overwintering both as prepupae and as adults, in the nests of *Agapostemon* (Halictidae) hosts. Also, *Nomada* adults were found within *Andrena* brood cells in the fall season, and presumably overwintered within the cells (Linsley and MacSwain 1955, Osgood 1989).

Overwintering within host brood cells can be advantageous since: (1) the wax-lined brood cells may deter microbial infestations (Duffield et al. 1984), thus providing a better hibernaculum than crevices in the ground; (2) it insures that opposite sexes are in the vicinity for mating soon after spring emergence; and (3) it eliminates the need to depart the emergence site to search for host nests, if *Andrena* offspring construct their nests in the site from which they emerged.

Nomada annulata emerged in May, several days after the major emergence of *A. macra*. *Nomada* sp. emerges days after the emergence of males of its potential host, *A.*

Table 1. *Nomada-Andrena* associations in America north of Mexico; an asterisk (*) denotes a definitive host, lack of an asterisk denotes a putative host.

Nomada sp.	*drena* host	Reference
N. annulata Smith	*A. macra* Mitchell	Hurd 1979, Iwata 1976
N. annulata Smith	**A. macra* Mitchell	This study
N. calloxantha Cockerell	**A. nivalis* Smith	Miliczky et al. 1990
N. cressonii (Robertson)	**A. crataegi* Robertson	Osgood 1989
N. crudelis Cresson	*A. obscuripennis* Smith	Linsley & MacSwain 1955
N. edwardsii Cresson	**A. perimelas* Cockerell	Linsley & MacSwain 1955
N. imbricata Smith	**A. vicina* Smith	Packard 1868
N. morrisoni Cresson	*A. irana* Cockerell	Hicks 1934
N. obliquella Fowler	*A. suavis* Timberlake	Linsley & MacSwain 1959
N. obliterata Cresson	*A. vicina* Smith	Hurd 1979
N. obscurella Fowler syn. *N. fowleri* Cockerell	**A. caerulea* Smith, syn. *A. complexa* (Viereck)	Linsley & MacSwain 1955, Rozen 1966
N. opacella Timberlake	**A. caerulea* Smith	Linsley & MacSwain 1955
N. opacella Timberlake	**A. suavis* Timberlake	Linsley & MacSwain 1955
N. pulchella Smith	**A. vicina* Smith	Packard 1868
N. vallesina Cockerell	*A. irana* Cockerell	Hicks 1934
N. vicina Cresson	*A. vicina* Smith	Hurd 1979
Nomada sp.	*A. basilicis* Viereck	Rozen 1966
Nomada sp.	**A. chalybaea* (Cresson)	Thorp 1969
Nomada sp.	*A. chylismiae* Linsley & MacSwain	Linsley et al. 1963b
Nomada sp.	*A. deserticola* Timberlake	Linsley et al. 1964
Nomada sp.	**A. flexa* Malloch	Rozen 1966
Nomada sp.	*A. helianthi* Robertson	Parker & Bohart 1982
Nomada sp.	*A. linsleyi* Timberlake	Linsley et al. 1963a
Nomada sp.	*A. miserabilis* Cresson syn. *B. bipunctata* Cresson	Michener & Rettenmeyer 1956
Nomada sp.	*A. raveni* Linsley & MacSwain	Linsley et al. 1963b
Nomada sp.	*A. rozeni* Linsley & MacSwain	Linsley et al. 1963a

macra, at a site in North Carolina (Sivik 1954). Emergence after *A. macra* can be advantageous because it provides time for mating and building of nests by the maternal host.

Female *N. annulata* often landed at *A. macra* nest tumuli and then vibrated the distal end of their antennae into the entrance. Olfactory cues present at the entrance or within the nest are received in this manner; indicating if a partially provisioned cell is available, if the maternal host is inside, and if another cleptoparasite visited the nest (Cane 1983). *Nomada opacella* Timberlake wait near *Andrena caerulea* Smith and *Andrena suavis* Timberlake nests, and enter them after the maternal females depart (Linsley and MacSwain 1955). Successful invasions may occur when the nest becomes temporarily vacant, as females depart to collect pollen and nectar for the provision mass of each cell.

Nomada annulata were seen entering *A. macra* nests and sometimes remaining inside them for at least one minute. Similarly, *N. opacella* remained inside *A. caerulea* and *A. suavis* nests for 5–7 min maximum (Linsley and MacSwain 1955); and *Nomada* sp. remained inside an *Andrena chalybaea* (Cresson) nest for 1–4 min (Thorp 1969). *Nomada* invade nests, locate partly provisioned brood cells and oviposit in the inner cell walls (Bohart 1970).

Upon hatching, the *Nomada* larva destroys the *Andrena* egg then progressively feeds on the provision mass intended for the victim (Linsley and MacSwain 1955, Rozen 1977). Each *Nomada* larva may achieve the prepupal stage of development during the summer season (Rozen 1977).

Nomada annulata prepupae were excavated from *A. macra* brood cells in the summer; three were reared to the mature adult stage in the fall. This evidence verifies that *N. annulata* is a cleptoparasite of *A. macra* nesting in Virginia. Other nesting populations of *A. macra* have been implicated as hosts for *N. annulata* (Hurd 1979, Iwata 1976), however, the methods used to confirm their associations are not given.

The 26 *Nomada-Andrena* associations reported in North America north of Mexico are listed in Table 1. Six were confirmed by rearing *Nomada* immatures, excavated from *Andrena* brood cells, to the adult stage in the laboratory. These previous associations include: *Nomada obscurella* Fowler-*A. caerulea, N. opacella-A. caerulea, Nomada edwardsii* Cresson-*Andrena perimelas* Cockerell, *N. opacella-A. suavis* (Linsley and MacSwain 1955); *Nomada calloxantha* Cockerell-*Andrena nivalis* Smith (Miliczky et al. 1990); and *Nomada* sp.-*A. chalybaea* (Thorp 1969).

Other associations were confirmed by locating *Nomada* prepupae or adults inside nests of *Andrena,* without rearing. For example, *Nomada imbricata* Smith and *Nomada pulchella* Smith larvae were found inside *Andrena vicina* Smith brood cells (Packard 1868), a *Nomada* sp. prepupa was found in an *Andrena flexa* Malloch brood cell (Rozen 1966), and *Nomada cressonii* (Robertson) adults were found in *Andrena crataegi* Robertson brood cells in the fall season (Osgood 1989).

Remaining associations were apparently determined by observing *Nomada* females as they entered *Andrena* nests. This method, by itself, is inadequate for confirming associations. It does not indicate whether parasitization had occurred. Also, this method does not reveal whether the *Nomada* immature can complete the larval stage on the pollen type in the host cell.

Effective methods for confirming *Nomada-Andrena* associations involve: (1) rearing *Nomada* immatures to the adult stage in the laboratory, or (2) locating *Nomada* prepupae in *Andrena* brood cells, when rearing is not feasible.

ACKNOWLEDGMENTS

Dr. Wallace E. LaBerge, Illinois Natural History Survey, identified the bees. This research was part of a Master's thesis submitted to the graduate faculty, Department of Zoology, at Howard University. I thank Dr. Richard Duffield and Dr. George Middendorf for their encouragement and support during this investigation.

LITERATURE CITED

Bohart, G. E. 1970. The Evolution of Parasitism Among Bees. Utah State University, Logan. 30 pp.

Cane, J. H. 1983. Olfactory evaluation of *Andrena* host nest suitability by cleptoparasitic *Nomada* bees (Apoidea, Hymenoptera). Animal Behavior 31: 138–144.

Duffield, R. M., J. W. Wheeler, and G. C. Eickwort. 1984. Sociochemicals of bees, pp. 387–428. *In* Bell, W. J. and R. T. Carde, eds., Chemical Ecology of Insects. Chapman and Hall, London.

Duffield, R. M., C. Simon-Jordan, E. W. Riddick, and J. W. Wheeler. 1990. Exocrine secretions of bees. X. 3,7-Dimethyldeca-2,6-dien-1,10-diol: A sex specific compound from *Nomada annulata* (Hymenoptera: Anthophoridae). Journal of Chemical Ecology 16: 1069–1076.

Eickwort, G. C. and J. Abrams. 1980. Parasitism of sweat bees in the genus *Agapostemon* by cuckoo bees in the genus *Nomada* (Hymenoptera: Halictidae, Anthophoridae). Pan-Pacific Entomologist 56: 144–152.

Hicks, C. H. 1934. Some reared insect parasites and their hosts. University of Colorado Studies 21: 265–271.

Hurd, P. D., Jr. 1979. The Apoidea, pp. 1741–2209. *In* Krombein, K. V., D. R. Smith, and B. D. Burks, eds., Vol. 2. Catalog of Hymenoptera in America North of Mexico. Smithsonian Institution Press, Washington, D.C.

Iwata, K. 1976. Behavior of cleptoparasitic wasps and bees, pp. 414–427. *In* Evolution of Instinct, Comparative Ethology of Hymenoptera. Amerind Publishing Co. Pvt. Ltd., New Delhi.

Linsley, E. G. and J. W. MacSwain. 1955. The habits of *Nomada opacella* Timberlake with notes on other species (Hymenoptera: Anthophoridae). Wasmann Journal of Biology 13: 253–276.

———. 1959. Ethology of some *Ranunculus* insects with emphasis on competition for pollen. University of California Publications in Entomology 16: 1–46.

Linsley, E. G., J. W. MacSwain, and P. H. Raven. 1963a. Comparative behavior of bees and Onagraceae. I. *Oenothera* bees of the Colorado Desert. University of California Publications in Entomology 33: 1–24.

———. 1963b. Comparative behavior of bees and Onagraceae. II. *Oenothera* bees of the Great Basin. University of California Publications in Entomology 33: 25–58.

———. 1964. Comparative behavior of bees and Onagraceae. III. *Oenothera* bees of the Mojave Desert. University of California Publications in Entomology 33: 59–98.

Michener, C. D. and C. W. Rettenmeyer. 1956. The ethology of *Andrena erythronii* with comparative data on other species (Hymenoptera: Andrenidae). University of Kansas Science Bulletin 37: 645–684.

Miliczky, E. R., D. F. Mayer, and J. D. Lunden. 1990. Notes on the nesting biology of *Andrena* (*Melandrena*) *nivalis* Smith (Hymenoptera: Andrenidae). Journal of the Kansas Entomological Society 63: 166–174.

Osgood, E. A. 1989. Biology of *Andrena crataegi* Robertson (Hymenoptera: Andrenidae), a communally nesting bee. Journal of the New York Entomological Society 97: 56–64.

Packard, A. S. 1868. The home of the bees. American Naturalist 1: 364–378, 596–606.

Parker, F. D. and G. E. Bohart. 1982. Notes on the biology of *Andrena* (*Callendrena*) *helianthi* Robertson (Hymenoptera: Andrenidae). Pan-Pacific Entomologist 58: 111–116.

Riddick, E. W. 1992. Nest distribution of the solitary bee *Andrena macra* (Hymenoptera: Andrenidae), with observations on nest structure. Proceedings of the Entomological Society of Washington 94: 568–575.

Rozen, J. G., Jr. 1966. The larvae of the Anthophoridae (Apoidea, Hymenoptera). Part II. The Nomadinae. American Museum Novitates 2244: 1–38.

———. 1977. Immature stages of and ethological observations on the cleptoparasitic bee tribe Nomadini (Apoidea, Anthophoridae). American Museum Novitates 2638: 1–16.

Sivik, F. P. 1954. Ecological notes on three species of solitary bees. Entomological News 65: 253–256.

Thorp, R. W. 1969. Systematics and ecology of bees of the subgenus *Diandrena* (Hymenoptera: Andrenidae). University of California Publications in Entomology 52: 1–146.

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, pp. 113–125

THE FIRST *HOLCOPASITES* FROM WESTERN CALIFORNIA, *H. RUTHAE* N. SP., AND *H. LINSLEYI*, A NEW SPECIES FROM SOUTHWESTERN ARIZONA (HYMENOPTERA, NOMADINAE)

KENNETH W. COOPER

Department of Biology, University of California, Riverside, California 92521.

Abstract.—Described are ***Holcopasites ruthae*** n. sp. from coastal sage scrub, the first species known from western California, and ***H. linsleyi*** n. sp. from southwestern Arizona, with notes on separation of both from similar species. Setose eyes are an attribute of species of *Holcopasites*, and at least the male of *Schmiedeknechtia gussakovskyi* Popov. Warncke's synonymization of the Nearctic *Holcopasites* with the Palearctic *Schmiedeknechtia* is briefly discussed, and for the present rejected.

Key Words: *Holcopasites*, new species, habitat, *Schmiedeknechtia*, synonymy

From the end of April through May of 1991, I found a striking new species of *Holcopasites* in moderate numbers on campus land of the University of California at Riverside. That occurrence is astonishing, for the general area had been intensively collected throughout the year, and nearly every year for 40 or more, by that paragon of collectors and authority on wild bees, P. N. Timberlake. Neither he, nor any other of the noted collectors of California bees have been fortunate enough to come upon this species, nor had I previously over a period of 23 years.

But two species of *Holcopasites* had earlier been found in California, in marked contrast to the twelve known from Arizona: a single specimen of *H. stevensi* Crawford, of unknown provenance, very old and labelled simply "Cal.," and four specimens of *H. bohartorum* Hurd and Linsley from southeastern California: 18 miles west of Blythe (Wiley's Well).[1] The new species is the first record of a member of the genus *Holcopasites* from western California.

The exact type locality, where all but two specimens of the new species were captured, is currently undeveloped. It is a small elevation of flatland, or "mesa," with a gentle downslope to the west (altitude 340 m, slope ca. 0.1°, where the bee was found). It remains a shrinking enclave of coastal sage scrub, from time to time reduced by university usages. It is now surrounded by developed areas, none more than 0.3 km distance: to the north and below a huge (674 vehicles), paved parking lot on level land formerly covered with scrub continuous with that on the mesa; adjacent and to the west, experimental groves; to the south, more agricultural land and the U.C.R. Botanic Garden; and to the west its downslope ending at a paved road and extension of the parking lot (64 vehicles) to the north. Amid the remaining scrub are scattered clumps of *Encelia farinosa* Gray & Torr. at which the *Holcopasites* were exclusively taken.

Nearly all of the bees were captured on the flat land of the mesa, within an area of less than 0.2 hectare. Apparently the *Hol-*

---

[1] Of the four specimens, one not earlier recorded was kindly given me by its collector, Dr. Eric M. Fisher of the California Department of Agriculture (date of capture: 8-IV-1972).

copasites shunned the downslope, even though flowering *Encelia* were equally abundant to each side of a dirt service road cut through the sloping land. Almost certainly that preference owed to the fact that the probable hosts of the bee are panurgine bees that nest on bare, level patches of ground, as is the case for known host bees of other species of *Holcopasites*. On the flatland of the mesa both *Holcopasites*' probable host, and the preferred flower of each was present.

An absence of suitable level nesting areas on the adjoining terrain, including the Botanic Garden, accounts for the scarcity of *Holcopasites* despite suitable stands of *Encelia*. Regrettably, not knowing the life span of the adult *Holcopasites*, I was too late in the season to find areas in which the likely host, *Calliopsis pugionis* Cockerell, was nesting.

METHODS

The distance from the costal sclerite to the fenestra between the pre- and pterostigma is a useful relative measure of length. It is ordinarily easily made, with good precision, and makes it possible to match related bees of comparable body sizes, regardless of flexion of head and metasoma and differing degrees of distention or contraction of the latter.

Statistical summaries of measured attributes and ratios include the median value only when mean and median differ. Because estimates of the coefficient of variability (V) from small samples tend to be too low, Haldane's (1955) $V^* = \left(1 + \frac{1}{4n}\right) \cdot V$ is given as a "nearly unbiased estimate." If no n is stated in a summary, the sample size is 16 for females, or 30 for males, namely all in the collection of the given sex.

Where certainty concerning the presence and distribution of very small ocular setae, or a very small, low labral papilla (= vestigial tubercle?) was required, a Leitz Ultropak lens with an annular condenser was used at a magnification of ca. 110×. Nevertheless, with attention to lighting, even the smallest ocular setae (but not their distribution) and labral papillae are detectable with a stereoscopic binocular microscope at magnifications of 50×.

Description.—Items preceded by an asterisk (*) are chief among those by which the first new species regularly or ordinarily differs from the described attributes of *H. stevensi* observed by Hurd and Linsley (1972) in a large sample of 162 females, 30 males, and the 5 females and 5 males at hand. Characterizations within quotation marks are from Hurd's and Linsley's description of *H. stevensi.*

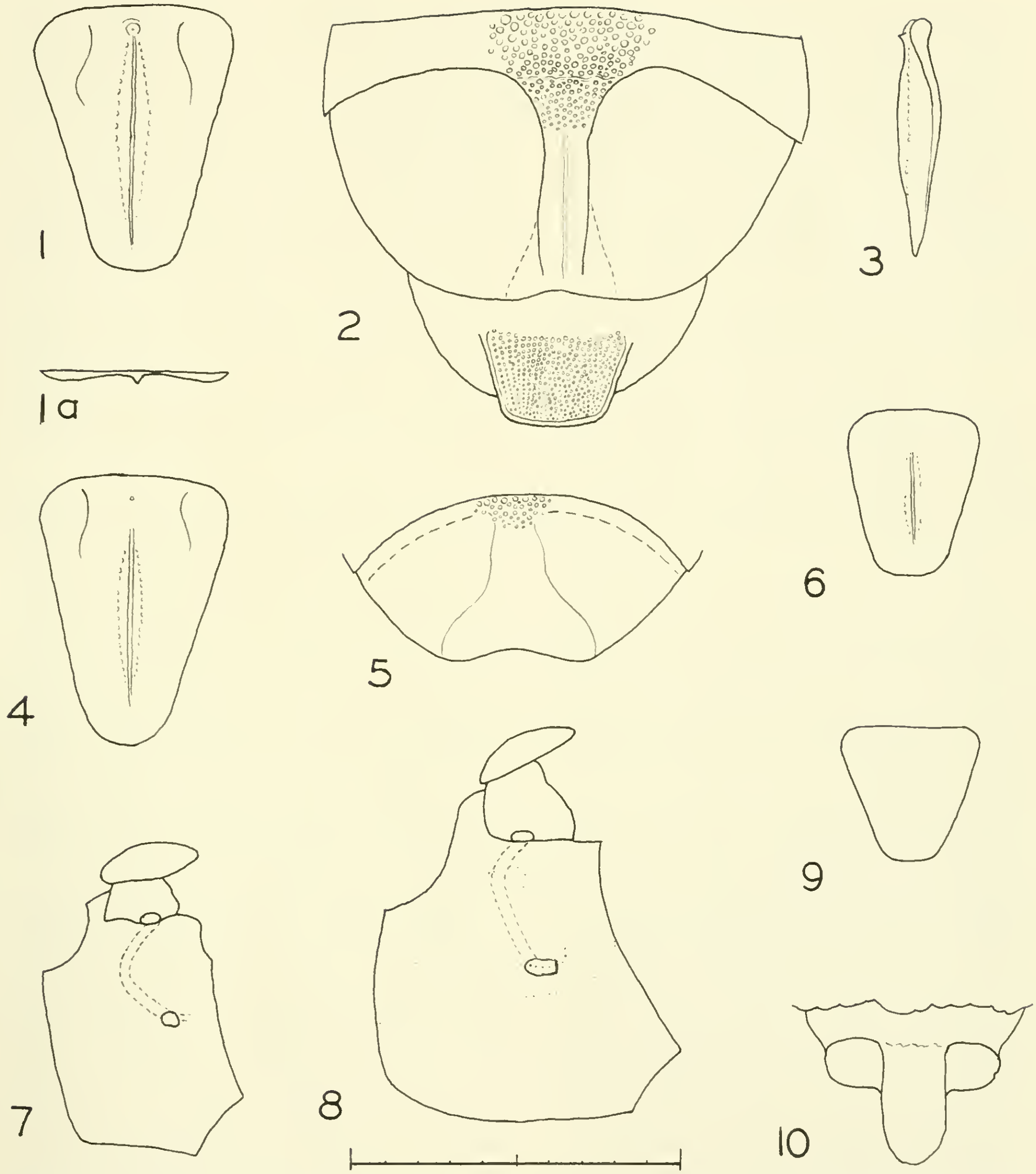
Apart from the terminal metasomal segments, and a tendency for dark areas of the metasoma to be darker in males, males and females of *H. ruthae* are externally similar. Identically numbered attributes (in parentheses) in the descriptions of both sexes denote those by which many or all males differ from females to a significant degree, easing cross-reference and constituting a partial list of secondary sexual attributes that are in addition to differences in the terminal metasomal segments and tarsal claws (Linsley and Michener, 1939).

***Holcopasites ruthae* Cooper,**
NEW SPECIES

(Figs. 1, 1a, 2, 3, 8, 9, 10)

Recognition.—Both sexes of *H. ruthae,* a banded species, are set apart from other described species by a small, median tubercle at the base of the labrum from which a strong, longitudinal labral carina directly arises; tubercle about as high as greatest height of carina (Figs. 1, 1a, 3). It also differs from *H. stevensi* Crawford, the only species with which it is likely to be confused, by its vernal flight period; *H. stevensi* flies from July to September, temporally isolated from *H. ruthae.*

Female (16 specimens).—Length, observed range = 5.1–6.6 mm, $\overline{m}$ = 5.8 mm, median = 5.7 mm, V* = 8.2; of forewing



Figs. 1–10. Scale = 1.0 mm. All figures drawn from camera lucida outlines, hence somewhat asymmetric and semidiagrammatic. Figs. 1–3, 8, 10, *Holcopasites ruthae* n. sp.: 1, Labrum, anterior surface with medial, basal tubercle and carina; 1a, transverse section of labrum at level of basal tubercle. 2, Terga-5 and -6 of female—gradulus and "pseudopygidium" (= medial ridge) of t-5; pygidum of t-6. 3, Labrum, left lateral aspect. 8, Mesepisternum, furrow from subalar pit to scrobe, and outline (dotted) of inner margin of open ring of white plumose setae. 10, Tergum-7 of male, gradulus, posterior ventral margin, and pygidium. Fig. 4, *H. stevensi* Crawford: Labrum, anterior surface with small papilla (not formed in all specimens) and medial carina. Figs. 5, 6, *H. linsleyi* n. sp.: 5, Tergum-5 of female, showing gradulus and large pseudopygidium. 6, Labrum, anterior surface with short, median carina. Figs. 7, 9, *Schmiedeknechtia gussakovskyi* Popov: 7, Mesepisternum: contrast proportions with that of *Holcopasites* (Fig. 8). 9, Short carinaless labrum, anterior aspect.

from apex of costal sclerite to fenestra between pre- and pterostigma: obs. r. = 1.8–2.1 mm, $\overline{m}$ = 1.9 mm, V* = 5.6.

Integumentary coloration.—Head and mesosoma black to very dark piceous; antennae black, dark brownish toward apex; mandibles exernally banded, tips dark to reddish brown, medially reddish, basally black and piceous, inner surface reddish; anterior smooth margin of clypeus black to dark brown; (1) labrum black, piceous to reddish brown laterally and apically; tegulae brown, margin translucent, a transverse clear band divides discal brown area; forewing iridescent, lightly infumate, slightly darker apically, *(2) a sooty area within apex of marginal cell, darker from apex of cell along wing margin, ending before wing tip; hindwing membrane similar but less infumate; legs black to dark piceous, tibia-3 deep reddish brown in some; tibial spurs: malar spine brown, spurs of tibiae-2, -3 dark brown, reddish brown in some; *metasoma: red, terga-2 to -5 increasingly darkened medially from brownish red or brown to piceous, black in some; tergum-6 testaceous.

White markings.—Conspicuous white, appressed, squamiform, plumose setae decorate the contrasting integuments with spots, bands, and scattered arrays as follows:

On head: Surrounding antennal bases and over the median facial carina to (or nearly to) median ocellus; 1–5 setae within ocellar triangle; (3) a scattering or patch on upper genae, usually less in length than maximum width of eye; clypeus (except at fronto-clypeal suture) without squamiform setae.

On mesosoma: A band on upper margin of pronotum and along margins of pronotal lobes; a narrow, posteriorly convergent patch on anterior third (or less) of mesoscutum divided lengthwise by medial scutal furrow; a lateral edging of mesoscutum reaching tegulae, a loose patch behind tegulae; (4) a band forming a ring on upper mesepisternum, covering subalar pit and lower half (or more) of scrobe, anterior to scrobe the ring is generally open (Fig. 8), or weakly closed by scattered squamiform setae; patch or scattering along axillae, scutal-scutellar suture, and scutellar rear margin; a small scattering above mesocoxa; dense coverings on lateral wings and projecting lateral angles of metanotum; scattering of *small* squamiform setae along upper lateral margin of propodeal triangle, below hindwing and above spiracle; scatterings ventrally along margins and distally on both meso- and metasterna.

On legs: On coxae anteriorly above, successively larger on meso- and metacoxae, half to one-third of ventral margins of femora-2, -3; (5) a loose band along dorsal margin of tibia-3.

On metasoma: A small postero-lateral spot and broad patch on anterior outer thirds of tergum-1 on each side, lapping over margin onto anterior face; terga-2, -3, -4 with small elongate postero-lateral spot and narrow anterior band on each side of middle; (6) none to one or more small, disconnected patches in subapical depression of posterior margin of tergum-4; tergum-5 without squamiform setae; (7) slender, more or less squamiform white setae on sternum-1, forming transverse basal bands on sterna-2 to -5; bands of short, inconspicuous, white hair along apical margins of sterna-2 to -4.

Other vestiture.—Clypeus with slender, yellowish plumose hairs sparsely distributed along anterior margin; *labrum with narrow, subbasal transverse fringe of long (greater than an ocellar diameter), nearly erect, slender, yellowish plumose hairs. Wing membranes with minute hairs, more dense beyond apical venation; ridge along ventrolateral face of hind tibia with row of long setae, tips bent ventrally; median ridge of tergum-5 widened anteriorly and posteriorly, bare above, fine silvery hairs over posterior two-thirds; tergum-6 with fine, lengthwise, subparallel silvery hairs on pygidium.

Structural features.—*Of head:* Flattened ventrally and posteriorly; width to length, observed range = 1.13–1.19, $\overline{m}$ = 1.16, V* = 1.5; head width to mesonotal width, obs.

r. = 1.11–1.21, $\overline{m}$ = 1.18, V* = 2.4; (8) clypeal width to length, obs. r. = 2.78–3.06, $\overline{m}$ = 2.92, med = 2.94, V* = 2.8 (N.B., fronto-clypeal suture overlain by squamiform setae); (9) labral length to width, obs. r. = 1.31–1.46, $\overline{m}$ = 1.38, med = 1.40, V* = 3.3; *eyes with short setae over entire surface except above the darkened rim; setae 12–15 μm long, visible at 50×; face coarsely punctate, puncta largest between upper margin of eye and ocelli, interspaces shining; *antennae with flagellar article-1 subequal to articles-(2 + 3), obs. r. = 0.92–1.08, $\overline{m}$ = 1.01, V* = 5.6, n = 15; distance from lateral to anterior ocelli subequal to distance between lateral ocelli from 0.23 to 0.31 mm ($\overline{m}$ ~ 0.26 mm); width of median ocellus; *(10) least ocellorbital distance to lateral interocellar distance from 1.12 to 1.31 ($\overline{m}$ = 1.19, V* = 3.8); posterior articulation of mandible slightly posterior to midpoint of lower margin of eye; (11) acetabular carina low at base; (12) clypeus with lateral extremities rounded, lateral carina (above clypeogenal suture) weak; *labrum with small, basal tubercle (use 50×), little more than own basal diameter from anterior margin of labrum, from which a well-defined carina (lower immediately behind tubercle) extends length of labrum, or nearly so, height of tubercle about same as greatest height of carina (Figs. 1, 1a, 3); *labrum punctate, densest basally (no basal, mesal, impunctate strip); punctation extending onto sides of carina, punctal size decreases laterally and distally, interspaces polished (at 50×); postgena uniformly, closely, coarsely punctate to hypostomal carina, interspaces less wide than punctal diameter; mouth parts short, reaching very slightly beyond proboscidial fossa.

Of mesosoma: Mesoscutum closely, coarsely punctate; tegulae with a strong, concentric microsculpture (at 50×), few discal puncta, mesepisternal puncta not "nearly rugosely punctate," interspaces ca. one-third of punctal diameters; a weakly impressed sulcus on mesepisternum, arising below subalar lobe, near subalar pit, ending in scrobe (Fig. 8); scutellum simple, posterior margin subtruncate, at most very slightly indented postero-medially; ratio internal length of marginal cell to distance from its apex to wing tip: obs. r. = 1.08–1.16, $\overline{m}$ = 1.13, V* = 6.0, n = 13; metanotum angularly produced to each side; a well-defined triangular region on upper metapostnotum of strong microsculpture, medially closed meshes, laterally and posteriorly appearing as though tracts of fine carinulae, triangular area about a third as long as wide.

Of appendages: Second submarginal cell three-fourths or more length of first along posterior sides; calcar of mid-tibia ca. one-half length of basitarsus; anterior, dorsal apical ends of mid and hind basitarsi projecting, spinelike.

Of metasoma: Tergum-5 with bare, coarsely punctate, piceous or black raised area at base of tergum interrupting gradulus medially, with a low lengthwise mesal ridge, widened below, forming a weak pseudopygideal area (Fig. 2); apex of tergum nearly truncate, slightly insinuate; pygidial plate of tergum-6 with sides slightly convergent apically, rounded apico-laterally, strongly punctate, puncta strongest proximally (Fig. 2); sternum-5 shallowly impressed medially in apical half, apex subtruncate, projecting beyond tergum-5; lateral lobes of sternum-6 nearly 0.6× as long as distance between them; each lobe at apex with 4 to 6 stout, curved, blunt setae below (m = 5.06, V* = 10.5, n = 16; no cases in which both lobes had 4 or 6 such setae), 10–12 additional lesser setae apically, slender hairs externolaterally and ventrally on lobes, very long hairs, especially on sides, in the horizontal plane within (above a close fringe of very short hairs along inner rim of sternum), tips of those in basal half nearly meeting medially.

Male (30 specimens): Similar in coloration and habitus to female. Length, observed range = 5.1–6.6 mm, $\overline{m}$ = 5.6 mm, V* = 5.8; of forewing from apex of costal sclerite to fenestra between pre- and pterostigma, obs. r. = 1.7–2.3 mm, $\bar{m}$ = 1.9 mm, med = 1.8 mm, V* = 6.7; for all but the last of the following, a random selection of measured individuals: head width to length, obs. r. = 1.12–1.19, $\bar{m}$ = 1.15, V* = 1.4, n = 16; head width to mesonotal width, obs. r. = 1.15–1.28, $\bar{m}$ = 1.21, V* = 2.2, n = 16; (8) clypeal width to length, obs. r. = 2.45–3.00, $\bar{m}$ = 2.79, V* = 4.8, n = 16; (9) labral length to width, obs. r. = 1.27–1.40, $\bar{m}$ = 1.34, med = 1.32, V* = 3.6, n = 16; length flagellar-1 to flagellar-(2 + 3), obs. r. = 0.91–1.11, $\bar{m}$ = 1.02, med = 1.00, V* = 7.3, n = 15; ratio length of marginal cell to distance from apex to wing tip: obs. r. = 1.06–1.28, $\bar{m}$ = 1.12, V* = 6.0, med = 1.11, n = 25; (10) least ocellorbital distance to inter-lateral ocellar distance, obs. r. = 1.16–1.40, $\bar{m}$ = 1.25, V* = 5.6, n = 30.

Secondary sexual differences, including (8), (9) and (10) above: (1) in 19 specimens labrum wholly black; (2) spot at apex of forewing marginal cell paler, smaller; (3) white patch on upper genae broader, generally longer than maximum width of eye; (4) white ring on the mesepisternum generally closed ventrally; (5) white, dorsal longitudinal band of hind tibia strong; (6) metasomal tergite-4 has no apical white band, a white spot at each postero-lateral angle; tergum-5 has a strong basal white band on each side, and a nearly complete white band in subapical sulcus; tergum-6 has a nearly complete apical white band, anterior to which a weak subapical bisinuation, producing a distinct median lobe in some, margin more or less crenulated; from above, tergum-7 has rounded postero-lateral angles, posterior ventral margin nearly at right angles to pygidial plate axis; pygidial plate parallel-sided (Fig. 10), *length to basal width, observed range = 1.64–2.00, $\bar{m}$ = 1.88, med = 1.89, V* = 7.4, n = 18; maximum width between lateral lobes of tergum-6 to width of pygidial lobe, obs. r. = 2.36–3.06, $\bar{m}$ = 2.72, V* = 7.6, n = 29; pygidium coarsely punctate, margins slightly reflexed; (7) setal and hair bands on sterna as in female, but much stronger; sternum-5 with both bands, apical band weak, often incomplete medially; (11) acetabular carina of mandible raised to a broad, triangular "tooth" at base, apex of triangle translucent amber; (12) clypeus with lateral extremities strongly angulate, lateral carina very strong.

Etymology.—The species name *ruthae* is in grateful recognition of my biologist wife, Dr. Ruth S. Cooper, who has been my constant field companion and scientific helpmate for more than half a century.

Holotype: Female; California, Riverside County, Riverside (University of California Campus), from flowers of *Encelia farinosa,* 18 V 1991; allotype: same locality and flower, but 9 V 1991. Both have been deposited in the U.S. National Museum of Natural History.

Paratypes: All from same general locality and year as holotype and allotype. Dates of capture: females—3 (4 V), 1 (8 V), 1 (9 V), 2 (11 V), 2 (12 V), 4 (13 V), 1 (15 V), 1 (17 V); males—1 (29 IV), 2 (30 IV), 6 (4 V), 4 (8 V), 3 (9 V), 1 (11 V), 3 (12 V), 3 (13 V), 1 (15 V), 2 (18 V), 1 (20 V); the following from *Encelia palmeri* Vasey & Rose in adjoining U.C.R. Botanic Garden, both males: namely 1 (collected by David Hawks, 4 V), 1 (15 V).[2] The last individual seen was on June 1.

Distribution: Paratypes will be deposited in the collections of the American Museum of Natural History, the British Museum (N.H.), the California Academy of Sciences; The University of California (at Berkeley, Davis, and Riverside), the Snow Museum of the University of Kansas, the Systematics Laboratory of the California Department of Agriculture, and the Bee Biology and Systematics Laboratory, Utah State University.

Possible host: Calliopsis pugionis Cockerell was common at the same flowers of

---

[2] The labels on specimens have the months indicated by a *single letter*; thus A or a = January, B or b = February, etc.; thus 29 d 91 or 91 D 29 = 29 IV 91.

Encelia before, during, and briefly after visits to them by *H. ruthae* had ended.

Taxonomic.—It should be noted that my sample of 46 specimens of this new species differs from most other large series of *Holcopasites* species, for all were collected at one small site in the same year. They may therefore display less variation in dimensions, coloration and vestiture than would a series of corresponding type from different years and from a variety of localities. For reasons discussed in the closing commentary, unless a specimen's eyes are strongly setose, all identifications should commence with Hurd's and Linsley's key (1972, p. 11).

Male *H. ruthae* reach couplet 5 of Hurd's and Linsley's (1972) key to the banded species. They differ (among other ways) from *H. illinoiensis* Robertson of that couplet by their apical metasomal terga which are not "chiefly or entirely blackish." Unlike the alternative, *H. stevensi,* the apical metasomal terga are not "at most vaguely clouded with blackish"; in *H. ruthae* markings are definite, clearly darker, often greatly so, than adjoining integument.

Female *H. ruthae* first run into ambiguity in couplet 10, for in *H. ruthae,* the first flagellar segment is subequal to, "or slightly longer than . . . combined length [of] succeeding two segments" as in *H. illinoiensis*; but from the latter it differs by having the ventral surface of head (the hypostomal area) closely punctate, not "sparingly punctate." Nor does *H. ruthae* fit either species separated by couplet 11. From *H. eamia* (Cockerell) it differs by having a strongly carinate labrum (I find no labral carina in *H. eamia,* nor has one been described by others), and by lacking "a subtriangular patch of white pubescence on either side of the middle" of metasomal tergum-4. Differences from the other member of the couplet, *H. stevensi,* are given below.

Most *H. stevensi,* perhaps all but a minority, can be separated from *H. ruthae* by their paler metasomata, and generally by an absence in both sexes of successively darker, brown to blackish, medial integumentary areas from tergum-2 to the last, and a somewhat greater squamiform setation of most of the closely corresponding white markings of head and body.

Unlike the labrum of *H. ruthae,* most *H. stevensi* have a mesally elongated, polished strip basally (upon which a tiny papilla may be found near its base in many—see Fig. 4); the median carina generally arises from the distal end of a polished mesal strip; basal brush of labral plumose hairs (if not abraded) not a simple transverse, near-linear array, but relatively wide, at mid-width almost reaching dorsal margins of closed mandibles. In *H. stevensi* the ocular setae are very much sparser; "first flagellar segment is shorter than the two succeeding segments"—in *H. ruthae* that ratio is female (0.92–1.08×, n = 16), male (0.91–1.11×, n = 30). *H. stevensi* has the "interocellar and ocellocular distances about equal"; in *H. ruthae,* the ratios of the distance between posterior ocelli to the ocellocular distance are: female (1.12–1.31×), male (1.25–1.40×). Spot on forewing at the apex of the marginal cell in female *H. stevensi* is very pale and short, still weaker in the male; the spot both larger and darker in both sexes of *H. ruthae.* Female *H. ruthae* have the two inner patches of the distal white band of tergum-4 short and poorly differentiated or, more often, lacking entirely; in *H. stevensi* that distal white band is well-formed, with the two inner patches strongly marked and much elongated (see fig. 13, Hurd and Linsley 1972). The male pygidial plate of *H. stevensi* is said to be "more than twice as long as maximum basal width." In *H. ruthae* the pygidial length *and* basal width could be measured in 18 males only, for in the remainder the base of the pygidial plate is covered by the apex of tergum-5; observed range in length to width is 1.64–2.00×. The above differences, and different seasonal flight times of the two bees, justify recognition of two entities by individual specific names.

Holcopasites linsleyi Cooper, New Species
(Figs. 5, 6)

Recognition.—The single female specimen is a member of the banded-species group. It differs strikingly from all described female *Holcopasites* by its predominantly ferrugineous integument and well-formed trapezoidal pseudopygidium, widest apically, of metasomal tergum-5.

Female.—Length 3.3 mm; of forewing from apex of costal sclerite to fenestra between pre- and pterostigma 0.9 mm.

Integumentary coloration.—Overall ferrugineous, except as follows: reddish-brown on upper frons, merging with a poorly defined, conspicuously darker, brown band from sides of ocellar triangle to upper frontal orbits; antennae brown above, pale below; mandibular tips dark brown to brown; approximately lateral thirds of mesonotum reddish-brown to brown; scutellum predominantly dark brown; tegulae brown, outer margins narrowly transparent, a broader transverse transparent band divides pigmented disc; wings iridescent, membrane grayish, veins brown, darker along leading edge and apically; anterior surfaces of femora-1, -2, paler, dark brown elsewhere; femur-3 pale anteriorly in basal two-thirds, posteriorly in basal half, dark brown elsewhere; tibiae dark brown; shaft and spine of malus yellow, tibial spurs brown; tarsi dark reddish-brown; metasomal tergum-3 with a transverse, dark brown spot medially; tergum-4 with a large, blackish-brown, medial, transverse area from near base to apex, narrowing laterally, covering about half of disc. Tergum-5 with a dull, grayish-brown, well-formed pseudopygidium, widest apically; broad, subbasal dark brown band reaching lateral margin, enclosing a dully ferrugineous spot each side of pseudopygidium; sternum-5, except for basal and antero-lateral margins, reddish-brown.

White markings (by appressed, squamiform setae).—*On head:* Above and onto upper clypeus, surrounding antennal sockets and along median facial carina nearly to median ocellus; a band across vertex, broadening laterally onto upper halves of genae.

On mesosoma: Along upper margin of pronotum onto base and rear of pronotal lobes; a posteriorly narrowing, elongate patch on basal half of mesoscutum divided lengthwise by median scutal furrow; lateral edging from antero-lateral margin of mesoscutum to transverse scutel-scutellar suture; dense patch covering each axilla, posterior margin of scutellum (within a shallow subapical furrow), and projecting lateral angles of the metanotum, between which transverse median portion is bare; narrow strip above propodeal spiracle, attenuating along upper lateral angles of triangle; dense, very large, roughly pentagonal patch over upper two-thirds of mesepisternum, posterior extension of which reaches nearly to mesocoxal margin; sparse, squamiform hairs along uninflected anterior margin of mesepisternum connecting large pentagonal patch with that to each side of the median mesepisternal sulcus ventrally and along meso-metasternal sutures, within and along borders and distal process of the metasternum; to each side of the main tracts of large squamiform setae on mesepisternum successively shorter, more slender, less white hairs.

On legs: On coxae a weak scattering laterally; two-thirds to three-fourths of ventral margins of femora-2, -3; a band along dorsal surface of tibia-3.

On metasoma: Tergum-1 anteriorly with a band on each lateral third, concavity with slender hairs, thin scattering of squamiform setae (laterally only) along distal margin; both terga-2, -3 with long bands basally, interrupted medially, on each side an elongate patch disto-laterally, broadest laterally; tergum-4 with elongated basal band interrupted medially, connected with uninterrupted apical band by scattered setae laterally and to each side of the bare, medial black spot, enclosing on each side a small bare spot of ferrugineous cuticle; tergum-5 has a small scattering of squamiform setae basally on each side; sternum-1 has a triangular patch medially; sternum-2 has an apico-marginal row; sternum-3 has a sparse basal band of small squamiform setae connecting medially with a distal wide band that narrows laterally; sternum-4 appears rubbed, evidently had a distal band similar to that of sternum-3; sternum-5 without squamiform setae.

Other vestiture: clypeal surface with sparse, slender, scantly plumose hairs, largest medially, progressively shorter laterally and along orbits; labrum with sparse, longer hairs on basal third. Wing membrane with minute hairs, more closely spaced beyond apical venation. Pseudopygidium of tergum-5 with exceptionally short, decumbent, silvery hairs.

Structural features.—*Of head:* Globose, very wide, 1.4× wider than long, 1.2× wider than mesonotum; clypeus 4× wider than long; labrum about 1.2× longer than wide (Fig. 6); lateral carina above clypeogenal suture strong; mouthparts short, extending only slightly beyond proboscidial fossa; setae of eyes sparsely distributed over entire surface, setae somewhat longer than ommatidial diameter; face closely punctate, more coarsely on upper frons, narrow interspaces shining; antenna: flagellar segment-1 ca. 0.8 length of flagellar-(2 + 3); more distal flagellar segments somewhat longer than broad, but antennae not unusually long for *Holcopasites* species; distance anterior ocellus to lateral ocellus subequal to an ocellar diameter; distance between posterior ocelli nearly 2× transverse width of anterior ocellus (which is wider than long); distance between posterior ocelli to ocellorbital distance about equal; eyes bulging, posterior articulation of mandible behind midpoint of lower margin of eye; labrum punctate, puncta weakly impressed, largest in basal third, diminishing laterally and distally, without a basal tubercle, with a low, sharp carina from near base to apical fourth (Fig. 6); hypostomal area uniformly, closely, coarsely punctate to hypostomal carina, interspaces narrow, shining.

Of mesosoma: Mesoscutum closely, coarsely punctate; tegulae polished (at 50×), with few, scattered discal puncta; exposed mesepisternal puncta coarse, close set; mesepisternal sulcus ending in scrobe (visible when covering squamiform setae moistened with benzene); scutellum entire, posterior margin weakly, outwardly curved; ratio of length of marginal cell to distance from its apex to wingtip: 0.93; metanotum angularly produced laterally; propodeal triangle on upper metapostnotum with narrow (length ca. 0.2× width), distally slightly curved basal area of microsculpture.

Of appendages: Second submarginal cell of forewing two-thirds length of first along posterior side; calcar of mid-tibia ca. half basitarsal length; hind trochanter with disto-ventral margin spine-like in silhouette.

Of metasoma: Tergum-5 with coarsely punctate piceous raised area interrupting gradulus medially, apex with well-formed, nearly isosceles trapezoidal pseudopygidium, ca. 4.5× wider apically than basally (Fig. 5), densely, minutely punctate, surface dull, very shallowly emarginate posteriorly; pygidial plate of tergum-6: not exposed; sternum-5 medially, longitudinally impressed on apical 0.7; lateral lobes of sternum-6 short, little more than one-third distance between their apices, with three stout, curved, blunt setae apically below, 8–9 lesser setae apically, hairs along inner margins of lobes with tips widely separated along distal half of apical emargination.

Etymology.—*H. linsleyi* is dedicated to E. Gorton Linsley, eminent field naturalist and systematist, whose wide-ranging studies of insects over many years, importantly including *Holcopasites* and other small nomadine bees, and warm friendship have been of such help and pleasure to his colleagues.

Holotype.—Female, Arizona, Yuma County, 2.5 miles east of Aztec, 15 VIII 64, E. I. Schlinger; from the Timberlake Collection at the University of California, Riverside, labelled "*Holcopasites* sp. female, det. Timb." It will be placed in the collections of the California Academy of Sciences in which all recovered types of the Timberlake Collection have been placed.

Comparisons.—There are four other described species of *Holcopasites* of which some females are as small, or smaller, than 3.5 mm. None have either a predominantly ferrugineous integument nor a well-formed pseudopygidium, there being only a low, median, longitudinal ridge on tergum-5. All have significant morphological differences from *H. linsleyi.*

H. pulchellus (Cresson) has the postgena between the hypostomal carina and lower margin of eye polished, with widely spaced, irregularly distributed puncta, as well as a medially cleft, prominently bilobed scutellum. *H. tegularis* Hurd and Linsley lacks a medial labral carina; second submarginal cell of forewing is "much shorter than one-half as long as first submarginal . . . when measured along posterior side." Additionally, both are members of the *spotted* species group.

Of the two small species belonging to the *banded* species group, of which *H. linsleyi* is a member, female *H. cazieri* Hurd and Linsley has the postgena sparsely punctate, polished and shining adjacent to hypostemal carina, and the apex of metasomal sternum-5 deeply emarginate medially.

At first glance, *H. illinoiensis minimus* (Linsley) appears strikingly similar to *H. linsleyi* (apart from coloration). However, like *H. pulchellus* and *H. cazieri, H. i. minimus* has the hypostomal area polished and sparsely punctate; also, flagellar article-1 about equal to flagellar-(2 + 3).

COMMENT

H. ruthae, H. linsleyi, and *H. stevensi* of the banded species group are not alone in having setose eyes; that is so for *H. cazieri* Hurd and Linsley, *H. eamia, H. illinoiensis* s. str. and *H. illinoiensis minimus* (Linsley). *H. bohartorum, H. calliopsidis* (Linsley), *H. heliopsis* (Robertson) and *H. pulchellus* (Cresson) of the spotted species group also have setose eyes.

In all of the above the setae are of uniform length and, though scattered, occur more or less regularly over the surface of the eye. In *H. ruthae* there is no significant difference in setal lengths of male and female; the setae are very slender and somewhat longer than an ommatidial diameter. Setae of some other species seem to differ in length, and certainly do differ in density over the surface of the eye. *H. eamia,* e.g. has exceedingly widely spaced setae, the sparsest set of ocular setae among all those examined.

In view of the above, it is likely that all *Holcopasites* have setate eyes. Nevertheless *Trichopasites* (Linsley 1942) remains a useful group, for its members stand apart by possession of very long, coarse setae which densely clothe their eyes. Those of *H.* (*Trichopasites*) *insoletus* (Linsley) are appreciably longer than twice the length of the longest setae found among *H.* (*Holcopasites*) species, and appear to be more than three times as wide. The setae of *H.* (*T.*) *arizonicus* (Linsley) are distinctly shorter and narrower than those of *H.* (*T.*) *insoletus.* Nevertheless, they are of such dimensions that none among the spotted and banded species can plausibly be considered to be transitional. Discontinuities in setal dimensions and density over the eyes are vastly different.

I examined a male of *Schmiedeknechtia gussakovskyi* Popov. Its eyes are also setose, but the setae are both shorter (<ommatidial diameters) and much more sparsely distributed than any among the 13 species of *Holcopasites* that I have examined. The two eyes of *S. gussakovskyi* are alike, and therefore probably not partially abraded. The labrum of the specimen is less elongated than that of any *Holcopasites* species now known (cf. Figs. 6, 9; also cf. Figs. 7, 9 of the very differently proportioned mesepisterna).

INTERRELATIONS OF *HOLCOPASITES* AND *SCHMIEDEKNECHTIA*

All who have studied at first hand (or considered the published) structural similarities and dissimilarities of the Palearctic *Schmiedeknechtia* (hereafter *Schm*) and Nearctic *Holcopasites* (*Holc*) agree, as I do: they are closely similar entities (Popov 1934, Grütte 1935, Linsley and Michener 1939, Mavromoustakis 1959, 1963, Hurd and Linsley 1972, Warncke 1982). However, not all agree as to their proper taxonomic status.

Popov doubted their separateness at a generic level. He pointed specifically to an absence of "sufficiently distinct differences" in forewing venation, and to the "complete similarity" of the male aedeagus ("genitalia") and male sterna-7 and -8 which he regarded to be of overriding significance. The dissimilarities he noted for the separation of *Holc* and *Schm* are weak by comparison. Of them, only the antennal differences hold for all *Holc*: 12-segmented antennae in both sexes of *Holc*, longer and 13-segmented antennae in the males of *Schm*. Nevertheless, Popov failed to propose their synonymy; Warncke, however, did so.

Because 12 ♀/12 ♂ antennal segmentation occurs in but one of the otherwise plesiomorphic species of *Biastes* (~9 species) and similarly in but one species of *his Pasites* (with more than 50 species),[3] Warncke (1982) claimed that the difference in male antennal segmentation is of specific value only. For that reason, he regarded the plesio-/apomorphic antennal difference between *Schm* and *Holc* males of no generic significance. In his view, therefore, *Holcopasites* Ashmead 1899 is a junior synonym of *Schmiedeknechtia* Friese 1896, and *Schmiedeknechtia* in turn is declared a subgenus of *Ammobatoides* Radoszkowski 1817.

Do cladistic and biogeographic studies shed light on the status of the two entities, *Schmiedeknechtia and Holcopasites*? Alexander's (1990) consensus tree (Fig. 4) and tables of character states (appendices 3, 5, largely drawn from the writings of others[4]) convincingly point to the monophyly of *Holc* and *Schm*, as expected. Michener's (1979) biogeographic study suggests that the Nomadinae *s. lat.* had their origins in the New World from anthophorine stocks which later spread from North America to the Old World; such spread and crossing of the North Atlantic may have occurred as recently as early Eocene, a time of suitable climate and a dry land connection (v. Smith et al. 1981, McKenna 1983).

At least two lines separated from the holcopasitine stem: that giving *Holc*, now found in Austral regions of North America, and that of *Schm*, now ranging the Mediterranean subregion of the Palearctic (see map 1, Bartholomew et al. 1911). Those two lines have been disjunct at least from the onset of Oligocene times, ±37 million years ago, and members of each now parasitize species of different panurgine genera. Significantly, *all* three described species of *Schm* retain the plesiomorphic antennal segmentation (12 ♀/13 ♂), and *all* 17 species of *Holc* display the distinguishing antennal apomorphism (12 ♀/12 ♂). Warncke cannot be supported in his claim that that distinction is

---

[3] Warncke, op. cit., regards the Nearctic *Neopasites* as a junior synonym of the Palearctic *Biastes*. He also lumps six genera, including *Ammobates*, with *Pasites*. The tribal name Pasitini thus replaces Ammobatini in his classification. Numbers of relevant species in Warncke's generic assignments are estimated from Alexander (1990; table 2).

[4] There are at least four relevant errors in scored character states, and one misstatement; they do not cause difficulty with the consensus cladogram as portrayed. They are: *Biastes* includes both states 8_0 and 8_1 (Friese 1895, Warncke 1982); species of both *Schm* (see Mavromoustakis 1959, figs. 2–4) and *Holc* have male pygidial conformations in addition to that of 29_1; character 1 would be better defined in terms of whether the labral apex surpasses the closed mandibles, for none of the 13 species of *Holc* examined by me has a ratio of labral length to width ≥ 1.5; a male of *S. gussakovskyi* Popov, with the labrum fully exposed, has a length : width ratio of 1.0.

only of a specific nature for *Holc* and *Schm* today. It may have been so for the immediate ancestor of today's *Holc,* but assuredly no longer applies to the numerous descendent species which are products of an early cladogenic event. Surely that is the likely history of most apomorphisms which separate supraspecific taxa today.

No thoroughgoing comparative study of both nominal genera and all of the species of the Holcopasitini has been made to date. That study should include mouthparts, aedeagus and male genital segments, details of at least female sternum-6, and of immature stages if available. The burden of proof of synonymy of *Holcopasites* with *Schmiedeknechtia* seems properly to lie with those who would accept Warncke's (1982) decision.

ACKNOWLEDGMENTS

I am grateful to Drs. E. Gorton Linsley, University of California, Berkeley, Charles D. Michener, University of Kansas, and Jerome G. Rozen, Jr., American Museum of Natural History, all of whom were provided with a male and female paratype of *Holcopasites ruthae,* for kindly reviewing the descriptions of the two new bees and my commentary upon them. Any errors remaining are my own.

Dr. Michener also provided me with a partial translation of Popov (1935), as well as loan of a male specimen of *Schmiedeknechtia gussakovskyi*; he could not have been more helpful. Dr. Ronald J. McGinley and Ms. Maureen Mello of the U.S. National Museum of Natural History made loans of specimens of five species of *Holcopasites.* Through the efforts of Saul Frommer (of the University of California, Riverside), the long missing collection of Timberlake's small nomadines was found and kindly placed at my disposal.

My warm thanks to the above and to John Chemsak, University of California, Berkeley, S. P. Cover, Museum of Comparative Zoology at Harvard, Andrew Sanders, University of California, Riverside, Botanical Garden, and Drs. Terry L. Griswold, U.S.D.A. Bee Biology and Systematics Laboratory at Logan, Utah, John LaSalle, C.A.B. International Institute of Entomology, Alvin F. Shinn, William Paterson College of New Jersey, and W. P. Stephens, Oregon State University, all of whom responded most helpfully to my requests for information.

LITERATURE CITED

Alexander, B. 1990. A cladistic analysis of the nomadine bees (Hymenoptera: Apoidea). Systematic Entomology 15: 121–152.

Bartholomew, J. G., W. E. Clarke, and P. H. Grimshaw. 1911. Atlas of Zoogeography. Bartholomew's Physical Atlas. Vol. 5. Royal Geographical Society. Edinburgh. (8) + 67 + XI pp., 36 plates.

Friese, H. 1895. Die Bienen Europas (Apidae Europaeae). I. Schmarotzerbienen. Akad. Verlags., Graz. 218 pp.

Grütte, E. 1935. Zur Abstammung der Kuckucksbienen (Hymenopt. Apid.). Archiv für Naturgeschichte, N.F. 4: 449–534.

Haldane, J. B. S. 1955. The measurement of variation. Evolution 9: 484.

Hurd, P. D., Jr. and E. G. Linsley. 1972. Parasitic bees of the genus *Holcopasites* Ashmead (Hymenoptera: Apoidea). Smithsonian Contributions to Zoology, No. 114, 41 pp.

Linsley, E. G. 1942. Notes and descriptions of some North American parasitic bees (Hymenoptera, Nomadidae). Pan-Pacific Entomologist 18: 127–132.

Linsley, E. G. and C. D. Michener. 1939. A generic revision of the North American Nomadidae. Transactions of the American Entomological Society 65: 265–305.

Mavromoustakis, G. A. 1959. New and interesting parasitic bees (Hymenoptera, Apoidea). Entomologische Berichte 19: 52–56.

———. 1963. On some parasitic bees (Hymenoptera, Apoidea). Annals and Magazine of Natural History (13)5: 751–754.

McKenna, M. C. 1983. Cenozoic paleogeography of North Atlantic land bridges, pp. 351–399. *In* Bott, M. H. P., et al., eds., Structure and Development of the Greenland-Scotland Ridge. Plenum Press, New York

Michener, C. D. 1979. Biogeography of the bees. Annals of the Missouri Botanical Garden 66: 277–347.

Popov, V. B. 1934 (1933). Notes on the parasitic bees allied to the genus *Biastes* Panz. (Hymenoptera, Nomadidae). Trav. Institute of Zoology, Academy of Sciences URSS. 1933: 51–75. [Russian; English summary.]

Smith, A. G., A. M. Hurley, and J. C. Briden. 1981. Phanerozoic Paleocontinental World Maps. Cambridge Earth Science Series, Cambridge. (3) + 102 pp.

Warncke, K. 1982. Zur systematik der bienen-die unterfamilie nomadinae (Hymenoptera, Apidae). Entomofauna 3: 97–126.

NOTE

Lectotype designation for *Xenochalepus medius* (Chapuis) (Coleoptera: Chrysomelidae, Hispinae)

While working on a nomenclatural problem in the genus *Xenochalepus* Weise, it became necessary to examine the type series of *X. medius* (Chapuis) (Annales de la Société Entomologique de Belgique 20: 19, 1877). Specimens were borrowed from the Institut Royal des Sciences Naturelles de Belgique. In order to fix the status of the species, a lectotype and two paralectotypes are herein designated.

Lectotype (first specimen in series with Chapuis determination label): Coll. I. R. Sc. N. B., Uruguay: Montevideo, coll. Chapuis (purple label)/Dr. Chapuis det. 1877, Odontota media Chap./cf Ann. Soc. Ent. Belg. XX, 1877, p. 19/sec. Weise Cat. Junk 1911, C. (Xenochalepus) medius (Chap.)/Ex. Types (red ink on white label)/O. media Chap., Montevideo (white label with green border)/Lectotype Xenochalepus medius (Chapuis) des. C. L. Staines 1991 (red label).

Paralectotypes: both with Paralectotype *Xenochalepus medius* (Chapuis) des. C. L. Staines 1991 (red label). Same labeling as lectotype except as follows:

> specimen 2 on top (purple) label—Montevideo (green paper glued to purple label); coll. et determ. D'Chapuis (white paper glued to purple label).
>
> specimen 3 with Coll. et determ. D'Chapuis (white paper glued to purple label).

All specimens are in the Institut Royal des Sciences Naturelles de Belgique collection.

Acknowledgments.—I thank the Institut Royal des Sciences Naturelles de Belgique for the loan of the Chapuis type and R. E. White, USDA, SEL, for access to the U.S. National Museum collection.

C. L. Staines, *3302 Decker Place, Edgewater, Maryland 21037.*

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, p. 127

NOTE

New Host Plant and Parasitoid Record in México for *Anastrepha alveata* Stone (Diptera: Tephritidae)

Anastrepha alveata Stone is a rare species belonging to the *spatulata* group (Norrbom, 1988, USDA-APHIS Special Publ. 81-52). The only known information about its biology stems from two individuals (paratype material) having been reared by C. H. Ballou from a myrtaceous fruit in El Valle, Venezuela (A. Stone, 1942, Misc. Publ. USDA No. 339: 72–73). *A. alveata* has been reported in the following countries: Panamá, Venezuela, Argentina and México (A. Stone, 1942, Misc. Publ. USDA No. 339: 72–73; V. Hernandez, 1991, Folia Entomol. Mex. 73: 183–184).

Here we report *A. alveata* infestations on *Ximenia americana* L. (Olacaceae). We collected 1.6 kg of ripe fruit from the ground adjacent to a *X. americana* tree which yielded 78 *A. alveata* pupae. Fruit were collected on May 7, 1991 and pupae harvested on May 14, 1991. The collection site was Llano Grande, Municipio de Teocelo, Veracruz, México.

Between May 22 and June 3 1991, 25 *A. alveata* adults (11 ♀ & 14 ♂) and 23 *Doryctobracon areolatus* (Szepligeti) parasitoids (11 ♀ & 12 ♂) emerged. Voucher specimens were placed in the insect collection and herbarium of the Instituto de Ecología, A.C. *A. alveata* individuals were also sent to the insect collection of the Systematic Entomology Laboratory, ARS-USDA, % National Museum of Natural History, HHB 168, Washington, D.C. 20560 (Allen Norrbom) and *Doryctobracon areolatus* individuals sent to the parasitoid collection of Texas A&M University, College Station, TX 77843 (Robert Wharton, TAMU voucher number 557).

Ximenia americana had been previously reported as a host plant of *Anastrepha fraterculus* Wiedemann (A. Stone, 1942, Misc. Publ. USDA No. 339: 72–73) and *A. obliqua* Macquart (L. C. McAlister, Jr., 1936, J. Econ. Entomol. 29: 440–445). It must be nevertheless noted that the *A. obliqua* infestation was observed under laboratory conditions and not in the field.

Acknowledgments.—Specimen identification was performed by the following specialists: *A. alveata* (Vicente Hernandez, Instituto de Ecología, A.C., Xalapa, Veracruz, México); *Doryctobracon areolatus* (Robert Wharton, Texas A&M University, College Station, Texas, USA) and *Ximenia americana* (Gonzalo Castillo, Instituto de Ecología, A.C., Xalapa, Veracruz, México). We also acknowledge valuable support by Allen Norrbom. Financial support was provided by the International Foundation for Science through Grant C/1741-1, the Secretaria de Educación Pública (SEP) through Grant C90-01-0562 and CONACYT through Grant D111-903537.

Enrique Piedra, Alberto Zuñiga and Martín Aluja, *Instituto de Ecología, A.C., Apartado Postal 63, 91000 Xalapa, Veracruz, MEXICO.*

NOTE

A Newly Discovered Homonym in *Ectomocoris* (Heteroptera: Reduviidae: Peiratinae)

In checking the literature I discovered that *Ectomocoris montanus* Ren is preoccupied by *E. montanus* Villiers. A new name is proposed for Ren's species as detailed below.

Ectomocoris montanus Villiers

Ectomocoris montanus Villiers. 1948. Faune de l'Empire Française. IX. Hémiptères Réduviides de l'Afrique Noire, page 249. Female holotype from Upper-Guinea, Africa.

***Ectomocoris reni* Maldonado, NEW NAME**

Ectomocoris montanus Ren Shuzhi. 1990. Acta Scientiarum Naturalium Universitatis Nan Kaiensis 3(1): 71 (Chinese), 75 (English). Male holotype from Xishuangbanna, Yunnan Province, China. Preoccupied by *E. montanus* Villiers.

J. Maldonado Capriles, *Department of Crop Protection, University of Puerto Rico, Mayagüez, PR, 00681. Mailing address: Urb. Aponte 6 I 1, Cayey, Puerto Rico, 00736.*

PROC. ENTOMOL. SOC. WASH.
95(1), 1993, p. 129

NOTE

A New Name For A Homonym In *Catinathrips* (Thysanoptera: Thripidae)

In my article entitled "A review of the genus *Catinathrips* (Thysanoptera: Thripidae)" (Proc. Entomol. Soc. Washington 94(3): 371–378, 1992), the wrong specific name, *vaccinophilus* Nakahara, was used for a new species on page 376, which created a junior primary homonym of *vaccinophilus* (Hood). The correct name for the new species is *vaccinicola* Nakahara. On pages 371, 373, and 378, *vaccinicolus* should be changed to *vaccinicola*. Two corrections are also necessary in the key on page 373. The couplet labeled 5(1) should be changed to 6(1) and in couplet 7, the author of *vaccinophilus* is Hood, not Morgan.

Sueo Nakahara, *Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, 10300 Baltimore Avenue, Beltsville, Maryland 20705-2350.*

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld. 124 pp. 1959	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld. 35 pp. 1960	3.00
Both papers on cynipid galls	6.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver. 25 pp. 1951	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney. 15 pp. 1976	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal. 35 pp. 1977	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal. 61 pp. 1979	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff. 85 pp. 1990	10.00

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
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00

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.

CONTENTS

(Continued from front cover)

WHEELER, A. G., JR. and JOHN E. RAWLINS—*Calophya triozomima* Schwarz, a sumac-feeding psyllid new to the eastern United States (Homoptera: Psylloidea: Calophyidae) .. 99

NOTES

MALDONADO CAPRILES, J.—A newly discovered homonym in *Ectomocoris* (Heteroptera: Reduviidae: Peiratinae) 128

NAKAHARA, SUEO—A new name for a homonym in *Catinathrips* (Thysanoptera: Thripidae) 129

PIEDRA, ENRIQUE, ALBERTO ZUÑIGA, and MARTÍN ALUJA—New host plant and parasitoid record in México for *Anastrepha alveata* Stone (Diptera: Tephritidae) 127

STAINES, C. L.—Lectotype designation for *Xenochalepus medius* (Chapuis) (Coleoptera: Chrysomelidae, Hispinae) 126

VOL. 95 APRIL 1993 NO. 2
(ISSN 0013-8797)

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY of WASHINGTON

PUBLISHED
QUARTERLY

CONTENTS

BAKER, GERALD T. and ANGSUMARN CHANDRAPATYA—Antennal sensilla of the Chinese lantern fly, *Pyrops candelaria* L. (Homoptera: Fulgoridae) 245

CLARK, WAYNE E. and HORACE R. BURKE—The *Anthonomus cavei* species group (Coleoptera: Curculionidae) 152

EISENBERG, R. M. and L. E. HURD—Relative egg success and implications for distribution of three sympatric mantids (Mantodea: Mantidae) 271

GOEDEN, RICHARD D., DAVID H. HEADRICK, and JEFFREY A. TEERINK—Life history and descriptions of immature stages of *Tephritis arizonaensis* Quisenberry (Diptera: Tephritidae) on *Baccharis sarothroides* Gray in southern California 210

GRISSELL, E. E.—*Zdenekius*, a new genus of Nearctic Torymidae (Hymenoptera: Chalcidoidea) 264

HANSSON, CHRISTER and RONALD D. CAVE—First record of *Kratoysma* (Hymenoptera: Eulophidae) from the New World, including the description of two new species 253

HARRIS, S. C. and S. G. TIEMANN—New species of *Neotrichia* from Texas and Panama, with a preliminary review of the *N. canixa* group (Trichoptera: Hydroptilidae) 286

LEWIS, ROBERT E., EDWARD C. BECKER, and ROBERT E. SKIDMORE—An annotated catalogue of the siphonapteran primary types in the Canadian National Collection of Insects (Insecta: Siphonaptera) 278

MALDONADO CAPRILES, J. and D. J. CARPINTERO—Redescription of the harpactorine genus *Sosius* Champion 1899, with the description of a new species (Heteroptera: Reduviidae) 223

MELO, GABRIEL AUGUSTO R. DE and HOWARD E. EVANS—Two new *Microstigmus* species (Hymenoptera, Sphecidae), with the description of their parasite, *Goniozus microstigmi* sp. n. (Hymenoptera, Bethylidae) 258

NORRBOM, ALLEN L.—New synonymy of *Epochra* Loew with *Euphranta* (*Rhacochlaena* Loew) (Diptera: Tephritidae) and description of a new species from Mexico 189

(*Continued on back cover*)

THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

ORGANIZED MARCH 12, 1884

OFFICERS FOR 1993

WAYNE N. MATHIS, *President*
RUSSELL D. STEWART, *President-Elect*
M. ALMA SOLIS, *Recording Secretary*
HOLLIS B. WILLIAMS, *Corresponding Secretary*
NATALIA J. VANDENBERG, *Custodian*
NORMAN E. WOODLEY, *Treasurer*
CHRISTOPHER H. DIETRICH, *Program Chairman*
RALPH P. ECKERLIN, *Membership Chairman*
DAVID R. SMITH, *Past President*

THOMAS J. HENRY, *Editor*
GARY L. MILLER, *Book Review Editor*

Publications Committee
DONALD R. DAVIS
TERRY L. ERWIN
F. CHRISTIAN THOMPSON
A. G. WHEELER, JR., *Special Publications Editor*

Honorary President
CURTIS W. SABROSKY

Honorary Members
LOUISE M. RUSSELL
ALAN STONE
KARL V. KROMBEIN

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, % 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 $25.00 (U.S. currency).

PROCEEDINGS.—The *Proceedings of the Entomological Society of Washington* (ISSN 0013-8797) are published quarterly beginning in January by The Entomological Society of Washington. POSTMASTER: Send address changes to the Entomological Society of Washington, % Department of Entomology, NHB-168, Smithsonian Institution, Washington, D.C. 20560. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember U.S. subscriptions are $60.00 per year and foreign subscriptions are $70.00 per year, payable (U.S. currency) 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. 218 OF THE JANUARY, 1991 ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Editor: Thomas J. Henry, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Books for Review: Gary L. Miller, Systematic Entomology Laboratory, ARS, USDA, Building 046, BARC-West, Beltsville, MD 20705.

Special Publications: A. G. Wheeler, Jr., Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, PA 17110-9408

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 7 May 1993

Second Class Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

THIS PUBLICATION IS PRINTED ON ACID-FREE PAPER

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 131–138

A METHOD OF GENITALIA PREPARATION AND DRY PRESERVATION FOR COLEOPTERA

PAUL E. SKELLEY

Department of Entomology and Nematology, Building 970, Hull Road, University of Florida, Gainesville, Florida 32611-0620, U.S.A.

Abstract.—A technique to evert, inflate, and dry preserve internal sacs of male genitalia is discussed. In addition to pigmented structures, many internal sacs observed have an asymmetrical form and microscopic structures on the white-fleshy parts. This technique is compared to more widely used methods of genitalia preservation and study.

Key Words: Genitalia, SEM, preparation, internal sac

Male genitalia and associated structures (collectively called terminalia) are utilized for taxonomic and systematic studies in most insect taxa. The male internal sacs are often ignored in studies of taxa where the sclerotized parameres are distinct among species. Internal sacs can yield additional information in taxa where the parameres are similar among species (e.g. Chandra 1991).

Most methods of internal sac (IS) (or endophallus) preparation and preservation are variations of two themes: 1) relax and mount on microscope slides, or 2) relax and store with glycerin in microvials. Microscope slides are mostly used for small genitalia that are studied at high magnifications with a compound microscope (transmitted light). With this method there are moderate distortions due to the weight of the coverslip. Some researchers omit the slides altogether and preserve the genitalia on a paper point in a drop of mounting medium (Angus 1969: 2).

Larger genitalia are stored in microvials under glycerin. The glycerin preserves the soft tissues and prevents them from drying out. This method allows study with the dissecting microscope (reflected light) and avoids distortions due to slide mounting. Some researchers combine the two methods by dissecting the IS's, cutting them down one side and mounting them flattened out on a microscope slide. With this variation all three-dimensional information is lost.

Internal sacs can be studied retracted (folded and held within the dark sclerotized genitalic structures) or everted (extended and swollen as during copulation). Occasionally a specimen is killed with the genitalia everted, but this is not a common occurrence. Techniques to evert the IS's are few and are usually delicate procedures.

Retracted IS's are studied with transmitted light in various small-sized taxa where everting the tissue is difficult or impossible (as illustrated in Gordon and Cartwright 1980, 1988). Larger insects IS's are often everted by pushing and pulling the relaxed tissues with hook-tipped pins or forceps (Sharp and Muir 1912, Sharp 1918, Howden 1982, d'Hotman and Schöltz 1990). After all of the work to prepare genitalia, most attention is given only to the pigmented structures on the IS's.

D'Hotman and Schöltz (1990) everted, compared, and illustrated the genitalia of many scarab beetles showing asymmetrical IS's (e.g., Figs. 1, 2). Thompson (1988) developed a glycerin-inflating technique to study the fleshy IS's of *Leptostethus* weevils. In both of these studies the IS's were observed and stored in glycerin. Thompson's inflation technique worked well, but the inflated IS's could be studied only when attached to the apparatus and under a dissecting scope. Once the genitalia are removed from the apparatus, they presumably deflate.

The intent of this study was to develop a method where IS's could be easily everted, preserved dry without collapse in their three-dimensional form, and studied under a scanning electron microscope (SEM).

MATERIALS AND METHODS

This technique involved two major steps: 1) eversion and potential inflation of the IS, and 2) drying the genitalia.

Dry museum specimens were relaxed in a weak solution of detergent water (approximately 1 part detergent : 9 parts water), and the genitalia dissected. The IS's were everted manually with hook-tipped pins and jewelers forceps as in Sharp and Muir (1912: 483–484). These specimens were dried for study, but inflating attempts failed and the tissues remained folded and wrinkled. Inflation with a syringe (Hardwick 1950) did not improve the results.

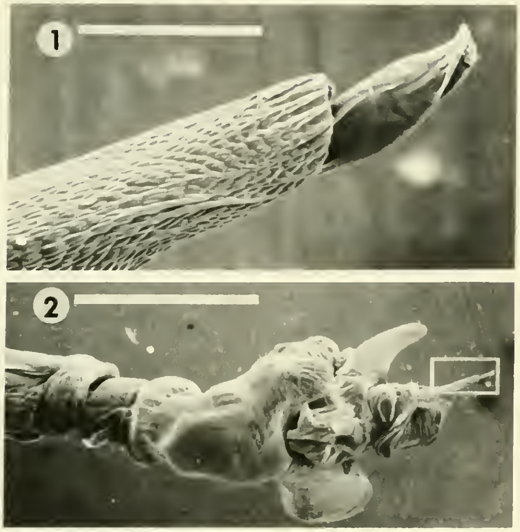
Inflated IS preparations were made from freshly killed specimens, the fresher the better. Rates of tissue hardening varied greatly among specimens depending on size, strength of tissues, and method of killing. Cyanide or ethyl acetate produced the best results. Alcohol submersion worked adequately but appeared to kill the insects in a tense state and rapidly hardened the tissues. Few good inflations were made from old alcohol-killed and preserved specimens.

After the insect died, the genitalia was removed and placed in weak detergent water solution (1 part detergent : 9 parts water). Care was taken to remove genitalia with the associated glands and musculature intact. The genitalia were then covered with detergent water solution, 1 ml in a 4 ml vial was sufficient. The fresh tissues retained much of their membrane integrity and swelled under osmotic pressure. Genitalia were then placed between the thumb and forefinger holding the glands and musculature. With a slow, gentle rolling motion (like squeezing tooth-paste out of a tube from the bottom to top) the tissues were forced up into the median lobe causing the IS to emerge from the apex. A similar technique for everting genitalia has been done with live camel crickets (Orthoptera: Gryllacrididae: *Ceuthophilus*) by T. J. Cohn and the late T. H. Hubbell (unpublished) and is also mentioned by Sharp and Muir (1912: 483). Hook-tipped pins or forceps were often helpful in this process.

Genitalia were again placed in the detergent water solution and the "squeezing" process repeated until the genitalia remained inflated. The time required in the detergent solution varied dramatically among specimens. Larger genitalia often took several days in the solution and several "squeezings." Small genitalia often required only one "squeezing" and a few hours in the detergent.

Delicate IS's could be fixed or hardened before drying. Various chemical fixatives like osmium tetroxide, hexamethyldisalizane (Nation 1983), or formaldehyde may be used. See Glauert (1980) for discussions of various fixation techniques which can be used. I did not employ any of these for this study.

The specimens, once everted and/or inflated, are ready to be dried with the critical point dryer. Other drying techniques (i.e. freeze drying) may be useful, but they were not used here. To be dried in a critical point dryer, the specimens needed to be dehydrated through alcohol baths into 100% ethanol. I raised the alcohol percentage in the vials by slowly adding 70% isopropanol; a few drops at first, then doubling the volume. When near 70%, I poured off the liquid and added straight 70% alcohol. From there a



Figs. 1–2. *Canthon pilularius* (Linnaeus) (Scarabaeidae) genitalia with everted internal sac, dorsal view. 1, Line = 0.18 mm. 2, Line = 1.83 mm.

normal dehydration series was used. I left the specimen in each liquid change from 1 to several hours allowing ample time for the specimen to come to an equilibrium with the solution before changing it.

Once dehydrated and in the third change of 100% ethanol, genitalia were critical point dried with a Tousimis, Samdri®-780A. The genitalia were mounted on a paper point and pinned under the rest of the specimen for study with a dissecting microscope or coated and studied under a scanning electron microscope (SEM). Specimens illustrated here were coated with gold-palladium in a Denton Vacuum DESK II sputter coater and photographed with a Hitachi S-570 SEM. Specimens studied are deposited in the Florida State Collection of Arthropods, Gainesville, Florida.

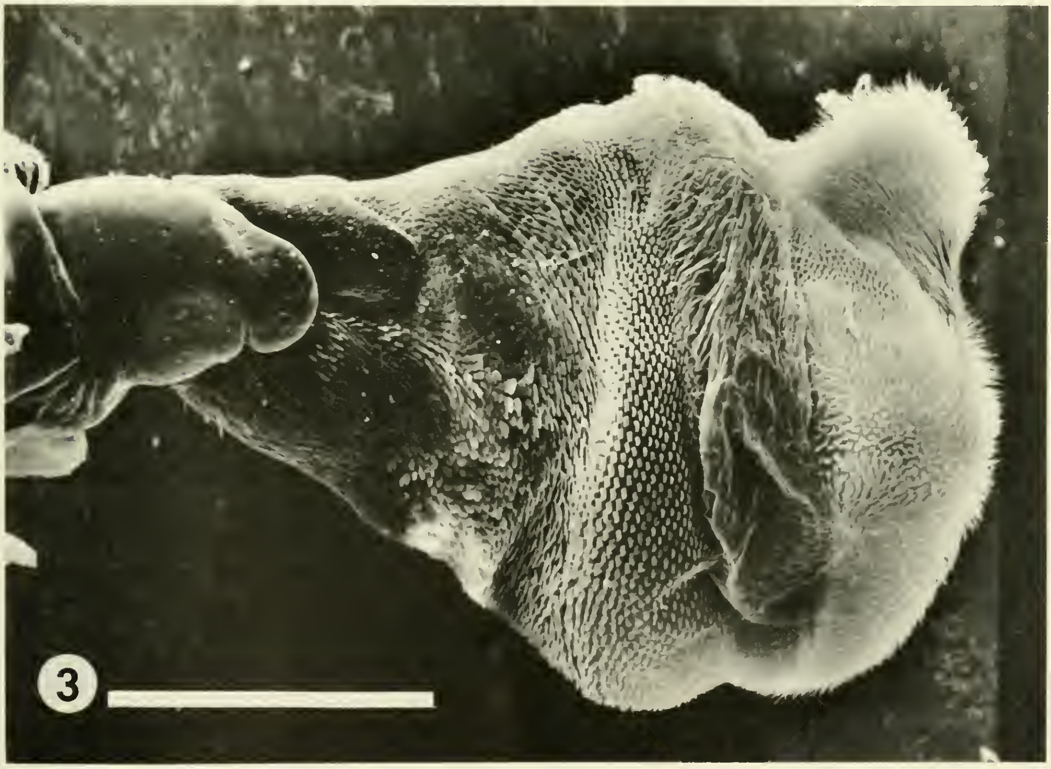
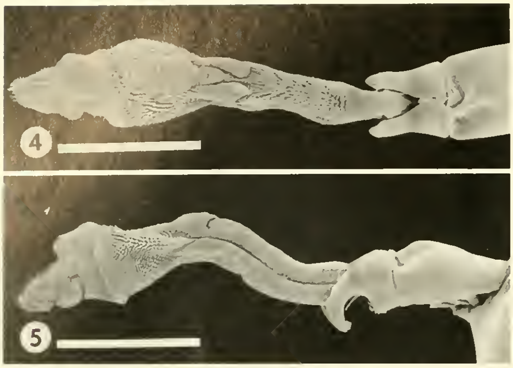


Fig. 3. *Ataenius saramari* Cartwright (Scarabaeidae) genitalia with everted internal sac, lateral view. Line = 0.23 mm.



Figs. 4–5. *Platytomus longulus* (Cartwright) (Scarabaeidae) genitalia with everted internal sac. Line = 0.20 mm. 4, Dorsal view. 5, Lateral view.

RESULTS

The original work was done on *Phyllophaga* (Scarabaeidae) while helping to prepare the SEM genitalia illustrations in Woodruff and Beck (1989). The technique proved useful on various other families and scarab genera, a few of which are illustrated.

In liquid IS's are clear, except for the obvious pigmented structures. When they are critical point dried, soft tissues turn an opaque white and any internal structures are obscured. This white tissue contrasts with pigmented structures and can be studied under a dissecting microscope at lower magnifications (20–100 ×). Specimens coated for study at higher magnifications (100–1000 ×) with the SEM lost this contrast. Examination with the SEM revealed varying amounts

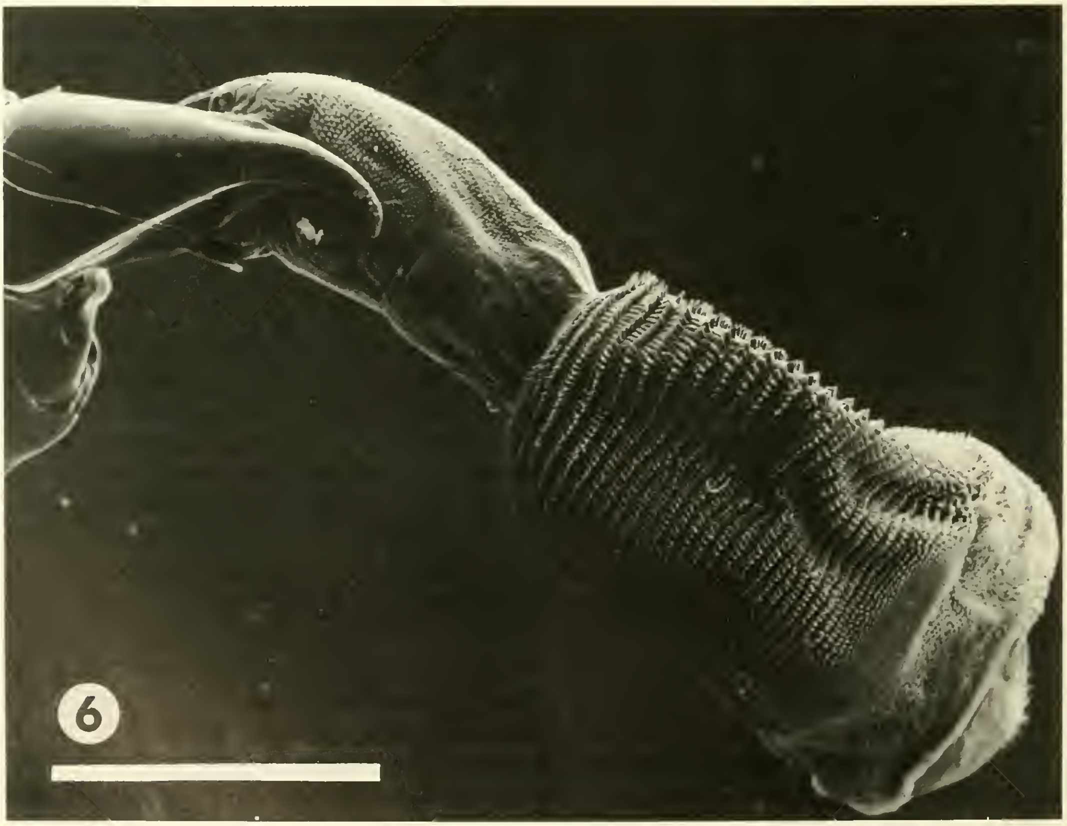
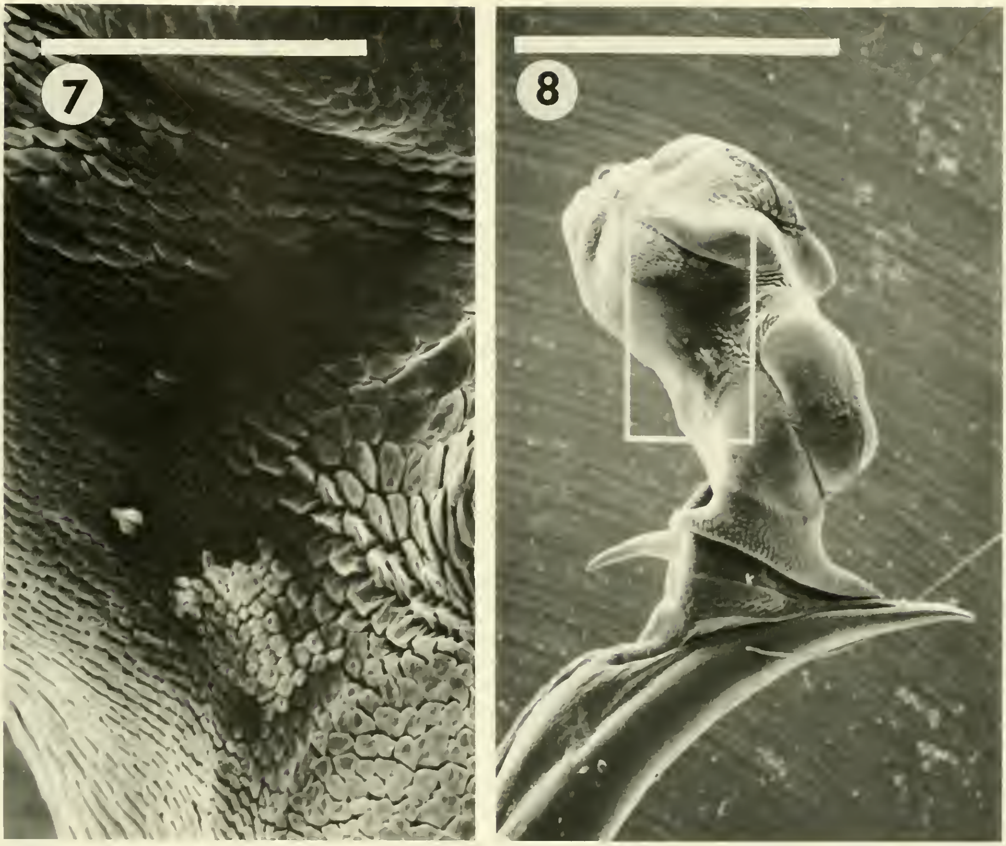


Fig. 6. *Aphodius badipes* Melsheimer (Scarabaeidae) genitalia with everted internal sac, lateral view. Line = 0.60 mm.



Figs. 7–8. *Notiobia terminata* (Say) (Carabidae) genitalia with everted internal sac, lateral view. 7, Line = 0.15 mm. 8, Line = 0.75 mm.

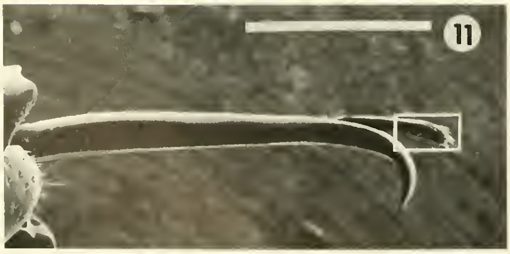
of microstructure on the non-sclerotized tissues not seen with the light microscopes (Figs. 6–13). Small beetles, like *Ataenius saramari* Cartwright (Fig. 3) and *Platytomus longulus* (Cartwright) (Figs. 4, 5), have unpigmented IS's which, under a light microscope, seem to lack structures. The SEM shows this to be in error, as their IS's are covered with patches of scales and spines. The potential usefulness of the SEM in studying IS's for taxonomic and systematic problems is tremendous.

The ease of eversion and inflation was largely dependent upon the amount of tissues associated with the IS. Many scarabs had IS completely enclosed with muscles. These muscles acted like the bulb on an eyedropper, making eversion and inflation easy. Beetles like *Ischyrus* (Erotylidae) simply had strands of muscles and little associated tissue. These genitalia were only everted manually with pins and forceps and inflations were not achieved. In contrast, the complexity of certain dynastine scarab (*Strategus*) IS's made eversion difficult by any method and I have not produced a good preparation.

Discussion of Techniques

All three preparation and storage techniques (microscope slide, microvial, and critical point dried) for IS studies have benefits and limitations. The method used is always limited by the availability of specimens, equipment, and the needs of the researcher.

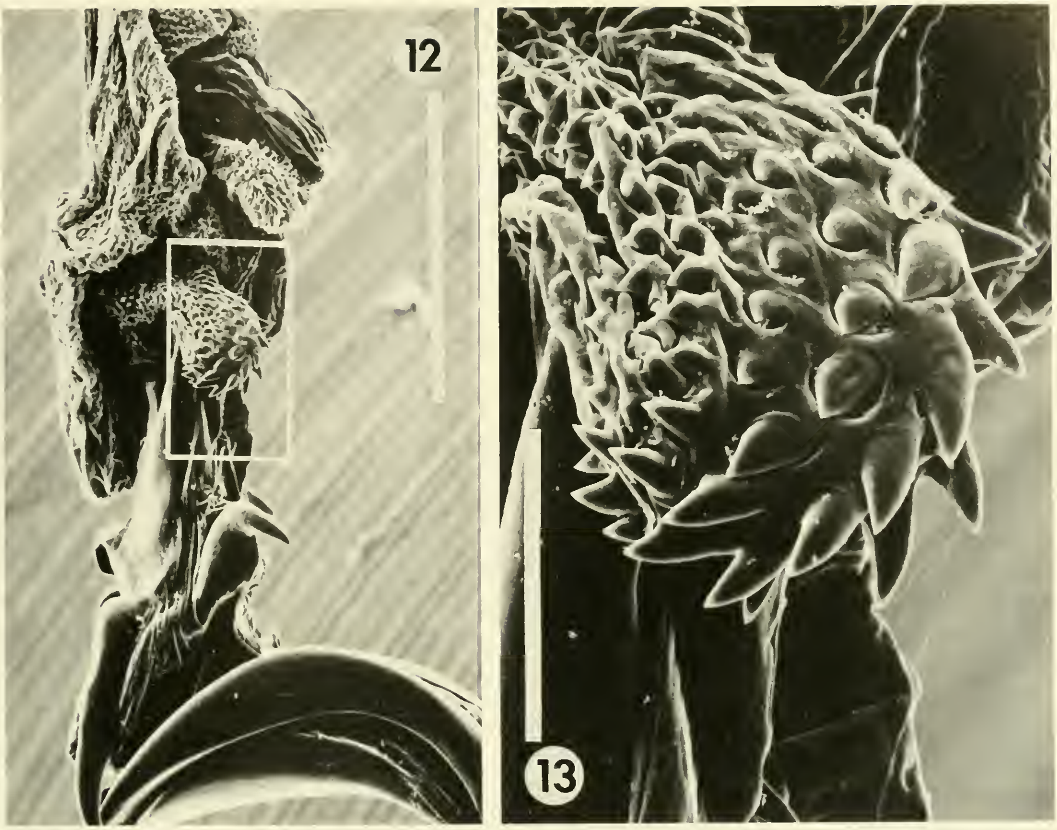
Fig. 9. *Epicauta heterodera* Horn (Meloidae) genitalia with everted internal sac, lateral view. Line = 0.23 mm.



Figs. 10–11. *Saprinus lugens* Erichson (Histeridae) genitalia with everted internal sac, lateral view. 10, Line = 0.06 mm. 11, Line = 0.60 mm.

Microscope slide mounting is the most widely available technique to study specimens at high magnifications. Genitalia can be adequately prepared from dried museum specimens and internal features studied with transmitted light. There are drawbacks to this technique. Slide mounted genitalia are kept separate from the pinned specimen, and the association between them is easily lost. Clarity with transmitted light at high magnifications is adequate but the fleshy microsculpture is difficult to discern. Once set in mounting medium, the specimen becomes two dimensional and can be viewed only from the top and bottom. Being three dimensional, there are distortions that occur as they are flattened.

Microvial-stored specimens can be removed and studied from all views, and may be re-inflated for later study if needed, as in *Leptostethus* preparations described by Thompson (1988). Specimens stored this



Figs. 12–13. *Listronotus echinodori* O'Brien (Curculionidae) genitalia with everted internal sac, lateral view. 12, Line = 0.43 mm. 13, Line = 0.086 mm.

way are generally larger and can be studied with both transmitted and reflected light. Pigmented structures, both internal and external, are obvious and easily studied, whereas unpigmented structures are difficult to discern. Microvials and glycerin are readily available. Problems can arise with the extra weight of the vial when added to the insect pin. The bulk can become a nuisance in usurping storage space and aid in dislodging specimens from the box bottoms. If too much glycerin is used, it can seep through the microvial stopper and soil the label or the specimen. If the specimen is large and takes up most of the insect pin, the microvial is pinned separately next to the specimen. This can lead to a loss of the association between the specimen and its genitalia.

Genitalia dried with a critical point dryer can be studied with a dissecting microscope or a SEM. Being dry, the genitalia can be pinned under the specimen with no chance for loss of the association. The genitalia are light in weight and take up little space, decreasing potential hazards to other specimens. The genitalia contain no liquid which can soil the specimens, although the body oils from specimens may soil the genitalia. The limitations of this technique can be formidable. The equipment needed is expensive and many institutions may not have a critical point dryer available. Dry museum specimens can be used, if a certain amount of wrinkling is acceptable. The best preparations come from freshly killed material, thus, rare or endangered taxa may be unavailable for study. Critical point drying turns the tissues opaque, eliminating study by transmitted light, but allows study with a SEM.

The use of critical point dryers and SEM's in IS studies have advantages and difficulties depending on the taxa. The exact procedures used for inflating, potential fixation, and drying IS's will vary with each taxon. The method described is not useful for all taxa. Because of the taxonomic information that can be gained, this method should be considered in systematic studies.

Acknowledgments

I thank R. E. Woodruff and B. M. Beck, Florida State Collection of Arthropods, Gainesville, FL, for their encouragement and help. I thank M. C. Thomas and J. M. Kingsolver, Florida State Collection of Arthropods, Gainesville, FL; H. Cromroy, University of Florida, Gainesville, FL; and the anonymous reviewers for their editorial comments.

I additionally thank P. M. Choate, University of Florida, Gainesville, FL; P. W. Kovarik, Ohio State University, Columbus, OH; C. W. O'Brien, Florida A. & M. University, Tallahassee, FL; and R. B. Selander, Florida State Collection of Arthropods, Gainesville, FL, for their determinations of taxa illustrated. Florida Agriculture Experiment Station Journal Series No. R-02560.

Literature Cited

Angus, R. B. 1969. Revisional notes on *Helophorus* F. (Col., Hydrophilidae). I. General introduction and some species resembling *H. minutus* F. Entomologists' Monthly Magazine 105: 1–24, pl. 1.

Chandra, K. 1991. New genitalic characters for distinguishing *Anomala dorsalis* from *Anomala fraterna*. The Coleopterists' Bulletin 45(3): 292–294.

Glauert, A. M. 1980. Fixation, dehydration and embedding of biological specimens. Vol. 3, Part I, 207 pp. *In* Glauert, A. M., ed., Practical Methods on Electron Microscopy. North-Holland Publishing Company, New York.

Gordon, R. D. and O. L. Cartwright. 1980. The Western Hemisphere species of *Rhyssemus* and *Trichiorhyssemus* (Coleoptera: Scarabaeidae). Smithsonian Contributions to Zoology 317, 29 pp.

———. 1988. North American representatives of the tribe Aegialiini (Coleoptera: Scarabaeidae: Aphodiinae). Smithsonian Contributions to Zoology 461, 37 pp.

Hardwick, D. F. 1950. Preparation of slide mounts of lepidopterous genitalia. The Canadian Entomologist 82: 231–235.

d'Hotman, D. and C. H. Schöltz. 1990. Comparative morphology of the male genitalia of derived groups of Scarabaeoidea (Coleoptera). Elytron 4: 3–39.

Howden, A. T. 1982. Revision of the New World genus *Hadromeropsis* Pierce (Coleoptera, Curculionidae, Tanymecini). Contributions of the American Entomological Institute 19(6), 180 pp.

Nation, J. L. 1983. A new method using hexamethyldisalizane for preparation of soft tissues for scanning electron microscopy. Stain Technology 58(6): 347–351.

Sharp, D. 1918. Studies in *Rhynchophora*. IV. A preliminary note on the male genitalia. Transactions of the Entomological Society of London 1918(1–2): 209–222, pl. IX.

Sharp, D. and F. A. G. Muir. 1912. The comparative anatomy of the male genital tube in Coleoptera. Transactions of the Royal Entomological Society of London 1912(3): 477–642, pls. 42–78.

Thompson, R. T. 1988. A method for inflating the internal sac in Curculionidae, appendix pp. 77–80. *In* R. T. Thompson. Revision of the weevil genus *Leptostethus* Waterhouse, 1853 (Coleoptera: Curculionidae: Entiminae). Cimbebasia Memoir 7, 80 pp.

Woodruff, R. E. and B. M. Beck. 1989. The scarab beetles of Florida (Coleoptera: Scarabaeidae) Part II. The May or June beetles (genus *Phyllophaga*). Arthropods of Florida and Neighboring Land Areas. Volume 13. Florida Department of Agriculture & Consumer Services. Division of Plant Industry, Gainesville, Florida, 226 pp.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 139–151

EXTRAFLORAL NECTAR FEEDING BY LADYBIRD BEETLES (COLEOPTERA: COCCINELLIDAE)

Robert W. Pemberton and Natalia J. Vandenberg

(RWP) Asian Parasite Laboratory, USDA, Agricultural Research Service, % American Embassy (Seoul, Korea), Unit #15550, APO AP 96205-0001, U.S.A.; (NJV) Systematic Entomology Laboratory, PSI, Agricultural Research Service, USDA, % U.S. National Museum of Natural History, Washington, D.C. 20560, U.S.A.

Abstract.—Coccinellid beetles belonging to 41 species in 19 genera and 5 of the family's 6 coccinellid subfamilies were observed in the United States, China, Japan, and Korea, or are reported in the literature to feed on the extrafloral nectar of 32 plant species in 23 genera and 15 families. Extrafloral nectar feeding by coccinellids occurred throughout the world in diverse natural and man-made habitats. Since ladybird beetles are, at times, common and occasionally abundant visitors to extrafloral nectaries, they could reduce insect herbivores of the plants that bear the glands, much as do many extrafloral nectar feeding ants. Most extrafloral nectary feeding by ladybird beetles, however, was not observed in the presence of prey, nor usually where ants were abundant. Ladybird beetles were less frequent and less constant visitors to extrafloral nectaries than were ants, and appear by contrast to be poor mutualists to extrafloral nectary-bearing plants. Extrafloral nectar seems to be an important energy source for coccinellids in the absence of prey. It probably enhances ladybird beetle survival and may maintain them in the habitat, to feed on insect herbivores as they appear.

Key Words: Coleoptera, Coccinellidae, ladybird beetles, ants, extrafloral nectar, insect nutrition, plant defense

Extrafloral nectaries are secretory glands of plants usually located on the leaves, but also on the outer surfaces of reproductive parts (Bentley 1977a). Plants belonging to at least 93 families and of worldwide occurrence bear the glands (Zimmermann 1932, Elias 1983, Pemberton and Keeler unpublished data). During the past 25 years, numerous studies have demonstrated the role of ants that feed on extrafloral nectaries in reducing the insect herbivore damage to plants that bear the glands (Janzen 1966, Elias and Gelband 1975, Bentley 1977b, Tilman 1978, Keeler 1981a, Stephenson 1982, Pickett and Clark 1979). Predators other than ants and parasitoids are also frequent visitors to extrafloral nectaries (Springensguth 1935, Keeler 1978, Bugg et al. 1989). Many of these visitors probably cause increased mortality to the insect herbivores that feed on extrafloral nectary-bearing plants (Keeler 1978, Koptur 1985, Hespenheide 1985). In contrast to the many studies involving ants that feed on extrafloral nectar, the effects of non-ant predators and parasitoids that feed at the extrafloral nectaries are virtually unstudied. This undoubtedly reflects the difficulties in excluding predators and parasitoids without excluding the herbivores, most of which also fly (Beattie

1985). The ease with which walking ants can be excluded with resin barriers has contributed, in part, to the emphasis on ant studies.

The unknown and unmeasured benefits that non-ant predator and parasitoid extrafloral nectar feeders bring to the plants may explain (1) the occurrence of extrafloral nectaries in plants living in places like Hawaii, where there are no native ants (Keeler 1985) and (2) the maintenance of extrafloral nectaries in plant populations having ant associates that are ineffective protectors (O'Dowd and Catchpole 1983, Tempel 1983, Koptur and Lawton 1988).

Among predators that feed on extrafloral nectar are the adults of Coccinellidae. Springensguth (1935) observed these beetles feeding at the extrafloral nectaries of many plants in Germany. Coccinellids are more abundant in cotton cultivars that have extrafloral nectaries than in those lacking the glands (Schuster et al. 1976, Adjei-Maafo and Wilson 1983), and they are conspicuous visitors to the extrafloral nectaries on the leaves of peach in Ontario (Putnam 1963). Stephenson (1982) observed *Coccinella* spp. feeding on the extrafloral nectaries of *Catalpa speciosa* Warder and then attacking the eggs and first instar larvae of *Ceratomia catalpae* (Boisduval) (Sphingidae), the plant's primary herbivore.

The objectives of this study were (1) to learn what kinds of coccinellids use extrafloral nectar and from which types of plants and in what situations, and (2) to use these observations and records to consider the benefits of extrafloral nectar feeding to the coccinellids and the plants that bear the glands.

Materials and Methods

Most observations of coccinellids feeding at extrafloral nectaries were made from 1986 through 1990 during research on the occurrence of extrafloral nectary plants in California, Korea, and Montana (Pemberton 1988, 1990, unpublished data). To increase the chances of seeing coccinellid feeding, extrafloral nectaries were also frequently examined during visits to gardens, parks, and during unrelated field work in China, Japan, Korea and the U.S.A. A few plants were monitored frequently including: *Prunus laurocerasus* L., *Prunus serratula* Lindley and *Viburnum opulus* L. in Berkeley, California in 1987; *Prunus virginiana* L. and *Populus tremuloides* Michaux in Bozeman, Montana in 1988; and *Prunus padus* L. in Seoul, Korea in 1989, and *Azukia radiatus* (L.) in Yangsuri, Korea in 1990. Care was taken to actually observe feeding and not merely resting at the site of the nectary. After feeding was observed, the beetle was captured and identified. The field observations were made by the first author (RWP) and the coccinellids identified by the second author (NJV), except for Korean material, which was identified by H. C. Park and a Japanese scymnine identified by R. D. Gordon.

The literature was examined for records of coccinellids feeding on extrafloral nectar. These records were interpreted and are reported using current coccinellid classification and nomenclature.

Results and Discussion

Forty-one coccinellid species were recorded to feed on extrafloral nectar from our observations and from the literature (Table 1). These species belong to 19 genera and 5 of the world's 6 coccinellid subfamilies (Fürsch 1990). The greatest number of extrafloral nectar-feeding species (26 in 8 genera) belong to the Coccinellinae. The Chilocorinae had seven species in three genera, the Scymninae five species in three genera, the Epilachninae two (or more) in one genus and the Coccidulinae a single species. The many observations of Coccinellinae may relate to the ease with which these brightly colored lady beetles can be observed, as well as their relative abundance at extrafloral nectaries.

All records are of adults feeding at extrafloral nectaries, except for Geyer's (1947)

Table 1. Observations and literature records of extrafloral nectar feeding by coccinellid beetles.

Coccinellid Species	Extrafloral Nectary Bearing Plant	Extrafloral Nectary Site	Locality or Literature Record
Scymninae			
Cryptolaemus montrouzieri Mulsant	*Prunus laurocerasus* L. (Rosaceae)	leaf	Berkeley, Calif. (IV.19–21.87)
	Prunus persica (L.) (Rosaceae)	leaf	Berkeley, Calif. (VI.12.87)
Scymnus (*Pullus*) *japonicus* (Weise)	*Prunus padus* L. (Rosaceae)	leaf	Seoul, Korea (IV.5.89)
Scymnus (*Pullus*) sp.	*Prunus amygdalus* Batsch (Rosaceae)	leaf	Berkeley, Calif. (VI.12.87)
	Aleurities cordata R. Brown (Euphorbiaceae)	leaf	Tokyo, Japan (IX.16.86)
Stethorus punctillum Weise	*Prunus persica* (Rosaceae)	leaf	Missouri (Caldwell 1981)
		leaf	Ontario, Canada (Putnam 1963)
Stethorus sp.	*Prunus padus* (Rosaceae)	leaf	Seoul, Korea (IV.19.89)
Chilocorinae			
Brachiacantha ursina (F.) (as *Brachyacantha ursina* (F.))	*Prunus persica* (Rosaceae)	leaf	Missouri (Caldwell 1981)
Brachiacantha sp.	*Ipomoea carnea* Jacq. (Convolvulaceae)	leaf and/or flower stalk	Costa Rica (Keeler 1978)
Chilocorus cacti (L.)	*Chilopsis linearifolius* (Cavanilles) Sweet (Bignoniaceae)	flower bract	near Las Vegas, Nevada (V.21.87)
Chilocorus renipustulatus Scriba	*Prunus avium* L. (Rosaceae)	leaf	Germany (Springensguth 1935)
Chilocorus sp.	*Ailanthus altissima* Swingle (Simbariaceae)	leaf	Baltimore, Md. (IX.1988)
Exochomus flavipes Thunberg larvae	Cucurbitaceous plants	leaf	South Africa (Geyer 1947)
Exochomus quadripustulatus (L.)	*Prunus laurocerasus* (Rosaceae)	leaf	Berkeley, Calif. (IV.86)
Coccidulinae			
Rhyzobius lophanthae (Blaisdell)	*Prunus amygdalus* Batsch (Rosaceae)	leaf	Berkeley, Calif. (VI.18.87)
	Prunus laurocerasus (Rosaceae)	leaf	Berkeley, Calif. (VI.19–21.87)
Coccinellinae			
Hippodamia convergens Guerin	*Chilopsis linearifolius* (Bignoniaceae)	flower buds	Red Rock, Las Vegas, Nevada (V.30.87)
	Helianthus sp. (Compositae)	flower phyllaries	Texas (Rogers 1985)
	Opuntia echinocarpa Engelmann & Bigelow (Cactaceae)	areoles	Deep Canyon, Calif. (III.25.86)
	Prunus laurocerasus (Rosaceae)	leaf	Berkeley, Calif. (IV.19–21.87)
	Prunus persica	leaf	Missouri

Table 1. Continued.

Coccinellid Species	Extrafloral Nectary Bearing Plant	Extrafloral Nectary Site	Locality or Literature Record
	(Rosaceae)		(Caldwell 1981)
	Pteridium aquilinum (L.) Kuhn (Pteridaceae)	rachis	Tamales Bay, Calif. (IV.25.87)
	Vicia angustifolia Reichard (Fabaceae)	stipules	Placer Co., Calif. (VI.87)
	Yucca sp. (Liliaceae)	fruit	Cliff Dwellers, Arizona (V.26.87)
Hippodamia parenthesis (Say)	*Prunus persica* (Rosaceae)	leaf	Missouri (Caldwell 1981)
Hippodamia quinquesignata (Kirby)	*Populus tremuloides* Michx. (Salicaceae)	leaf	Bozeman, Mont. (V.12.88)
	Yucca glauca Nutt. (Liliaceae)	flower buds	Logan, Mont. (VI.19.88)
Hippodamia tredecimpunctata (L.)	*Prunus padus* (Rosaceae)	leaf	Germany (Springensguth 1935)
Hippodamia variegata (Goeze)	*Azukia radiatus* (L.) (Fabaceae)	flower stalk	Yangsuri, Korea (IX.20.90)
	Helianthus annuus L. (Compositae)	flower bracts and phyllaries	Seoul, Korea (VIII.1.89)
	Prunus avium (Rosaceae)	leaf	Germany (Springensguth 1935)
	Salix alba L. (Salicaceae)	leaf	Germany (Springensguth 1935)
	Serratula sp. (Compositae)	flower phyllaries	near Si Lin Houte, Inner Mongolia, China (VII.26.87)
Adalia bipunctata (L.)	*Helianthus annuus* (Compositae)	flower bracts and/or phyllaries	Germany (Springensguth 1935)
	Populus tremuloides (Salicaceae)	leaf	New York (Trelease 1881) Bozeman, Mont. (V.12.88)
	Prunus cerasus L. (Rosaceae)	leaf	Germany (Springensguth 1935)
	Prunus persica (Rosaceae)	leaf	Berkeley, Calif. (VI.12.87) Missouri (Caldwell 1981)
	Prunus virginiana L. (Rosaceae)	leaf	Bozeman, Mont. (V.5.88)
	Salix alba (Salicaceae)	leaf	Germany (Springensguth 1935)
	Sambucus nigra L. (Caprifoliaceae)	stipules	Germany (Springensguth 1935)
	Sambucus racemosa L. (Caprifoliaceae)	stipules	Bozeman, Mont. (V.13.88)
	Viburnum opulus L. (Caprifoliaceae)	leaf	Bozeman, Mont. (V.12.88)
	Vicia faba L. (Fabaceae)	stipules	Austria (Hetschko 1908)

Table 1. Continued.

Coccinellid Species	Extrafloral Nectary Bearing Plant	Extrafloral Nectary Site	Locality or Literature Record
	Vicia villosa Roth. (Fabaceae)	stipules	Germany (Springensguth 1935)
Coccinella novemnotata Herbst	*Helianthella uniflora* (Nutt.) Torr. & Gray (Compositae)	flower phyllaries	Bozeman, Mont. (VI.15.88)
	Yucca glauca (Liliaceae)	flower buds	Logan, Mont. (VI.19.88)
Coccinella quinquepunctata L.	*Centaurea jacea* L. (Compositae)	leaf	Germany (Springensguth 1935)
	Impatiens balsamina L. (Balsaminaceae)	leaf	Germany (Springensguth 1935)
	Prunus avium (Rosaceae)	leaf	Germany (Springensguth 1935)
	Vicia villosa (Fabaceae)	stipules	Germany (Springensguth 1935)
Coccinella septempunctata (L.)	*Centaurea jacea* (Compositae)	leaf	Germany (Springensguth 1935)
	Prunus avium (Rosaceae)	leaf	Germany (Springensguth 1935)
	Prunus cerasus (Rosaceae)	leaf	Germany (Springensguth 1935)
	Prunus spinosa (Rosaceae)	leaf	Germany (Springensguth 1935)
	Ricinus communis L. (Euphorbiaceae)	leaf and/or inflorescence	Germany (Springensguth 1935)
	Serratula sp. (Compositae)	flower phyllaries	near Si Lin Houte, Inner Mongolia, China (VII.26.87)
	Vicia cracca L. (Fabaceae)	stipules	Germany (Springensguth 1935)
(as *C. 7-punctata* L.)	*Vicia faba* L. (Fabaceae)	stipules	Austria (Hetschko 1908)
(as *C. 7-punctata* L.)	*Vicia sativa* L. (Fabaceae)	stipules	Austria (Hetschko 1908)
	Vicia sepium L. (Fabaceae)	stipules	Germany (Springensguth 1935)
Coccinella transversalis F.[a] (as *C. repanda* Thunberg)	*Gossypium* sp. (Malvaceae)	leaf and/or flower bracts	Australia (Adjei-Maafo and Wilson 1983)
Coccinella transversoguttata Faldermann	*Helianthella uniflora* (Compositae)	flower bracts	Bozeman, Mont. (VI.15.88)
	Populus tremuloides (Salicaceae)	leaf	Bozeman, Mont. (V.12.88)
	Prunus virginiana (Rosaceae)	leaf	Bozeman, Mont. (V.5.88)
	Sambucus raceomosa (Camprifoliaceae)	stipules	Hyalite Reservoir, Mont. (VI.18.88)
	Saussurea sp. (Compositae)	flower phyllaries	near Si Lin Houte, Inner Mongolia, China (VII.27.87)
	Yucca glauca (Liliaceae)	flower buds	Logan, Mont. (VI.19.88)

Table 1. Continued.

Coccinellid Species	Extrafloral Nectary Bearing Plant	Extrafloral Nectary Site	Locality or Literature Record
Coccinella trifasciata Mulsant	*Prunus laurocerasus* (Rosaceae)	leaf	Berkeley, Calif. (VI.12.87)
	Prunus persica (Rosaceae)	leaf	Berkeley, Calif. (VI.12.87)
Coccinella undecimpunctata L.[a]	*Gossypium* sp. (Malvaceae)	leaf and/or flower bracts	Egypt (Ibrahim 1955)
Coccinella sp.	*Prunus persica* (Rosaceae)	leaf	Missouri (Caldwell 1981)
Coccinula quatuordecimpustalata (L.) (as *Coccinella* 14-*pustulata* L.)	*Vicia faba* L. (Fabaceae)	stipules	Austria (Hetschko 1908)
	Vicia sativa L. (Fabaceae)	stipules	Austria (Hetschko 1908)
Coelophora inaequalis (F.)[a]	*Gossypium* sp. (Malvaceae)	leaf and/or flower bracts	Australia (Adjei-Maafo and Wilson 1983)
	Ricinus communis (Euphorbiaceae)	leaf and/or inflorescence	Hawaii (Nishida 1958)
Cycloneda munda Say (as *C. mundo* and *C. sanguinea* (L.))	*Prunus persica* (Rosaceae)	leaf	Missouri (Caldwell 1981)
Cycloneda polita Casey	*Prunus laurocerasus* (Rosaceae)	leaf	Berkeley, Calif. (VI.19–21.87)
	Prunus persica (Rosaceae)	leaf	Berkeley, Calif. (VI.18.87)
Cycloneda sanguinea (L.)	*Ipomoea carnea* (Convolvulaceae)	leaf and/or flower stalk	Costa Rica (Keeler 1978)
Harmonia axyridis (Pallas)	*Ailanthus altissima* (Simbariaceae)	leaf	Ming Tombs, Beijing, China (VII.10.87)
	Azukia radiatus L. (Fabaceae)	inflorescence	Yangsuri, Korea (IX.20.90)
adults and larvae	*Populus* sp. (Salicaceae)	leaf	Seoul, Korea (VII.19.89)
	Prunus persica (Rosaceae)	leaf	Beijing, China (VII.9.87)
	Prunus sp. (Rosaceae)	leaf	Yangsuri, Korea (IV.18.89)
	Sambucus sp. (Caprifoliaceae)	stipules	Yangsuri, Korea (IV.18.89)
Harmonia conformis (Boisduval)[a] (as *Leis conformis* Boisduval)	*Crotalaria striata (Fabaceae)*	flower stalk	Florida (Watson and Thompson 1933)
Harmonia octomaculata (F.)[a] (as *H. arcuata* (F.))	*Gossypium* sp. (Malvaceae)	leaf and/or flower bracts	Australia (Adjei-Maafo and Wilson 1983)
Micraspis frenata Erichson[a] (as *Verania freneta*)	*Gossypium* sp. (Malvaceae)	leaf and/or flower bracts	Australia (Adjei-Maafo and Wilson 1983)
Propylea japonica (Thunberg)	*Populus* sp. (Salicaceae)	leaf	Seoul, Korea (V.19.89)
Psyllobora vigintimaculata (Say)	*Prunus laurocerasus* (Rosaceae)	leaf	Berkeley, Calif. (IV.19–21.87)

Table 1. Continued.

Coccinellid Species	Extrafloral Nectary Bearing Plant	Extrafloral Nectary Site	Locality or Literature Record
	Prunus serrulata Lindley (Rosaceae)	leaf	Berkeley, Calif. (IV.22.87)
	Viburnum opulus (Caprifoliaceae)	leaf	Berkeley, Calif. (VI.2.87)
Subcoccinella viginti-quatuorpunctata (L.)	*Helianthus annuus* (Compositae)	flower phyllaries	Germany (Springensguth 1935)
	Prunus avium (Rosaceae)	leaf	Germany (Springensguth 1935)
	Pteridium aquilinum (Pteridaceae)	rachis	New Jersey (Tempel 1983)
	Viburnum opulus (Caprifoliaceae)	leaf	Germany (Springensguth 1935)
Epilachninae			
Epilachna spp.	*Ipomoea carnea* (Convolvulaceae)	leaf and/or flower stalk	Costa Rica (Keeler 1978)

[a] The reference implied but did not explicitly state that extrafloral nectar feeding occurred.

report of larval *Exochomus flavipes* Thunberg feeding on the glands of "curcurbits" in South Africa, and larvae of *Harmonia axyridis* (Pallas) feeding on the leaf glands of a hybrid *Populus* in Korea in 1989. In addition, an unidentified coccinellid larva was seen in 1988 feeding on the extrafloral nectaries of a quaking aspen (*Populus tremuloides*) planted in Washington, D.C. (Pemberton unpublished observation).

Coccinellids were observed to feed at the extrafloral nectaries of 32 plant species belonging to 23 genera and 15 families, in a total of 97 different coccinellid–plant associations. Plants bearing extrafloral nectaries were very diverse, ranging from a primitive fern (*Pteridium aquilinum* (L.) Kuhn) to advanced species of Compositae (*Helianthus* spp., etc.). Of the 18 coccinellid species that fed at the extrafloral nectaries of at least two plant species, 13 fed on those of plants belonging to two or more families. *Hippodamia convergens* Guerin fed on the extrafloral nectar of eight plants in seven families, and *Adalia bipunctata* (L.) used the extrafloral nectar of ten plants in five families. No specificity in coccinellid–extrafloral nectary plant associations was evident, although the beetles may well prefer some nectars over others.

There was a high incidence of feeding on the extrafloral nectaries of *Prunus* spp. (Rosaceae). Ten species of *Prunus*, including peach, cherry, and almond, were used by 24 of the 41 coccinellid species. *Prunus* extrafloral nectar feeding accounted for 35 of 97 coccinellid–plant associations. We suspect that the prominence of *Prunus* use relates to attention given this genus by the observers, as much as to the attractive qualities of its extrafloral nectar. Virtually all of the world's 430 *Prunus* species (Willis 1985) have extrafloral nectaries on the leaf petiole or leaf blade (unpublished data). *Prunus* species occur in most north temperate environments, and many species secrete large amounts of extrafloral nectar.

Coccinellid feeding on extrafloral nectaries occurred throughout most of the world, including Germany, Egypt, South Africa, Australia, China, Korea, Japan, Hawaii, North America, and Costa Rica. This behavior also occurred in a great diversity of environments and habitats such as deserts, grasslands, temperate deciduous and conifer forests, tropical dry forests, row-crop and orchard agriculture, and many urban situations. Rather than specializing on the extrafloral nectar of particular kinds of plants or environments, coccinellids appear to exploit available extrafloral nectar in the diverse environments they inhabit. *Hippodamia convergens* Guerin, for example, uses the extrafloral nectar of a cactus and a yucca in southwestern deserts, a fern in a moist Pacific Coast conifer forest, an ornamental *Prunus* shrub in urban Berkeley, California, and peach in Ontario orchards.

The coccinellids fed at extrafloral nectaries at various sites on the plants. Most glands were on leaf petioles and blades, but they also occurred on: stipules; flower stalks, buds, calyxes, phyllaries and bracts; fruits; the areoles or spine clusters of cacti; and the rachis (stem) branches of a fern.

Coccinellids fed on extrafloral nectar most frequently during April and May in California, April through August in Seoul, South Korea, and during May and June in Montana. These dates correspond to the periods in which extrafloral nectar is most readily available in these areas (Pemberton 1990, unpublished data). Secretion of extrafloral nectar is usually associated with new growth and often slows or ceases when leaves mature. Korea's rainy climate promotes new growth and active extrafloral nectaries throughout the summer, whereas the drier summers of central California and Montana limit new growth and most extrafloral nectary secretion to spring and early summer.

Most of the observations involved one or a few beetles. Most of the time that extrafloral nectaries were observed, coccinellids were not seen. This contrasts strongly with ants, which were frequently seen feeding at the glands of many plants. Due to the chanciness of seeing coccinellids actually feeding at extrafloral nectaries and the general uncommonness of such observations, quantitative data on the frequency of visitation were not collected, except for mung bean, *Azukia radiatus* (L.).

Of the plants monitored in Berkeley, *Prunus laurocerasus* (an ornamental, broadleafed, evergreen shrub) commonly had coccinellids feeding at its foliar glands. Solitary adults of six species were observed at the glands for several weeks in April 1987. Nearby flowering cherries (*Prunus serratula*) were seen to have only one coccinellid visitor, *Psyllobora vigintimaculata* (Say), feeding at the leaf glands of one tree on one occasion, despite the copious amounts of extrafloral nectar produced by the leaves and the commonness of coccinellids in the environment. Similarly, fruit cherry trees (*Prunus avium* L.), growing in adjacent Albany, California, were not observed to have coccinellid visitors to their extrafloral nectaries. Many coccinellids, including *Adalia bipunctata,* which commonly feed on extrafloral nectar, were seen on these cherry trees feeding on aphids. Springensguth (1935) observed five coccinellid species feeding on cherry leaf extrafloral nectar in Germany. No coccinellids were seen on an ornamental "snowball" (*Viburnum opulus*) shrub for the first two months of observation, then in early June many *P. vigintimaculata* were seen feeding at the glands. *Prunus padus,* monitored in Seoul, Korea, had several *Scymnus japonicus* (Weise) feeding on the nectaries of its young leaves, daily for about two weeks in early April 1989, but not many afterwards. In Korea, the extrafloral nectaries on the inflorescences of 46 mung bean plants were observed (as a group) for two hours every week from September 20 through October 29, and then every four hours during a 24-hour period on September 20–21, 1990. Only two coccinellid individuals, one each of *Harmonia axyridis* and *Hippodamia variegata* (Goeze), were seen feeding at the extrafloral nectaries. They were on plants that had two and eight ants (*Formica fusca* L.), fewer ants than occurred on many other plants.

Only a few coccinellid species fed on extrafloral nectaries in large numbers. *Coccinella transversoguttata* Falderman fed in large numbers at the extrafloral nectaries on the newly opened leaves of quaking aspen, in Bozeman, Montana, for about one week in mid-May 1988. No aphids or other apparent food sources were present on the trees. Numerous *Harmonia axyridis* (Pallas) fed on extrafloral nectar from hybrid *Populus* leaf glands on the sucker growth and saplings growing along a canal in Seoul in mid-July 1989. Many *Hippodamia variegata* were seen feeding on nectar exuding from the outer surfaces of the flower head phyllaries of a *Serratula* sp., a thistle tribe member in the Compositae, on grasslands of Inner Mongolia, China in late July 1987. *Prunus virginiana* was observed to have *Adalia bipunctata* and *C. transversoguttata* frequently feeding on its leaf glands in early May 1988 in Bozeman, Montana.

Most coccinellids fed on extrafloral nectar where ants were either absent or less common than usual. Ant aggression was observed towards *Coccinella transversoguttata* when the beetles approached or fed at the glands of *Prunus virginiana* in Montana. The coccinellid ran away or pressed its body against the leaf or stem substrate. Aphid-tending ants have been observed to chase coccinellids from plants (McLain 1980) and have been thought to protect aphids from coccinellids (Nault and Montgomery 1976). The ant aggression exhibited towards coccinellids feeding at or approaching extrafloral nectaries may be analogous to ant protection of their homopteran honeydew resources.

Benefits to the coccinellids.—Studies on the composition of extrafloral nectar have shown that sucrose, glucose and fructose are the predominant solutes, but other sugars, amino acids, and miscellaneous organic compounds may be present in some species (Bentley 1977a). Many extrafloral nectars have all the 20 protein building amino acids, as well as a varying number of other amino acids (Baker et al. 1978, Pickett and Clark 1979, Rogers 1985, Caldwell and Gerhardt 1986).

The ten amino acids required for insect growth (Hagen et al. 1984) are usually found in extrafloral nectar. The primary benefit of feeding on extrafloral nectar appears to be the energy that sugars provide (Hagen 1962). If the amino acids were abundant enough, they could contribute to growth in coccinellid larvae and tissue maintenance in adults.

Extrafloral nectar may allow coccinellids to survive in the absence of prey (Hodek 1973). *Harmonia conformis* Boisduval (as *Leis conformis* Boisduval) uses extrafloral nectar when prey is scarce (Watson and Thompson 1933). *Coccinella undecimpunctata* (Reiche) is sustained on cotton extrafloral nectar in Egypt, during the summertime when normal foods are insufficient (Ibrahim 1955). Similarly, *Stethorus punctillum* Weise can survive for long periods on peach leaf nectar alone (Putnam 1963). Geyer (1947) increased adult longevity in *Exochomus flavipes* Thunberg from 8.6 days in the absence of food to 20.6 days with *Euphorbia ledienii* A. Berger floral nectar, which is probably nutritionally similar to extrafloral nectar.

Extrafloral nectar (and floral nectar) is probably nutritionally deficient for egg production or fat deposition (needed for egg production) (Hagen 1962). Prey or protein-rich artificial diets are nearly always necessary for egg development in predaceous ladybird beetles (Hodek 1973). *Stethorus punctillum* was unable to reproduce when fed only peach leaf nectar (Putnam 1963). The water component of extrafloral nectar could be valuable for coccinellids inhabiting deserts or other dry regions, particularly when insect prey is scarce or unavailable.

The abundance of extrafloral nectar food resources varies greatly in different plant communities. Reported percentages of cover occupied by extrafloral nectary-bearing plants include: 0.0% for four northern California communities (Keeler 1981); 0.0 to 28% for seven warm desert communities in southern California (Pemberton 1988); 7, 23, and 55% of three temperate deciduous forests in Korea (Pemberton 1990); and frequencies of 28 and 0.0% respectively for lowland and highland wet tropical communities in Jamaica (Keeler 1979).

Extrafloral nectar may well have been a food source for coccinellids since ancient times. Impressions of leaves with extrafloral nectaries and coccinellids have been found in the 35-million year old Florissant Formation of Colorado (Pemberton 1992).

Benefits to the plants.—Most (38 of 41) of the coccinellids observed to feed at extrafloral nectaries are predators of plant feeding arthropods, with various Homoptera being the most common prey. The others are two epilachinines (*Epilachna* spp.) that are plant feeders, and *Psyllobora vigintimaculata* (Say), a member of an unusual coccinelline tribe (Psylloborini) that feeds on powdery mildews (*Erisyphe* spp.). The following are summaries of the usual prey (Hodek 1973) for the coccinellid subfamilies with extrafloral nectary feeding species: Scymninae—phytophagous mites, coccids, whiteflies, mealybugs and other Homoptera; Chilocorinae—coccids, diaspine scales and aphids; Coccidulinae—coccids; Coccinellinae—aphids, also psyllids, whiteflies, coccids, immature chrysomelid beetles, and the plant pathogenic powdery mildews mentioned above for the Psylloborini; Epilachninae—phytophagous. Some coccinellids also feed on young instar larvae of Lepidoptera, Coleoptera, Hymenoptera, small nematocerous Diptera and Thysanoptera (Hodek 1973); all are prey groups in which plant feeders are dominant or common.

The ability of coccinellids to diminish the abundance of insect herbivores that feed on plants bearing extrafloral nectaries may be considerable. Whether predation is usually associated with extrafloral nectary feeding is unclear. Most of the coccinellid extrafloral nectar feeding observed in this study occurred where prey was not present or abundant. The benefit to plants may be a delayed effect. Coccinellids may be maintained on or near the plants, in the absence or scarcity of prey, by the extrafloral nectar resource. These coccinellids are then in a position to prey upon colonizing or outbreaking herbivores. *Coccinella undecimpunctata* adults, which fed on cotton extrafloral nectaries during the summer, were able to survive to produce a fall generation (Ibrahim 1955). *Coccinella transversoguttata,* which fed in large numbers at the extrafloral nectaries of quaking aspen in Montana (before aphids were apparent), were seen feeding on aphids on those same trees later in the season.

Most of our observations involved relatively few individuals seen once or only briefly. When larger numbers of coccinellids were seen feeding at the extrafloral nectaries of plants that were monitored over time (*Populus tremuloides, Prunus virginiana*), the feeding episodes were also brief. The pulses of large numbers of coccinellids feeding at the extrafloral nectaries could reduce important pests affecting the plants.

These observations suggest that coccinellid–extrafloral nectary associations are less predictable and constant than the relationships between many ants and extrafloral nectary bearing plants. Ants can be remarkably constant visitors to extrafloral nectaries, maintaining their presence throughout a plant's secretory period and regulating their densities according to the amount of nectar produced (Ruffner and Clark 1986). Korean *Formica fusca* were observed on the active extrafloral nectaries of mung bean 24 hours a day. On some plants (*Vicia angustifolia* Reichard in California), an assemblage of ant species provides a 24-hour presence at the extrafloral nectaries (unpublished data). Ants are often seen foraging at extrafloral nectaries in foggy or even rainy weather, whereas most coccinellids are usually active during the day in clear weather. Most ants have a stable and persistent presence in the habitats where they live, in contrast to coccinellids which are often quite transitory, either migrating or becoming dormant during part of the season. Most ants have a greater prey breadth than do coccinellids, many of which are specialized feeders. The predatory behavior of ants is often directly associated with extrafloral nectar feeding, which does not appear to be the case in coccinellids. In contrast to ants, coccinellids appear to be poor mutualists to plants that bear extrafloral nectaries.

One of the more interesting differences between coccinellid and ant visitors to extrafloral nectaries is their relationship to Homoptera. Many ants have mutualist interactions with Homoptera in which the ants protect aphids, scales, etc., for honeydew rewards (Way 1963). Homoptera are, as noted above, the primary prey of coccinellids. Extrafloral nectary plants particularly subject to homopteran attack could, in theory, benefit more from maintaining a coccinellid presence instead of ant-guards. The relative commonness of ants at extrafloral nectaries and their apparent protection of Homoptera from coccinellids probably precludes this kind of specialization for coccinellid-guards, even if coccinellids were more constant visitors. Not all ant species, however, can successfully protect aphids from coccinellid predation (McLain 1980). In addition, ants and coccinellids may be additive mortality factors of some insect herbivores, such as they are on the catalpa sphinx moth, the primary herbivore of the extrafloral nectary-bearing tree *Catalpa speciosa* (Stephenson 1982). Coccinellids may often contribute mortality that complements that of ants and other beneficial insects that feed on the extrafloral nectaries of plants.

The increased survival that extrafloral nectar feeding brings to coccinellids, coupled with the mobility of many lady beetles, probably results in increased coccinellid predation in the community of plants associated with extrafloral nectary-bearing species. Rogers (1985) suggested planting extrafloral nectary-bearing sunflowers in agricultural situations as a food source for nectar-feeding natural enemies (such as coccinellids). Planting sunflowers near crops, such as small grains, which are nectar poor, could increase the presence and feeding activities of natural enemies in the crops.

Gordon (1985) reported that 179 coccinellid species have been introduced to North America for biological control purposes. Most of these species have failed to establish. A better knowledge of coccinellid adult food sources, such as extrafloral nectar, and of the interactions between coccinellids and competing species such as ants, can assist in the colonization and management of these valuable insects.

ACKNOWLEDGMENTS

We thank Robert Gordon for identifying the *Scymnus* sp. from Japan and Hai Chul Park for determining the Korean coccinellids; and Robert Gordon and Hyo Suk Yu for reviewing the manuscript.

LITERATURE CITED

Adjei-Maafo, I. K. and L. T. Wilson. 1983. Factors affecting the relative abundance of arthropods on nectaried and nectariless cotton. Environmental Entomology 12: 349–352.

Baker, H. G., P. A. Opler, and I. Baker. 1978. A comparison of the amino acid complements of floral and extrafloral nectars. Botanical Gazette 139: 322–332.

Beattie, A. J. 1985. The Evolutionary Ecology of Ant–Plant Mutualisms. Cambridge University Press, Cambridge.

Bentley, B. L. 1977a. Extrafloral nectaries and protection by pugnacious bodyguards. Annual Review of Ecology and Systematics 8: 407–428.

———. 1977b. The protective function of ants visiting the extrafloral nectaries of *Bixa orellana* (Bixaceae). Journal of Ecology 65: 27–38.

Bugg, R. L., R. T. Ellis, and R. W. Carlson. 1989. Ichneumonidae (Hymenoptera) using extrafloral nectar of faba bean (*Vicia faba* L., Fabaceae) in Massachusetts. Biological Agriculture and Horticulture 6: 107–114.

Caldwell, D. L. 1981. The control and impact of *Lygus lineolaris* (P. de B.) on first-year peach scion stock in Missouri. Ph.D. dissertation, University of Missouri, Columbia; not seen, cited on p. 17 of Rogers, C. E. 1985. Extrafloral nectar, entomological implications. Bulletin of the Entomological Society of America 3: 15–20.

Caldwell, D. L. and K. O. Gerhardt. 1986. Chemical analysis of peach extrafloral nectar exudate. Phytochemistry 25: 411–413.

Elias, T. S. 1983. Extrafloral nectaries: Their structure and distribution, pp. 174–203. *In* Bentley, B. L. and T. S. Elias, eds., The Biology of Nectaries. Columbia University Press, New York.

Elias, T. S. and H. Gelband. 1975. Nectar: Its production and functions in trumpet creeper. Science 189: 289–291.

Fürsch, H. 1990. Taxonomy of Coccinellids. Coccinella 2: 4–6.

Geyer, J. W. C. 1947. A study of the biology and ecology of *Exochomus flavipes* Thunb. (Coccinellidae, Coleoptera) part 1. Journal of the Entomological Society of South Africa 9: 219–234.

Gordon, R. D. 1985. Coccinellidae (Coleoptera) of America north of Mexico. Journal of the New York Entomological Society 93: 1–912.

Hagen, K. S. 1962. Biology and ecology of predaceous Coccinellidae. Annual Review of Entomology 7: 289–326.

Hagen, K. S., R. H. Dadd, and J. Reese. 1984. The food of insects, pp. 80–112. *In* Huffaker, C. B. and R. L. Rabb, eds., Ecological Entomology. John Wiley and Sons, New York.

Hespenheide, H. A. 1985. Insect visitors to extrafloral nectaries of *Byttneria aculeata* (Sterculiaceae): Relative importance and roles. Ecological Entomology 10: 191–204.

Hetschko, A. 1908. Über den Insektenbesuch bei einigen *Vicia*-arten mit extrafloralen Nektarien. Wiener Entomologische Zeitung 27: 299–305.

Hodek, I. 1973. Biology of Coccinellidae. Dr. W. Junk Publications, The Hague.

Ibrahim, M. M. 1955. Studies on *Coccinella undecimpunctata aegyptiaca* Rche. II. Biology and life history. Bulletin Societe Entomologique d'Egypte 39: 395–423.

Janzen, D. H. 1966. Coevolution of mutualism between ants and acacias in Central America. Evolution 20: 249–275.

Keeler, K. H. 1978. Insects feeding at extrafloral nectaries of *Ipomoea carnea* (Convolvulaceae). Entomological News 89: 163–168.

———. 1979. Distribution of plants with extrafloral nectaries and ants at two elevations in Jamaica. Biotropica 11: 152–154.

———. 1981a. Function of *Mentzelia nuda* (Loasaceae) postfloral nectaries in seed defense. American Journal of Botany 68: 295–299.

———. 1981b. Cover of plants with extrafloral nectaries at four northern California sites. Madroño 28: 26–29.

———. 1985. Extrafloral nectaries on plants in communities without ants: Hawaii (USA). Oikos 44: 407–414.

Koptur, S. 1985. Alternative defenses against herbivores in *Inga* (Fabaceae: Mimosoideae) over an elevational gradient. Ecology 66: 1639–1650.

Koptur, S. and J. H. Lawton. 1988. Interactions among vetches bearing extrafloral nectaries, their biotic protective agents, and herbivores. Ecology 69: 278–283.

McLain, D. K. 1980. Relationship among ants, aphids, and coccinellids. Journal of the Georgia Entomological Society 15: 417–418.

Nault, L. R. and M. E. Montgomery. 1976. Ant-aphid association: Role of aphid alarm pheromone. Science 192: 1349–1351.

Nishida, T. 1958. Extrafloral glandular secretions, a food source for certain insects. Proceedings of the Hawaiian Entomological Society 16: 379–386.

O'Dowd, D. J. and E. A. Catchpole. 1983. Ants and extrafloral nectaries: No evidence for plant protection in *Helichrysum* spp.–ant interactions. Oecologia 59: 191–200.

Pemberton, R. W. 1988. The abundance of plant bearing extrafloral nectaries in Colorado and Mojave Desert communities of southern California. Madroño 35: 238–246.

———. 1990. The occurrence of extrafloral nectaries in Korean plants. Korean Journal of Ecology (Seoul) 13: 251–266.

———. 1992. Fossil extrafloral nectaries, evidence for the ant-guard antiherbivore defense in an Oligocene Populus. American Journal of Botany 79 (In press).

Pickett, C. H. and W. D. Clark. 1979. The function of extrafloral nectaries in *Opuntia acanthocarpa* (Cactaceae). American Journal of Botany 66: 618–625.

Putnam, W. L. 1963. Nectar of peach leaf glands as insect food. Canadian Entomologist 95: 108–109.

Rogers, C. E. 1985. Extrafloral nectar: Entomological implications. Bulletin of the Entomological Society of America 3: 15–20.

Ruffner, G. A. and W. D. Clark. 1986. Extrafloral nectar of *Ferocactus acanthodes* (Cactaceae): Composition and its importance to ants. American Journal of Botany 73: 185–189.

Schuster, M. F., M. J. Lukefahr, and F. G. Maxwell. 1976. Impact of nectariless cotton on plant bugs and natural enemies. Journal of Economic Entomology 69: 400–402.

Springensguth, W. 1935. Physiologische und ökologische Untersuchungen über extraflorale Nektarien und die sie besuchenden Insekten. Sitzungsberichte der Naturforschenden Gesellschaft zu Rostock 5(3): 31–110.

Stephenson, A. G. 1982. The role of the extrafloral nectaries of *Catalpa speciosa* in limiting herbivory and increasing fruit production. Ecology 63: 663–669.

Tempel, A. S. 1983. Bracken fern (*Pteridium aquilinum* Kuhn) and nectar-feeding ants: A non-mutualistic interaction. Ecology 64: 1411–1422.

Tilman, D. 1978. Cherries, ants and tent caterpillars: Timing of nectar production in relation to susceptibility of caterpillars to ant predation. Ecology 59: 686–692.

Trelease, W. 1881. The foliar nectar glands of *Populus*. Botanical Gazette 6: 284–290.

Watson, J. K. and W. L. Thompson. 1933. Food habits of *Leis conformis* Boisd. (Chinese lady beetle). Florida Entomologist 17: 27–29.

Way, M. J. 1963. Mutualism between ants and honeydew-producing Homoptera. Annual Review of Entomology 8: 307–344.

Willis, J. C. 1985. A Dictionary of Flowering Plants and Ferns, 8th ed. (revised by H. K. Airy Shaw). Cambridge University Press, Cambridge.

Zimmermann, J. G. 1932. Über die extrafloralen Nektarien der Angiospermen. Botanisches Centralblatt Beihefle 49: 99–196.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 152–162

THE *ANTHONOMUS CAVEI* SPECIES GROUP (COLEOPTERA: CURCULIONIDAE)

Wayne E. Clark and Horace R. Burke

(WEC) Alabama Agricultural Experiment Station, Department of Entomology, Auburn University, Alabama 36849-5413, U.S.A.; (HRB) Department of Entomology, Texas A&M University, College Station, Texas 77843, U.S.A.

Abstract.—Three new species of neotropical Anthonomini, ***A. cavei*** (El Salvador, Honduras, México, Panamá), ***A. ironia*** (Colombia) and ***A. praetextum*** (Brazil), are assigned to the *Anthonomus cavei* group. Adults, larvae and pupae of *A. cavei* were collected on *Byrsonima crassifolia* (L.) H.B.K. (Malpighiaceae), and adults of *A. praetextum* were collected on an unidentified Malpighiaceae. Characters diagnostic of the *A. cavei* group and of each of the species are described and some are illustrated. A key to the species is presented. The *A. cavei* group appears to be most closely related to the *A. furcatus* group.

Key Words: Neotropical Anthonomini, Malpighiaceae, *Byrsonima,* immature insects

The assertion "... not found in BCA ..." is part of a label on a Panamanian weevil in the collections of the U.S. National Museum of Natural History (USNM). Made with a lead pencil on folded yellow paper, the inscription is in the hand of the U.S. Department of Agriculture scientist in charge of the weevil collections at the USNM between 1929 and 1949, L. L. Buchanan. The statement alludes to the fact that the specimen represents a species that is not among the Central American Anthonomini treated in the *Biologia Centrali-Americana* (Champion 1903, 1906, 1910).

The aforementioned label also states "... *Anthonomus* of *flavirostris* group ...," but the species does not belong with the species presently assigned to the *A. flavirostris* group (Clark 1990). Nor does the species fit conveniently in any of the other previously recognized *Anthonomus* species group. Thus it is placed along with two additional, related, likewise previously undescribed species, in the *A. cavei* group.

Descriptions, illustrations, and a key to adults of these three species in the *A. cavei* group are presented in this paper. Descriptions of the larval and pupal stages of one of the species are also provided.

Materials and Methods

The 149 adult weevil specimens examined are from the collections of the following individuals and institutions (letter codens identify the collections in the text):

AUEM	Auburn University Entomological Collections, Auburn, Alabama, USA;
CNCI	Canadian National Collection of Insects and Arachnids, Ottawa, Canada;
CWOB	Collection of C. W. O'Brien, Tallahassee, Florida, USA;
DEIC	Deutsches Entomologisches Institut, Eberswalde, Germany;
DZUP	Universidade Federal do Paraná, Curitiba, Brazil;
EAPZ	Escuela Agricola Panamericana, El Zamorano, Francisco Mora-

	zán, Honduras;
HAHC	Collection of H. and A. Howden, Ottawa, Canada;
HPSC	Collection of H. P. Stockwell, Smithsonian Tropical Research Institute, Panamá;
MCZC	Museum of Comparative Zoology, Cambridge, Massachusetts, USA;
MZSP	Museu de Zoología, Universidade de São Paulo, São Paulo, Brazil;
TAMU	Texas A&M University, College Station, Texas, USA;
USNM	National Museum of Natural History, Washington, D.C., USA.

Measurements were made with an ocular micrometer in a dissecting microscope as follows: total body length from anterior margin of eye to elytral apex in lateral view; width across elytra at widest point; length of pronotum from anterior to posterior margins; length of rostrum from anteroventral margin of eye to apex, across arc, in lateral view; length of apical portion of rostrum from antennal insertion to apex in lateral view; width of frons at narrowest point between eyes; width of base of rostrum just distad of eyes in dorsal view; and width of pro- and metafemora, in anterior view, excluding inner marginal teeth. The range and, in parentheses, the mean and sample size of each measurement, are given for each species.

Exact label data are cited for types. Separate labels are indicated by brackets ([ ]), separate lines by slashes (/).

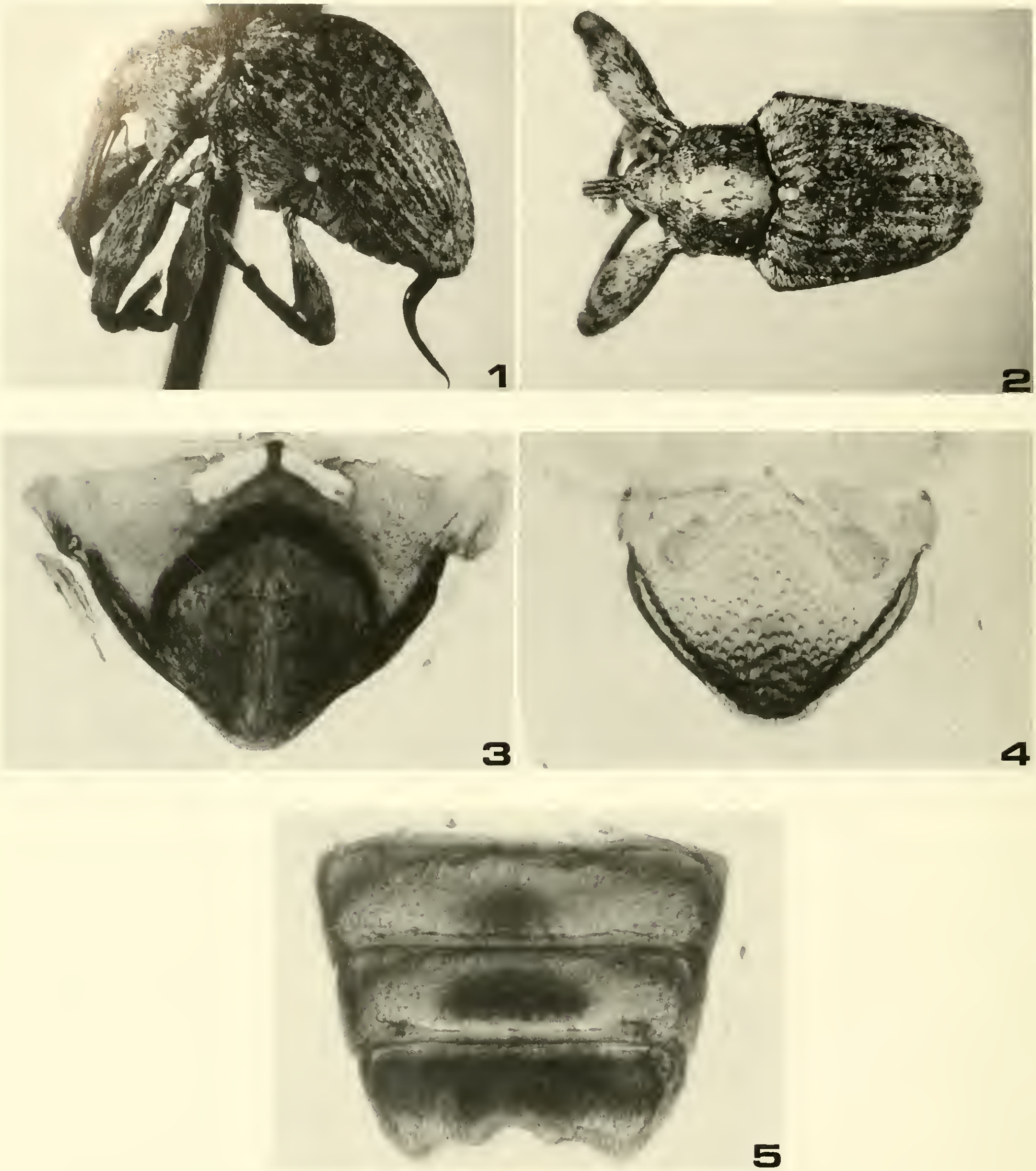
Terminology used to describe pupal characters follows Burke (1968). Terminology of larval characters is that of Anderson (1947) and Thomas (1957). Where differences in terminology exist between the latter two systems, terms used by Thomas are placed in parentheses following those of Anderson. Description of the larval stage is based on fullgrown specimens.

The *Anthonomus cavei* Species Group

Recognition characters.—The species in the *A. cavei* group have the following unique combination of characters: Elytral humeri prominent, sides converging posteriorly (Figs. 1, 2); interstriae 3 and 4 with subbasal prominences; interstria 3 with median prominence that is slightly to much higher anteriorly and especially posteriorly than in the middle; tegmen thick, with short, slender parameres; profemur enlarged, ca. 1.3–1.6× as wide as metafemur, with a large, conical, somewhat flattened, ventral tooth with a deep anterobasal emargination that produces a much smaller, slightly curved, slightly more apical tooth.

The species in the group are additionally characterized as follows:

Adult.—*Length:* 3.4–4.7 mm. *Width:* 1.7–2.4 mm. *Head:* Slightly constricted behind eyes; vertex with long, slender, attenuate, ferruginous scales and broader, intermixed, cretaceous scales; venter with slightly broader, slightly imbricated, cretaceous scales; eyes round, strongly, evenly convex, separated by distance ca. equal to 0.6 × width of rostrum at base. *Rostrum:* Strongly tricarinate; feebly curved basally, more strongly curved over antennal insertions. *Antenna:* Funiculus 7-articulate. *Prothorax:* In dorsal view, sides rounded behind subapical constriction, slightly widened at extreme base; dorsum with two, low, anteromedian prominences and two, lower, posteromedian prominences; dorsum with broad, spindle-shaped, median vitta of elongate, attenuate, imbricated, cinereous scales; lateral portions of dorsum and pleuron with elongate, attenuate, ferruginous scales and broader, cinereous scales, the latter broadest and most dense posterolaterally and in small postocular cluster. *Elytra:* Sutural interstriae slightly elevated from slightly beyond scutellum; interstriae with elongate, attenuate ferruginous scales and broader, cretaceous scales, the latter fascic-



Figs. 1–5. 1, 2, *Anthonomus cavei*, lateral and dorsal habitus, ♂, Pacora, Panamá, Panamá. 3, 4, *Anthonomus cavei* group members, pygidium, ♀, dorsal view. 3) *A. cavei*, El Zamorano, Francisco Morazán, Honduras. 4) *A. ironia*, Espinal, Tolima, Colombia. 5, *Anthonomus cavei*, abdominal sternae 3–5, ♂ holotype, ventral view.

ulate, most dense on posteromedian portions of interstriae 1–4; striae shallow, strial punctures small; strial scales absent or small. *Pygidium* (Figs. 3, 4): Male explanate apicomedially, with sparse, elongate scales replaced by setiform scales apicomedially; female slightly extended to bluntly rounded apex. *Abdomen:* Sterna 1–4 with long, attenuate, leucine scales, with broader, more pallid scales on posterolateral margins. *Legs:*

Protibia of male with preapical, inner-marginal tooth; mesotibial and metatibial mucrones of female obsolete.

Relationships.—The species in the *A. cavei* group appear to be closely related to the species in the *A. furcatus* group. Adults of the species of both groups are relatively large and have large profemora with a large ventral tooth and a smaller, more apical tooth. The armature of the endophallus is also similar in the two groups. The species in the *A. cavei* group do not have apicolateral aedeagal prominences like the ones that characterize the species in the *A. furcatus* group (Clark 1988: Figs. 23–32). They also lack the isolated posteromedian sclerite characteristic of sternum 5 of the male abdomen of members of the *A. furcatus* group (Clark 1988: Figs. 19, 20) and most of the species in the *Anthonomus* subgenus *Anthomorphus* (Clark 1987).

Plant associations.—Adults of *A. cavei* were collected on *Byrsonima crassifolia* (L.) H.B.K. (Malpighiaceae) in Honduras. Larvae, pupae and pre-emergent adults of the same species were removed from flower buds of the same plants. Adults of *A. praetextum* were collected on unidentified Malpighiaceae at Cardeal Mota, Minas Gerais, Brazil.

KEY TO SPECIES IN THE *ANTHONOMUS CAVEI* GROUP

1 Mesotibia of male with broad, subacute, median prominence on inner margin (Fig. 6); mesotibial mucro of male with long basal prominence (Fig. 6); metatibia of male with broader, more blunt, inner marginal prominence (Fig. 7); metatibial mucro of male short, truncated, emarginate, with a long, blunt, hooked basal prominence (Fig. 7); sternum 5 of male abdomen with deep apicomedian emargination (Fig. 5); aedeagus strongly sinuate in lateral view (Fig. 12); 9th sternite of male with apodeme expanded at apex, basal plates short, thick, rounded (Fig. 9); female pygidium with deep, crescent shaped, posteromedian depression (Fig. 3) . . . . *A. cavei*

1′ Mesotibia of male with slight, broadly rounded, median prominence on inner margin; mesotibial mucro of male without basal prominence; metatibia of male with inner margin nearly straight (Fig. 8); metatibial mucro of male short, slightly curved, extended parallel to long axis of tibia, without basal prominence (Fig. 8); sternum 5 of male without apicomedian emargination; aedeagus broadly, evenly curved in lateral view (Fig. 14); 9th sternite with apodeme not expanded at apex, basal plates narrowed apically (Fig. 10); female pygidium without posteromedian depression (Fig. 4) 2

2 Aedeagus symmetrical, bluntly rounded apically, subparallel-sided in dorsal view; endophallus with two large, strongly curved, basal spines with a smaller, curved spine between them and with a slender, straight, more apical sclerite (Fig. 13); profemur ca. 1.6× as wide as metafemur . . . . *A. ironia*

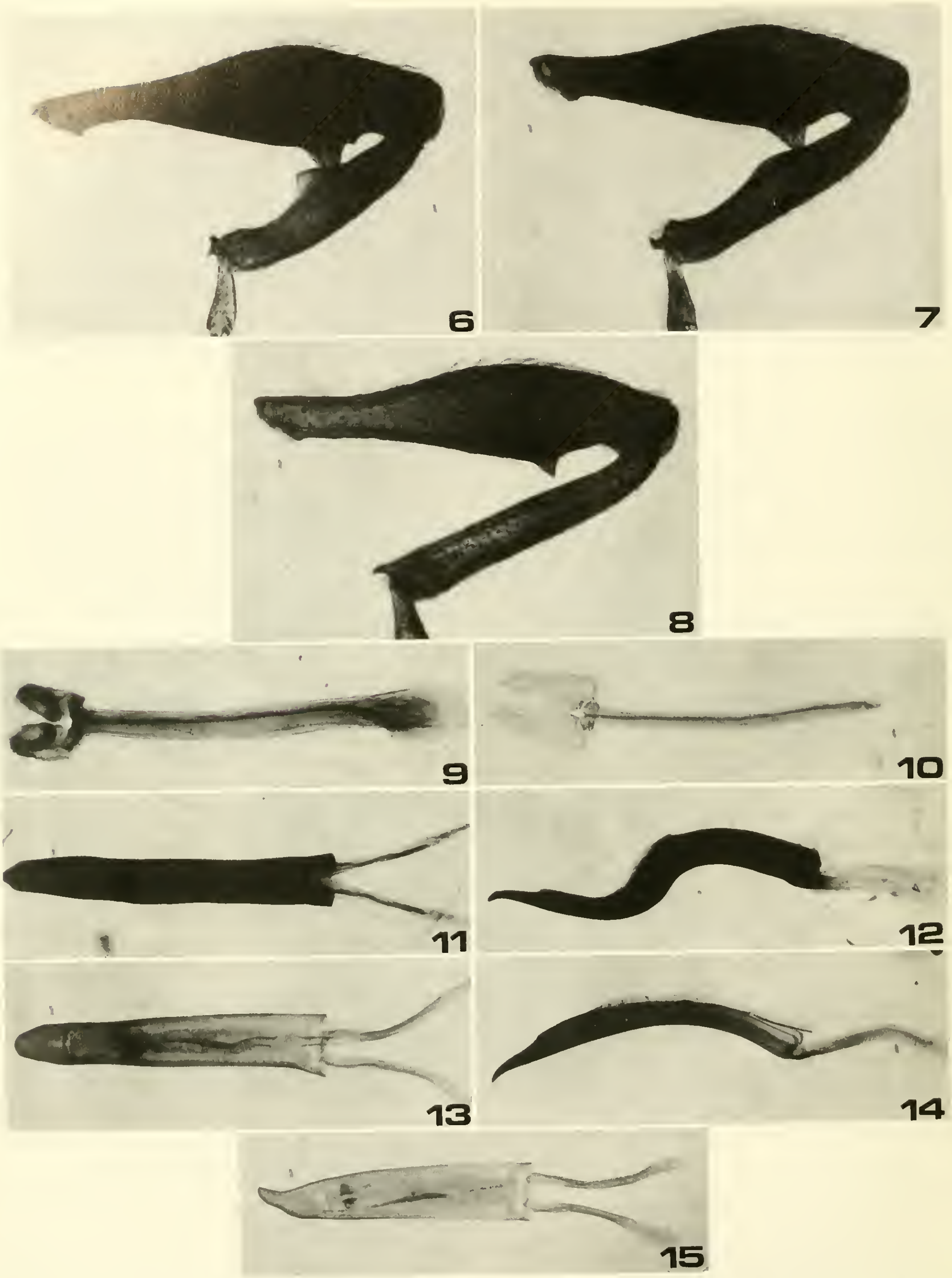
2′ Aedeagus asymmetrical in apical ⅓ in dorsal view; endophallus with two strongly curved, basal spines and with a long, slender, more apical sclerite (Fig. 15); profemur ca. 1.3× as wide as metafemur (Fig. 8) . . . . *A. praetextum*

***Anthonomus cavei* Clark, NEW SPECIES**

Figs. 1–3, 5–7, 9, 11, 12

Holotype.—HONDURAS. *Francisco Morazán:* male [Honduras: F. Mora./ El Zamorano/ 12 July, 1989/ W. E. Clark] (USNM).

Paratypes (132).—HONDURAS. *Comayagua:* [COMAYAGUA. HOND/ 0-6-79/ No 20641] [Dr. Jerome/ V. Mankins] (1 female USNM). *El Paraíso:* [Honduras: El Par./ Jacaleapa/ 20 July, 1989/ W. E. Clark] (1 male, 3 females AUEM). *Francisco Morazán:* [Honduras: F. Mora./ El Zamorano/ 12 July, 1989/ W. E. Clark] (3 males, 5 females AUEM); [Honduras: F. Mora./ El Zamorano/ 17 July, 1989/ W. E. Clark] (16 males, 7 females AUEM); [Honduras: F. Mora./ foothills e. El/ Zamorano 12 July/ 1989 W. E. Clark] (6 males, 1 female AUEM); [Honduras: F. Mora./ foothills e. El/ Zamorano 18 July/ 1989 W. E. Clark] [reared from/ flower buds] [Byrsonima/ crassifolia] (19 males, 13 females AUEM; 4 males, 4 females EAPZ; 4 males, 4 females TAMU). EL SALVADOR. *Cabañas:* [EL SALVADOR, Cab./ 3 mi. SE.



Figs. 6–15. 6, *Anthonomus cavei*, left mesothoracic leg, ♂ holotype, anterior view. 7, 8, *Anthonomus cavei* group members, metathoracic leg, ♂, anterior view. 7) *A. cavei*, holotype. 8) *A. praetextum*, holotype. 9, 10, *Anthonomus cavei* group members, ♂ 9th sternite, ventral view. 9) *A. cavei*, holotype. 10) *A. ironia*, holotype. 11–15, *Anthonomus cavei* group members, aedeagus, dorsal and lateral views. 11) *A. cavei*, holotype, dorsal view; 12) *A. cavei*, holotype, lateral view; 13) *A. ironia*, holotype, dorsal view; 14) *A. ironia*, holotype, lateral view; 15) *A. praetextum*, dorsal view.

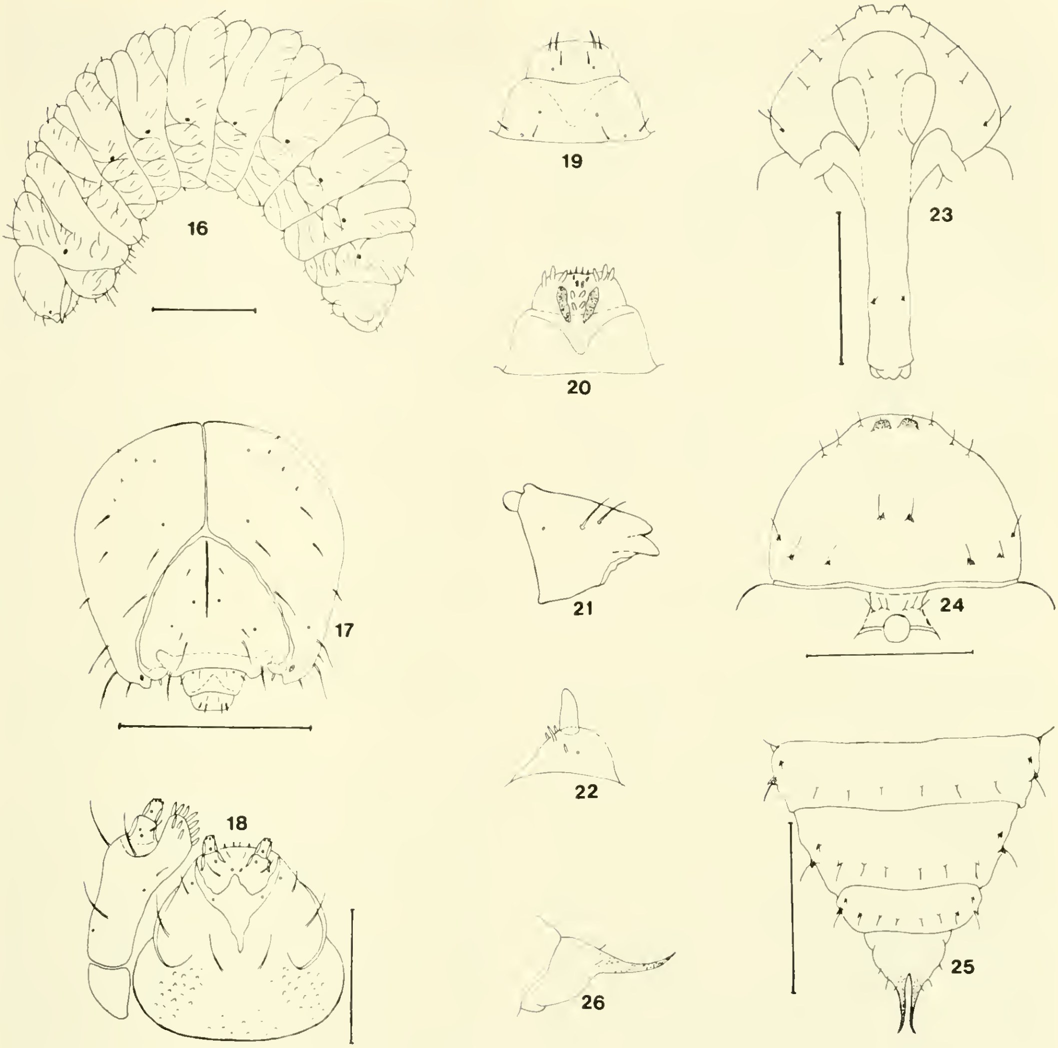
Ilobasco,/ 2100′ VI-9-1974 C&L/ O'Brien & Marshall] (1 male CWOB). *La Libertad:* [El Salvador/ 20 km./ E. La Libertad, V.3, / 1971 H. F. Howden] (11 males, 12 females HAHC). MEXICO. [337/ S] [Mex] (1 male MCZC). PANAMA. *Panamá:* [PANAMA: Panamá/ 5 mi.NW Gamboa/ 15JUL76 Y Lubin/ canopy fog] (1 male HPSC); [Pacora Panama/ II-5-45/ H. H. Stage] [Area E on sheet/ 6 hrs. after/ treatment/ 45-4519] [genus nr./ Anthonomus] (1 male USNM); [Pacora Panama/ II-6-45/ H. H. Stage] [Area C sheet/ 6 hrs. after/ treatment/ 45-4519] (2 males, 1 female USNM); [Pacora Panama/ II-6-45/ H. H. Stage] [Area E sheet/ 24 hrs. after/ treatment/ 45-4519] (1 male USNM); [Pacora Panama/ II-6-45/ H. H. Stage H-214/ 45-8914] (1 male USNM); [Pacora Panama/ II-7-45/ H. H. Stage H212/ in jungle/ 45-8914] (2 males 1 female USNM); [Pacora Panama/ II-7-45/ H. H. Stage/ Area C 24 hrs. / 45-4519] [Appar an/ Anthonomus/ of *flavirostris*/ group – not/ found in BCA/ (See. S. Amer.)] [Note/ remarkable/ ♂ med. lobe/ (mating end/ to end?)] (1 male USNM); [Pacora Panama/ II-7-45/ H. H. Stage/ Area C 24 hrs./ 45-4519] (4 females USNM); [Pacora Panama/ II-9-45/ H. H. Stage] [Nr. Trap B-4/ on sheet/ 45-4519] [Nr. Trap B4/ 2-9-45/ on sheet] (1 female USNM).

Recognition characters (Figs. 1, 2).—*Anthonomus cavei* is distinguished from the other two species in the *A. cavei* group by the characters of the meso- and metatibia of the male, sternum 5 of the male abdomen, the aedeagus and 9th sternite of the male genitalia, and of the female pygidium listed in the key to the species of the group.

Adult male.—*Length:* 4.2–4.7 mm (mean = 4.5, n = 10). *Width:* 2.1–2.3 mm (mean = 2.2, n = 10). *Rostrum:* Length 1.4–1.6 (mean = 1.5, n = 10) × pronotal length; length of apical portion 21–26% (mean = 23, n = 10) of total rostral length. *Abdomen* (Fig. 5): Sternum 5 flattened and sparsely setose medially, with deep apicomedian emargination. *Legs* (Figs. 6, 7): Profemur ca. 1.3× as wide as metafemur; protibia with slight inner marginal prominence in apical ⅔; protibial uncus long, nearly straight, with slight basal prominence; mesotibia with broad, subacute, median prominence on inner margin, mesotibial mucro short, with long basal prominence; metatibia with broader, more blunt, inner marginal prominence; metatibial mucro short, truncated, emarginate, with a long, blunt, hooked basal prominence. *Genitalia* (Figs. 9, 11, 12): 9th sternite with apodeme expanded at apex, basal plates short, thick, rounded; aedeagus subparallel-sided in dorsal view, with slight, obtuse, subapicolateral prominences, strongly sinuate in lateral view; endophallus with two strongly curved basal spines, a slender, slightly curved sclerite between them and with a slender, straight, more apical sclerite.

Adult female.—*Length:* 4.1–4.6 mm (mean = 4.2, n = 10). *Width:* 1.8–2.4 mm (mean = 2.2, n = 10). *Rostrum:* Length 1.3–1.5 (mean = 1.4, n = 10) × pronotal length; length of apical portion 26–31% (mean = 27, n = 10) of total rostral length. *Pygidium* (Fig. 3): With deep, crescent shaped, posteromedian depression. *Legs:* Protibial uncus short, slender, without basal prominence.

Larva.—*Body* (Fig. 16): Strongly curved; length 2.6–4.9 mm (measured across arc of body). Asperities minute, varying from rounded to somewhat acutely pointed, fairly evenly distributed over body. Setae pale, inconspicuous. Color dingy white; pronotum not pigmented. *Head* (Fig. 17): Color amber. Broadly rounded posteriorly with sides becoming less rounded anteriorly. Width 0.67–0.77 mm (n = 30). *Antenna* (Fig. 22): Basal article bearing elongate-oval appendage and four short, stout setae, one of which is longer than others. *Endocarina* (endocarinal line): Distinct, extending slightly past middle of frons. *Epicranial suture* (coronal suture): Slightly less than ½ length of head capsule. *Frontal setae:* Four pairs; setae 1 and 3 short, seta 3 located dorsad and slightly laterad of 4; setae 4 and 5 approximately equal in length, distinctly longer than 1 and 3. *Frontal sensilla:* Two pairs; one pair located approximately equidistant from setae 1 and 3, other pair laterad and slightly dorsad of seta 3. *Dorsal epicranial setae:* Five pairs; setae 1, 4 and 5 slender, long; seta 2 longer than 3, both distinctly shorter than other dorsal epicranial setae; seta 4 located close to frontal suture. *Posterior epicranial setae:* Four pairs; minute, peglike arranged in strongly curved line; lower seta of series located above and slightly mesad of dorsal epicranial seta 2. *Dorsal epicranial sensilla:* Three pairs; one pair located between innermost posterior epicranial setae; one pair directly above dorsal epicranial setae 1; one pair approximately midway between dorsal epicranial setae 4 and 5. *Lateral epicranial seta:* 1, ca. length of lateral epicranial seta 2. *Ventral epicranial seta:* 1, slightly shorter than ventral epicranial seta 2. *Clypeal setae* (Fig. 19): Ca. same length, seta 1 located closer to anterior margin of frons than 2. *Clypeal sensilla:* Two pairs; one pair located ca. equidistant between clypeal setae 1 and 2; one pair located in front of setae 1. *Labral setae:* Three pairs; setae 1 and 2 ca. same length; seta 3 shorter. One pair of sensilla located laterad of labral setae 1. *Epipharynx* (Fig. 20) (epipharyngeal lining): Bearing two pairs of anteromedian setae. Three pairs of stout anterolateral setae present. *Labral rods* (tormae): Elongate, converging posteriorly. *Epipharyngeal sensory pores:* Four, arranged in two clusters of two pores each. Two pairs of stout median epipharyngeal spines present between labral rods. *Mandibles* (Fig. 21): Each with two bluntly to fairly sharply pointed teeth; two long setae ca. same length; one sensillum located near base of mandible. *Maxillary palpus* (Fig. 18): With apical article ca. same length as basal article; bearing several minute papillae at apex; sensillum located near middle. Basal article bearing seta of moderate length and two sensilla. *Stipital setae:* 1, 3 and 4 long, ca. equal in length; seta 2 much shorter. *Mala* (lacinial lobe): Bearing 10 stout setae, seven dorsal (dorsal lacinial) and three ventral (ventral lacinial). *Labial palpus* (Fig. 18): Consists of two articles; apical article bears several minute papillae and a sensillum. Basal article bears two sensilla. *Premental sclerite:* With moderately long posterior process and pair of sensilla near bases of lateral arms. One pair of long premental (prelabial) setae present. Three pairs of glossal setae, posteriormost pair slightly longer. Three pairs of postmental setae, setae 1 and 2 subequal in length, seta 3 much shorter. *Thorax* (Fig. 16) (setae described on one side of body only): Pronotum bearing eight long setae. One prodorsal and five postdorsal setae present on each of meso- and metathorax; postdorsal setae 2 and 4 shorter than setae 1, 3 and 5. Two spiracular (alar) setae of unequal length present. Epipleural (dorsopleural) lobe bearing one long seta. Two pleural (ventropleural) setae of unequal length on prothorax; one long seta on each of meso- and metathorax. Three long pedal (laterosternal) setae, one of which is much longer than others. Sternal (mediosternal) seta short, inconspicuous. *Abdomen* (Fig. 16): Abdominal segments 1–7 with three distinct dorsal folds. Prodorsum (fold I) of segments 1–8 each with short seta. Five postdorsal (fold III) setae on each of segments 1–8; setae 1, 3 and 5 longer than setae 2 and 4. Two spiracular (alar) setae; one seta distinctly longer than other. Epipleurum (dorsopleurum) bearing one long and one short seta. One short pleural (ventropleural) seta. Two minute pedal setae. Anus subterminal; surrounded by four lobes, each bearing a minute seta; anterior and posterior lobes prominent, lateral lobes narrow and inconspicuous. Segment 9 bearing prominent lateral lobe and eight short setae. Spiracles bicameral; air tubes each with four or five annuli. (Thirty specimens from the foothills east of El Zamorano, Francisco Morazán, Honduras, extracted from flower buds of *Byrsonima crassifolia,* 18 July, 1989, by W. E. Clark (TAMU); identified by association with adults.)



Figs. 16–26. 16–22, Third instar larva of *Anthonomus cavei.* 16) lateral view; 17) head capsule, frontal view; 18) labium and right maxilla, ventral view; 19) clypeus and labrum; 20) epipharynx; 21) mandible; 22) antenna. Line accompanying Fig. 16 = 1.0 mm; Fig. 17 = 0.5 mm; Fig. 18 = 0.25 mm; other larval figures greatly enlarged. 23–26, Pupa of *Anthonomus cavei.* 23) head, rostrum and ventral view of prothorax; 24) pronotum and mesonotum, dorsal view; 25) terminal abdominal segments, dorsal view; 26) 9th abdominal segment, lateral view. Lines accompanying Figs. 23, 24 and 25 = 1.0 mm; Fig. 26 greatly enlarged.

Pupa.—*Length:* 4.4–5.6 mm (n = 7). *Head* (Fig. 23): Frontal setae inconspicuous, straight, each borne on summit of low, rounded tubercle; pair separated by distance 2× length of a seta. Supraorbital setae absent. One pair of fine, straight basisrostral (interocular) setae; each approximately same length as frontal seta; each borne on small tubercle. One pair of distirostral setae; each seta short, inconspicuous, ca. same length as sharply pointed tubercle on which it is borne. *Pronotum* (Fig. 24): Pronotal setae fine, straight to slightly curved; setae on anterior margin slightly shorter than on posterior margin. Anteromedian setae minute, each borne on anterior face of transverse, truncate tubercle; tubercles separated by distance less than width of a tubercle. Three pairs of anterolateral setae; each borne on summit of low, rounded tubercle; tubercles usually ca. equidistant from each other. Posteromedian setae each borne on side of sharply pointed tubercle; tubercles separated by distance equal to length of a seta. Three pairs of posterolateral setae arranged in moderately strongly curved line on each side of pronotum; each seta borne subapically on sharply pointed tubercle. *Mesonotum* (Fig. 24): Three pairs of straight mesonotal setae; each borne on summit of low, rounded tubercle; outer seta slightly longer than others. *Metanotum:* Three pairs of straight metanotal setae; each borne on low tubercle; setae increasing in length outward; more widely separated than mesonotals. *Abdomen* (Fig. 25): Three pairs of pale, inconspicuous discotergal setae; each borne on summit of small, rounded tubercle except outer seta on tergites 6–8 which arises from side of sharply pointed tubercle. Laterotergal seta 1 short, not longer than sharply pointed tubercle on which it is borne. Laterotergal seta 2 located subapically on sharply pointed tubercle; on basal tergites tubercle occasionally without sharp point. Spiracles well developed on first five abdominal segments, absent on others. Laterosternal and sublaterosternal setae absent. Segment 9 bearing pair of slender, pigmented, sharply pointed processes which curve upward near apex (Fig. 26); one pair of fine setae borne laterally on segment anteriorly to bases of processes: two pairs of setae on bases of processes, one pair of which is located dorsally. (Seven specimens from the foothills east of El Zamorano, Francisco Morazán, Honduras, extracted from flower buds of *Byrsonima crassifolia,* 18 July, 1989, by W. E. Clark (TAMU); identified by association with adults.)

Plant associations.—The paratypes of *A. cavei* from the foothills east of El Zamorano, Honduras, were collected on *Byrsonima crassifolia* (L.) H.B.K. Most of these adults were collected with a beating sheet, but larvae and pupae were extracted from flower buds taken from the same trees on 18 July, 1989, and adults emerged from some of these buds on each of the following several days. Infested buds remain attached to the inflorescence, secured by what is apparently a larval secretion.

Distribution.—*Anthonomus cavei* is known only from the type series from El Salvador (*Cabañas, La Libertad*), Honduras (*Comayagua, Francisco Morazán*), México (locality unspecified), and Panamá (*Panamá*).

Observations.—An inscription in the hand of L. L. Buchanan on a label on one of the paratypes of *A. cavei* from Panama states "Note remarkable ♂ med. lobe (mating end/ to end?)." This refers to the unusual sinuate shape of the aedeagus (Figs. 1, 12). When extruded, as it is in several of the paratypes (Fig. 1), the apical ½ of the aedeagus projects posteriorly, parallel to the long axis of the body of the insect, instead of downward at roughly a right angle, as in the other two species in the *A. cavei* group and in Anthonomini in general.

The elytral elevations exhibit individual, sexual, and geographic variation. The length and height of the median elevation on interstria 3 varies geographically. Specimens from Panamá have this much longer and higher than do specimens from El Salvador, whereas length and height is intermediate in the specimens from Honduras. In the Panamanian males, and to a lesser extent, the males from Honduras, there is also a tendency for the anterior and especially the posterior ends of these prominences to be higher than the middle portions. This is evident in all of the females, even in the ones from El Salvador, but is markedly pronounced in the Panamanian specimens in which the posterior portion is very high. In the Panamanian specimens, and to a lesser extent in the Honduran ones, interstria 5 has a slight, elongate, elevated section, and interstriae 3 and 5 have variously elevated apical sections.

Etymological note.—This species is

named for Ronald D. Cave in appreciation for his assistance in collecting the holotype and many of the paratypes.

Anthonomus ironia Clark, New Species

Figs. 4, 10, 13, 14

Holotype.—COLOMBIA. *Tolima:* male [Colombia: Tolima/ Espinal/ 18 June 1982/ Clark and Cave] (USNM).

Paratypes (2).—COLOMBIA. *Tolima:* [Colombia: Tolima/ Espinal/ 18 June 1982/ Clark and Cave] (2 females AUEM).

Recognition characters.—*Anthonomus ironia* is distinguished from *A. cavei* by the characters of the meso- and metatibia of the male, sternum 5 of the male abdomen, the aedeagus and 9th sternite of the male genitalia, and of the female pygidium listed in the key to the species of the group. It is distinguished from *A. praetextum* by the characters of the profemur and male genitalia listed in the key.

Adult male.—*Length:* 3.7 mm (n = 10). *Width:* 1.8 (n = 10). *Rostrum:* Length 1.4 (n = 1) × pronotal length; length of apical portion 25 (n = 1) of total rostral length. *Abdomen:* Sternum 5 not flattened medially, without apicomedian emargination. *Legs:* Profemur ca. 1.6× as wide as metafemur; protibia without significant inner marginal prominence; protibial uncus short, slightly curved, without basal prominence; mesotibia with slight, broad, median, inner marginal prominence; mesotibial mucro slender, without basal prominence; metatibia with inner margin nearly straight; metatibial mucro short, slightly curved, extended parallel to long axis of tibia, without basal prominence. *Genitalia* (Figs. 10, 13, 14): 9th sternite with apodeme not expanded at apex, basal plates narrowed apically; aedeagus symmetrical, bluntly rounded apically, subparallel-sided in dorsal view, broadly, evenly curved in lateral view; endophallus with two large, strongly curved, basal spines with a smaller, curved spine between them and with a slender, straight, more apical sclerite.

Adult female.—*Length:* 3.7–3.8 mm (mean = 3.8, n = 2). *Width:* 1.8–1.9 mm (mean = 1.9, n = 2). *Rostrum:* Length 1.4–1.5 (mean = 1.4, n = 2) × pronotal length; length of apical portion 27–34% (mean = 31, n = 2) of total rostral length. *Pygidium* (Fig. 4): Without posteromedian depression.

Plant associations.—Unknown.

Distribution.—*Anthonomus ironia* is known only from the type series from Colombia (*Tolima*).

Etymological note.—The specific epithet is a Latin noun meaning the saying of one thing but meaning the opposite.

Anthonomus praetextum Clark, New Species

Figs. 8, 15

Holotype.—BRAZIL. *Goiás:* male [Cristalina 1200m/ GOIAS, BRASIL/ Bordon 16 XI 83] (DZUP).

Paratypes (12).—BRAZIL. *Distrito Federal:* [BRAZIL, DF, 1000m/ Parque Nacional/ III-II-1970, JM/ & BA Campbell] (1 male CNCI). *Goiás:* [Aragarças/ Goiás – Brasil/ 12.IV.1953/ Sick Col.] (1 female MZSP); [BRESIL/ GOYAZ – JATAHY/ coll. A. Hust.] [Hustache det.] [COTYPUS] [Anthonomus/ triangulipennis/ m./ cotype] [Dtsch. Entomol./ Institut Berlin] [Coll. DEI/ Eberswalde] [A./ triangulipennis/ Hust.] (1 male DEIC). *Minas Gerais:* [BRAZIL: M. G./ Cardeal Mota/ 17 Sept. 1985/ Clark & Martíns] (2 males, 6 females AUEM). *Pernambuco:* [Col on/ Cotton] [Bonito Prov./ Pernambuco/ Brazil. 17.I.82] (1 female USNM).

Recognition characters.—*Anthonomus praetextum* is distinguished from *A. cavei* by the characters of the meso- and metatibia of the male, sternum 5 of the male abdomen, the aedeagus and 9th sternite of the male genitalia, and of the female pygidium listed in the key to the species of the group. It is distinguished from *A. ironia* by the characters of the profemur and male genitalia listed in the key.

Adult male.—*Length:* 3.6–3.8 mm (mean = 3.7, n = 5). *Width:* 1.7–1.8 mm (mean = 1.8, n = 5). *Rostrum:* Length 1.4–1.5 (mean = 1.5, n = 5) × pronotal length; length of apical portion 26–31% (mean = 29, n = 5) of total rostral length. *Abdomen:* Sternum 5 not flattened medially, without apicomedian emargination. *Legs* (Fig. 8): Profemur ca. 1.3× as wide as metafemur; protibia without significant inner marginal prominence; protibial uncus short, slightly curved, without basal prominence; mesotibia with slight, broad, median, inner marginal prominence; mesotibial mucro slender, without basal prominence; metatibia with inner margin nearly straight; metatibial mucro short, slightly curved, extended parallel to long axis of tibia, without basal prominence. *Genitalia* (Fig. 15): 9th sternite with apodeme not expanded at apex, basal plates narrowed apically; aedeagus asymmetrical in apical ⅓ in dorsal view, broadly, evenly curved in lateral view; endophallus with two strongly curved, basal spines and with a long, slender, more apical sclerite.

Adult female.—*Length:* 3.4–3.8 mm (mean = 3.7, n = 7). *Width:* 1.7–1.9 mm (mean = 1.8, n = 7). *Rostrum:* Length 1.4–1.6 (mean = 1.5, n = 7) × pronotal length; length of apical portion 28–31% (mean = 30, n = 7) of total rostral length. *Pygidium:* Without posteromedian depression.

Plant associations.—The paratypes of *A. praetextum* collected at Cardeal Mota, Minas Gerais, Brazil, were on unidentified Malpighiaceae.

Distribution.—*Anthonomus praetextum* is known only from the type series from Brazil (*Distrito Federal, Goiás, Pernambuco*).

Etymological note.—The specific epithet is a Latin noun meaning a pretext or excuse. The name listed on the paratype bearing the "cotype" label is a *nomen nudum.*

ACKNOWLEDGMENTS

Thanks are extended to the individuals and institutions listed in the Materials and Methods section for loans of specimens. Antonio Molina A. identified some of the host plants. James Cane provided a critical review of the manuscript which is published as Alabama Agricultural Experiment Station Journal Series No. 17-923283.

LITERATURE CITED

Anderson, W. H. 1947. A terminology of the anatomical characters useful in the taxonomy of weevil larvae. Proceedings of the Entomological Society of Washington 49: 123–132.

Burke, H. R. 1968. Pupae of the weevil tribe Anthonomini (Coleoptera: Curculionidae). Technical Monograph 5, Texas Agricultural Experiment Station, 92 pp.

Champion, G. C. 1903. Insecta. Coleoptera. Rhynchophora. Curculionidae. Curculionoidea. Curculioninae (part), vol. 4, pt. 4, pp. 145–312. *In* Godman, F. D. and O. Salvin, eds., 1879–1911. Biologia Centrali-Americana, Insecta, Coleoptera, 7 volumes in 17 parts. London, Dulau.

———. 1906. Insecta. Coleoptera. Rhynchophora. Curculionidae. Curculionoidea. Curculioninae (part), vol. 4, pt. 4, pp. 601–750. *In* Godman, F. D. and O. Salvin, eds., 1879–1911. Biologia Centrali-Americana, Insecta, Coleoptera, 7 volumes in 17 parts. London, Dulau.

———. 1910. Insecta. Coleoptera. Rhynchophora. Curculionidae. Curculioninae (concluded) and Calandrinae, vol. 4, pt. 7, pp. 79–221. *In* Godman, F. D. and O. Salvin, eds., 1879–1911. Biologia Centrali-Americana, Insecta, Coleoptera, 7 volumes in 17 parts. London, Dulau.

Clark, W. E. 1987. Revision of the *Anthonomus* subgenus *Anthomorphus* Weise (Coleoptera: Curculionidae). Quaestiones Entomologicae 23: 317–364.

———. 1988. Revision of the *furcatus* species group of the weevil genus *Anthonomus* Germar (Coleoptera: Curculionidae). Coleopterists' Bulletin 42(4): 359–377.

———. 1990. Revision of the *flavirostris* species group of the genus *Anthonomus* Germar (Coleoptera: Curculionidae). Transactions of the American Entomological Society 116(1): 261–294.

Thomas, J. B. 1957. The use of larval anatomy in the study of bark beetles (Coleoptera: Scolytidae). The Canadian Entomologist 89, Supplement 5, 45 pp.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 163–164

TWO BIOTYPES OF *BANGASTERNUS ORIENTALIS* (COLEOPTERA: CURCULIONIDAE) FOUND IN GREECE

R. SOBHIAN

European Biological Control Laboratory, USDA–ARS, BP 4168 Agropolis, 34092 Montpellier, Cedex 5, France.

Abstract.—Adults of *Bangasternus orientalis* (Capiomont) were collected on *Centaurea calcitrapa* L., purple starthistle (PST) and *C. solstitialis* L., yellow starthistle (YST) in Greece. The adults collected on YST did not breed on PST and the adults collected on PST did not breed on YST, indicating that they are two biotypes, each one specialized on one *Centaurea* species.

Key Words: Weeds, *Centaurea*, starthistle, Insecta, Curculionidae, weevils

Adults of *Bangasternus orientalis* (Capiomont) were collected on *Centaurea calcitrapa* L., purple starthistle (PST), on June 26, 1982, 44 km south of Igoumenitsa, along the road to Preveza, Greece. Two males and two females were placed on branches of *Centaurea solstitialis* L., yellow starthistle (YST), in a sleeve cage of about 20 × 50 cm at the University Farm, Thessaloniki. The weevils lived for over one month on the plant without ovipositing. Specimens were also collected on YST during May and June 1981–1982, in Thermi, 8 km south of Thessaloniki and oviposited on YST under the same conditions. All of the specimens were identified by the late D. R. Whitehead (Systematic Entomology Laboratory, Washington, D.C.) and by E. Colonnelli (University of Rome) as *B. orientalis.* There was, however, an indication that there were different biotypes or perhaps subspecies which could not be identified on the basis of morphological characters.

A more detailed study was carried out during 1991 in Greece to determine the host specificity and oviposition of *B. orientalis* on YST and PST. Rosettes of YST and PST were collected from the area near Thessaloniki and were planted at the University Farm on March 23. Three field cages (1 × 1 × 1 m) were placed over the plants on May 15 to prevent the attack of capitulum-feeding insects. Five YST plants were planted under one cage and three PST plants under each of the other cages. Ten male and ten female weevils were field collected on YST plants on May 31 and released in one of the cages with the PST plants. Twenty males and twenty females were collected on PST plants on May 31 (at the beginning of their oviposition period); of these, ten males and ten females were released in the cage with YST plants and ten males and ten females were released in the other cage with PST plants (control). Females were field collected at the beginning of the season and when used in a longevity test, they lived up to 118 days and females laid eggs for up to 95 days. Therefore, there was no risk of females having laid all their eggs in the field, before they were collected (Sobhian et al. 1992). All of the adults were collected near Thermi. No *B. orientalis* from YST were caged on YST as a control because from previous studies it was known that they would breed on YST under similar condi-

Table 1. Susceptibility of YST and PST as hosts for *Bangasternus orientalis* collected on YST or PST

	Adults Collected on YST and Caged on PST	Adults Collected on PST and Caged on YST and PST	
	PST	YST	PST (control)
No. larvae	0	0	15
No. pupae	0	0	2
No. adults	0	0	4

tions (Sobhian et al. 1992). Samples of seedheads of YST and PST test plants were collected on August 1, and dissected under a stereomicroscope (n = 150/cage). The results are summarized in Table 1. Adults collected on YST did not breed on PST and adults collected on PST did not breed on YST, however adults collected on PST bred on the control plants. The experiment carried out during 1991 confirmed the results that were obtained during 1982.

Following the definition suggested by Diehl and Bush (1984), there appear to be two biotypes of *B. orientalis* in Greece. Diehl and Bush defined biotypes as conspecific populations which differ in some biological trait. As Zwoelfer and Romstoeck-Voelkl (1991) noted, biotypes have important implications for the biological control of insect pests and weeds as well as for pest management.

A host race study using electrophoresis is planned to determine the enzymatic differences between these weevils. It is also planned to carry out a cross-mating study between the two biotypes to determine if they produce fertile eggs.

ACKNOWLEDGMENTS

I wish to thank J. Pakaluk (SEL, Washington, D.C.), L. Knutson, A. Kirk, and L. Fornasari (USDA–ARS, Montpellier, France) for reviewing the manuscript.

REFERENCES

Diehl, S. L. and G. L. Bush. 1984. An evolutionary and applied perspective of insect biotypes. Annual Review of Entomology 29: 471–504.

Sobhian, R., G. Campobasso, and P. H. Dunn. 1992. Contribution to the biology of *Bangasternus orientalis* Capiomont (Col., Curculionidae). Journal of Applied Entomology 113: 93–102.

Zwoelfer, H. and M. Romstoeck-Voelkl. 1991. Pp. 487–507 *in* Price, Peter W., et al., eds., Plant–Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions. John Wiley & Sons, New York.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 165–174

HIPPELATES FLIES (DIPTERA: CHLOROPIDAE) POSSIBLY ASSOCIATED WITH BRAZILIAN PURPURIC FEVER

CELUTA H. PAGANELLI AND CURTIS W. SABROSKY

(CHP) Paganelli Consultoria Ambiental S/C Ltda., Rua Nazaré Paulista 163/114 E, 05448 São Paulo, SP, Brazil; (CWS) Cooperating Scientist, Systematic Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C. 20560, U.S.A. Present address: 205 Medford Leas, Medford, New Jersey 08055, U.S.A.

Abstract.—Five new Brazilian species of *Hippelates* are described: ***H. neoproboscideus*, H. carrerai, H. parvicalcar, H. pseudodorsalis**, and ***H. coxipo.*** These and four species of *Liohippelates* are included in a key to possible vectors of an acute conjuctivitis that is a precursor of Brazilian Purpuric Fever.

Key Words: Taxonomy, Diptera, Chloropidae, *Hippelates, Liohippelates, Olcanabates,* eye gnats, Brazilian Purpuric Fever, *Haemophilus,* bacteria, conjunctivitis

In 1990–91 an outbreak of Brazilian Purpuric Fever (BPF) occurred in the states of Mato Grosso, Mato Grosso do Sul, and interior São Paulo. The fever, highly fatal to young children, was caused by a virulent invasor clone of the bacterium *Haemophilus influenzae* biogroup *aegyptius* (Hae), which initially produced an acute conjunctivitis that was followed by a high fever and the characteristic pupura or rash, after which vital organs were attacked. In children 3 months to 9 years of age, as little as four hours would elapse from the time the purpura appeared until death ensued. For general information on this new disease (the first case was recorded in 1984), see Harrison et al. (1989) and Brazilian Purpuric Fever Study Group (1992).

The obvious presence of numerous eye gnats around the eyes and the association of these flies with conjunctivitis, as recorded in various parts of the Western Hemisphere, directed attention to them as potential vectors in the affected states of Brazil. Flies were collected by sweeping in places where BPF cases were registered and in other places without registered cases but treated as part of a case-control study. All chloropid genera already known to be attracted to and feeding on eye secretions were found during this study, i.e. *Hippelates* and *Liohippelates* in abundance, *Siphunculina* rarely. The following species were present in collections from Mato Grosso: Five new species of *Hippelates* herein described, *Liohippelates currani* (Aldrich), *L. flavipes* (Loew), *L. peruanus* (Becker), *L.* sp. (*pusio* complex), and *Siphunculina striolata* (Wiedemann). Among these, *L. currani* and *L. peruanus* were most common in urban areas, and *Hippelates neoproboscideus,* n. sp., most frequent in rural areas. In the northwest of São Paulo State, only *L. flavipes, L. peruanus,* and *H. parvicalcar,* n. sp., were collected.

These gnats, all previously classified in the genus *Hippelates,* are characteristically attracted to animal fluids, whether from various body openings, sores, or wounds. 'Eye gnats' is a commonly used term, but not all species of the group are attracted to the eyes, e.g. yaws flies feed at sores on the lower limbs.

Knowing that some of these gnats are not attracted to eyes, some collections were made by aspirator around children's eyes in order to determine which species occurred there. These would be likely vectors of conjunctivitis and BPF in Brazil. In those eye collections, only *L. currani, L. peruanus,* and two new species, *H. neoproboscideus* and *H. parvicalcar,* were present. The BPF clone was also isolated from a macerate of *L. peruanus* and *H. neoproboscideus* collected from children's eyes in Mato Grosso (Tondella et al. 1991), which further shows that at least one or both species are possible vectors of this disease.

Five new species of the genus *Hippelates* Loew were found, some in abundance, and these are described here so that they may be properly recorded in subsequent reports on the study of the disease. The key includes these and four species of *Liohippelates* Duda, three of which were numerous in the collections made during surveys for possible vectors of *Haemophilus.* There are no reliable published keys to the Neotropical species of either genus of flies, and the present study is part of our on-going revision of the species of the group for the entire Western Hemisphere. The nearly 60 known species were catalogued by Sabrosky and Paganelli (1984), including four then recognized in *Olcanabates* Enderlein (see remarks under *H. parvicalcar,* n. sp.).

The terminology follows that of McAlpine (1981) in the *Manual of Nearctic Diptera,* except that we follow traditional usage in acalyptrate Diptera: 3rd antennal segment instead of first flagellomere, humeral callus instead of postpronotum, and mesopleuron and sternopleuron instead of anepisternum and katepisternum; also microtomentose instead of pruinose.

The following characteristics are present in all the new species of *Hippelates* described in this paper: Epandrium well developed, compared to the small size of the hypandrium which is small, narrow and completely closed; cerci distinctly separated from each other, well developed, in some species very long with a few setae; surstyli with many long internal setae (cf. Fig. 10a); gonopods (pregonites) fused with the phallapodic sclerite; parameres (postgonites) convergent, with a few setae; basiphallus cylindrical, elongate; distiphallus long, membranous.

For brevity in listing localities, we have used the present standard abbreviations for the Brazilian states, as follows:

MG	Minas Gerais
MT	Mato Grosso
PA	Pará
PE	Pernambuco
PR	Paraná
RJ	Rio de Janeiro
SC	Santa Catarina
SP	São Paulo

The notation (BPF Group) on labeled specimens refers to about six collectors in various combinations at different times and places.

Holotypes, allotypes, and paratypes of the new species will be deposited in the Museu de Zoologia, Universidade de São Paulo. Paratypes when available will be deposited in the natural history museums in Washington, D.C.; London, England; Ottawa, Canada; San Francisco, California; and Berlin, Germany.

KEY TO SPECIES OF *HIPPELATES* AND *LIOHIPPELATES* POSSIBLY ASSOCIATED WITH BRAZILIAN PURPURIC FEVER

1. Frontal triangle and dorsum of thorax dull, densely gray microtomentose, the triangle in some species with glossy black spots (*Hippelates*) 2
– Frontal triangle and dorsum of thorax highly shining, smooth and glossy black except as interrupted by punctures (*Liohippelates*) 6
2. Thorax entirely black in ground color; frontal triangle with three glossy black spots, the median usually large and long, occasionally narrow 3
– Thorax chiefly black in ground color, but humeral calli and scutellum entirely or partly red-

dish yellow; frontal triangle gray, at most with tiny glossy area by each ocellus 4

3. Spur on hind tibia only slightly preapical, and its apex at ¾ length of first tersomere (Fig. 1) .... 1. ***H. neoproboscideus***, n. sp.
– Spur on hind tibia decidedly preapical, strongly curved and at or little beyond half length of first tarsomere (Fig. 2) ..... 2. ***H. carrerai***, n. sp.
4. Spur on hind tibia long, length greater than widest diameter of tibia 5
– Spur on hind tibia short, about equal in length to diameter of tibia (Fig. 3) .... 3. ***H. parvicalcar***, n. sp.
5. Hind femur and tibia yellow .... 4. ***H. pseudodorsalis***, n. sp.
– Hind femur and tibia each infuscate mesally, dark area on hind tibia especially distinct .... 5. ***H. coxipo***, n. sp.
6. Legs predominantly yellow 7
– Legs predominantly black, including all coxae, all femora except knees narrowly, and hind tibia except narrowly at each end .... 6. *L.* sp. (*pusio* complex)
7. Apex of hind tibia excised and angulate (Fig. 4); hind tibia black to apex, narrowly yellowish at base ....7. *L. tibialis* Duda
– Hind tibia distally not angulate, the tibia yellowish at both ends (Figs. 5, 6) 8
8. Prosternum black; frontal triangle ending well before anterior margin, black, usually appearing equilateral with straight sides because its narrow acute apex is yellowish and inconspicuous; spur on hind tibia moderately stout, gently curved, slightly longer than tibial diameter opposite base of spur (Fig. 5) .... 8. *L. currani* (Aldrich)
– Prosternum yellow; frontal triangle appearing longer and narrower than in *currani* because attenuated to apex and sides somewhat concave, the triangle often reddish laterally, especially in males; spur on hind tibia almost straight, short, subequal to diameter of tibia opposite base of spur (Fig. 6) .... 9. *L. peruanus* (Becker)

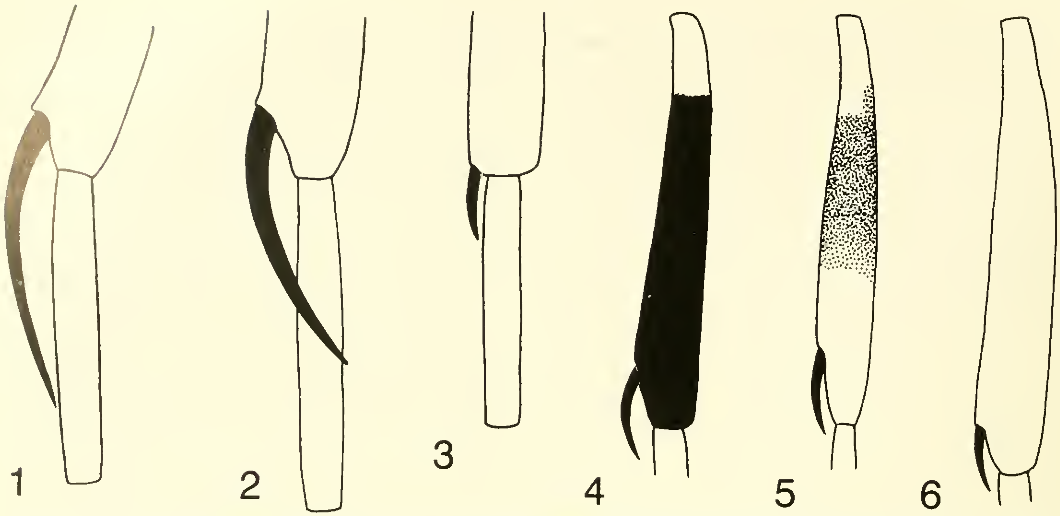
1. *Hippelates neoproboscideus*, N. Sp.

Diagnosis.—Densely gray microtomentose, including most of lower half of pleuron; frontal triangle with three glossy black spots; spur on hind tibia long, gently curved, only slightly preapical.

Male, female.—*Color:* Head with occiput and frontal triangle black, the latter dull, densely gray microtomentose except for three glossy black spots, one laterad of each posterior ocellus and one between median ocellus and apex of triangle, this median area varying from a parallel-sided stripe to a large oval or almost circular spot; frons bright yellowish, slightly infuscate in posterior corners toward base of triangle; narrow parafrontal, face, cheek and palpus whitish; antenna whitish yellow in male, 3rd segment orange yellow in female, brownish on anterodorsal ⅓ to ½. Thorax entirely black in ground color except for yellow prosternum, densely gray microtomentose except for glossy black propleuron, posterior slope of sternopleuron, and mediotergite of postnotum; all bristles black. Abdomen with tergites 1–2 yellow, 3–5 dark brown, in females typically all brown except apex of 5, ocasionally narrowly yellow on hind margins, in males more yellow on hind margins, often like 3 connected spots on each tergite, rarely chiefly yellow with median and lateral spots weakly or not at all connected; male genitalia yellow. Legs bright yellow with weak median brown band on hind tibia; spur on hind tibia black. Wing clear, veins yellow; halter yellow.

Head: Frons parallel-sided, 1.2–1.4 times longer than broad, width at vertex about 1.5 times width of an eye as viewed from above; frontal triangle equilateral, apex at middle of frons, with row of short interfrontal setulae on each extreme side; cheek of moderate width, its height ¾ breadth of 3rd antennal segment and ¼ eye height, vibrissal angle 90 degrees; each section of slender and geniculate proboscis as long as lower margin of head; 3rd antennal segment approximately orbicular; arista micropubescent.

Thorax: Median acrostichal and dorsocentral lines slightly impressed, distinct, and with numerous setulae in fine punctures, 2 rows intermediate between the median acrostichal and each dorsocentral row; spur on hind tibia long and gently curved, inserted slightly preapical, with ⅔ of its length beyond apex of tibia, the tibia slightly excised (Fig. 1). Wing with 2nd costal section long, twice 3rd section.



Figs. 1–6. 1–3, apex of hind tibia, spur, and first tarsomere of *Hippelates* species: *neoproboscideus* (1), *carrerai* (2), *parvicalcar* (3). 4–6, hind tibia and spur of *Liohippelates* species: *tibialis* (4), *currani* (5), *peruanus* (6).

Male genitalia (Fig. 7): Cerci elongate, each less than half length of a surstylus. Surstyli subconical, with many long setae internally (as in Fig. 10a).

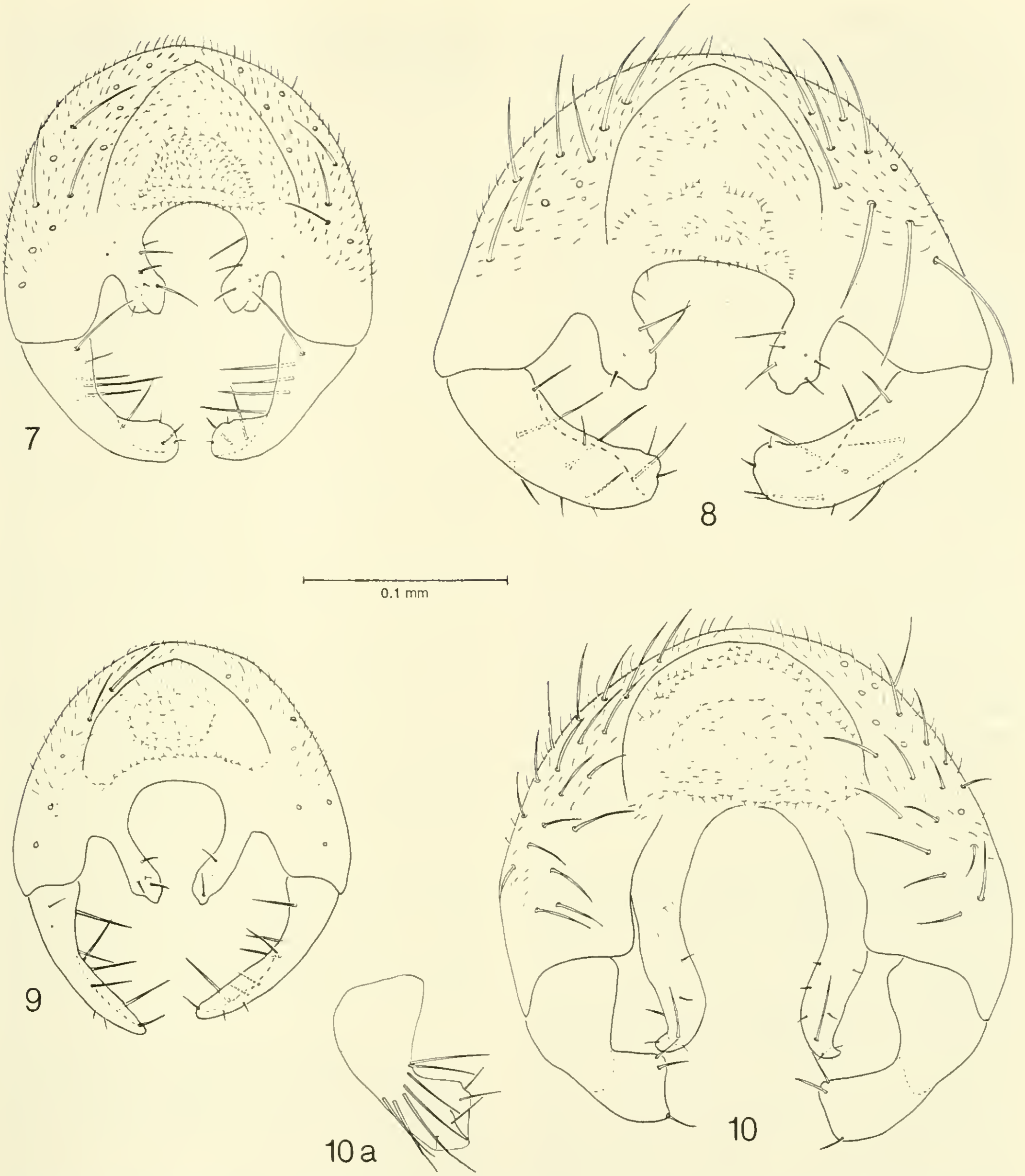
Length: 1.25–1.5 mm.

Holotype male and allotype.—**Brazil, MT:** Coxipó do Ouro, 17.xi.1990 (Paganelli). Paratypes, **Brazil, MT** except as noted: 9 males, 32 females, same data as holotype; 4 females, Cuiabá, 7.iii.1990 and 2 males, 5 females, Cuiabá, iii.1990 (BPF Group); 71 males, 8 females, Cuiabá, São Gerônimo, 4.iv.1990 (BPF Group); 17 males, 20 females, Cuiabá, São Gerônimo, 17.ii (4-0), 10.v (3-19), and 12.v (10-1), 1990 (BPF Group); 3 females, Poconé, 15.xi. and 17.xi. (two) 1990 (Paganelli); male, Várzea Grande, Vila Artur, Jardim Glória, 18.xi.1990 (Paganelli); female, Fazenda Canaa, Três Lagoas, x.1966 (F. Lane); **SC:** 2 females, Nova Teutônia, 300–500 m, 11.i.71 and 1.x.71 (Fritz Plaumann); **SP:** 6 females, Guatapará, i.1945 (M. Carrera); **SP:** female, Itirapina, Cerrado, 6.iv.1991 (A. L. Serra).

In all, over 600 specimens were examined but many were not in good enough condition for inclusion in the type series. Most localities in the type series were duplicated, except as follows: **MT:** Nova Mutum and Várzea Grande, Mapim; **RJ:** Nova Friburgo.

Etymology.—From its similarity to *H. proboscideus* (Williston).

This species resembles *H. proboscideus* (Williston) of the Caribbean region and has been so identified in the past, until we realized that the glossy black lower pleuron characterizes typical *proboscideus* and the chiefly gray microtomentose lower pleuron characterizes the present geographically distinct species. The male genitalia of *H. proboscideus* also differ from those of *H. neoproboscideus* in darker color, epandrium wider than long in posterior view, surstyli long and curved, and each cercus longer than half length of a surstylus. There are several other Neotropical species in what might be termed the "*proboscideus* group," and in all of them the range in the shape and extent of the glossy black spots on the frontal triangle were puzzling when available material was limited. The exceptionally long series resulting from the attention given to possible vectors of Brazilian Purpuric Fever was



Figs. 7–10. Epandrium, cerci and surstyli of *Hippelates* species: *neoproboscideus* (7), *carrerai* (8), *parvicalcar* (9) and *coxipo* (10, 10a). Fig. 10a, inner view of right surstylus.

a welcome addition to the study of *Hippelates.*

2. *Hippelates carrerai*, N. Sp.

Diagnosis.—Frontal triangle gray with three large glossy black spots; thorax gray microtomentose, with propleural area shining reddish yellow; leg predominantly yellow; spur on hind tibia decidedly preapical.

Male, female.—*Color:* Head chiefly yellow, entire occiput and frontal triangle black in ground color, the latter densely gray microtomentose with 3 large glossy black spots, the anterior somewhat oval; frons yellow, brown in posterior corners beside triangle; 3rd antennal segment infuscate anterodorsally, less so in male than in female. Thorax black in ground color, densely brownish gray microtomentose except for shining reddish yellow propleuron and anterior spiracle, some glossy black areas on lower half of pleuron, and glossy black mediotergite of postnotum; knob of halter whitish yellow, stalk yellow. Abdomen chiefly brown, finely brownish microtomentose; male genitalia blackish. Legs chiefly yellow; hind femur somewhat infuscate mesally, hind tibia with brown band on mesal third, and all tarsi infuscate; spur on hind tibia black.

Head: Frons broad, at vertex 1.4 times width of an eye as seen from above, and 1.1 times its length; frontal triangle large, barely broader at base than its length, apex almost at middle of frons; cheek of moderate width, 0.70 times breadth of 3rd antennal segment and ⅕ eye height. *Thorax:* Mesoscutum distinctly punctured, the intermediate acrostichal hairs in 1–2 rows on each side of median row, typically one row at least anteriorly. Spur on hind tibia preapical by a bit less than half its length, strongly curved, the tibia excised distally (Fig. 2). *Wing:* 2nd costal section longer than usual, twice 3rd section.

Male genitalia (Fig. 8): Cerci as in *neoproboscideus*. Surstyli large, flattened and curved.

Length: 1.5–1.75 mm.

Holotype male.—**Brazil, MG:** Ouro Prêto, 18.vii.1970 (F. Val). Allotype, **MG:** Cachoeira do Brumado, vii.1970 (F. Val). Paratypes.—2 males, same data as holotype; **PR:** 3 females, Rio Negro, one of 18.i.1924 (erroneously labeled Cotypus of "*Siphonella proboscidea* Duda"), and two of i.1929; **RJ:** 4 females, Alto da Mosela, Petrópolis, 1200 m. 6.ii. (two), 9.ii., and 15.ii.1971 (D. O. Albuquerque); **RJ:** female, Itatiaia, 14.viii.1971 (H. F. Berla); **SP:** male, São Paulo, 7.ii.1977 (Alin).

Specimens not paratypes.—One, abdomen missing, same data as holotype; headless male, **RJ:** Petrópolis, 2.12.1922 (Borgmeier) (also erroneously labeled Cotypus of *S. proboscidea*).

Duda's identification label of "*S. proboscidea*" was misinterpreted by someone as *Siphonella proboscidea* Duda, rather than *Siphomyia proboscidea* Williston. The so called cotypes have no standing.

A male and five females resemble *carrerai* except in having the propleuron and area around the anterior spiracle glossy black. For the present thay have been left as a variety of *carrerai*: **MT:** Nossa Senhora do Livramento and Cuiabá; **RJ:** Alto da Mosela, Petrópolis, 1200 m; **SP:** Araçoiaba.

Etymology.—The species *H. carrerai* is dedicated with respect and affection to our friend of many years, Dr. Messias Carrera, who has contributed greatly to the study of Diptera in Brazil and who collected many earlier specimens of these gnats.

This species, or at least a variety of it, was a very minor factor in the BPF Survey, but it is included here for completeness.

Realization of the significance of the microtomentose lower pleuron has separated a group of undescribed species. Among those with three glossy black spots on the frontal triangle, the preapical spur and predominantly yellow legs stand out as recognition features for *carrerai*.

3. *Hippelates parvicalcar*, N. Sp.

Diagnosis.—Small, thorax partly reddish yellow, spur on hind tibia very short, almost bristlelike.

Male, female.—*Color:* Head chiefly yellow, occiput except extreme edges and the frontal triangle black, latter densely gray microtomentose without glossy spots; cheek whitish yellow; antenna yellow, arista and 3rd segment anterodorsally infuscate. Thorax chiefly yellow, including humeral calli and scutellum, the mesoscutum black except laterally, densely gray microtomentose; some scattered infuscate areas on pleuron; mediotergite of postnotum glossy black.

Abdomen with tergites chiefly brown to brown-black, tergites 2–4 with yellow hind margins. All legs yellow except for infuscate distal tarsomeres.

Frons broad, parallel-sided or narrowed slightly anteriorly, width at vertex 1.8 times width of an eye as viewed from above and 0.92 times its length, the frontal triangle short, less than half way to anterior margin of frons, and broader at base than long (1.70×); cheek moderately broad, its height about equal to breadth of 3rd antennal segment and nearly 0.30 times the eye height; proboscis slender and geniculate but not as long as in the other species. Mesoscutum with short hairs set in fine and inconspicuous punctures; two rows of intermediate acrostichals on each side of midline. Spur on hind tibia (Fig. 3) very short, subequal diameter of tibia at base of spur, slightly preapical; tibia not excised. Wing with 2nd section moderately long, 1.7 times 3rd section.

Male genitalia (Fig. 9): Cerci elongate, each half as long as a surstylus. Surstyli convex, flattened, platelike, not narrowed at tips, almost as long as height of epandrium.

Length: 1.25 mm.

Holotype male and allotype.—**Brazil, SP:** Valparaíso, Bairro Santa Casa, 25.x.1990, "aspirador" (Paganelli). Paratypes.—**Brazil, SP:** 10 females, including three, Araçoiaba da Serra, 26.iv.1981 (Paganelli), four (also 1 male), Bebedouro, 17.xii.1990 (Paganelli), and one each, Coxipó do Ouro, 17.xi.1990 (Paganelli), Nova Europa, Crêche Municipal, 26.i.1991 (G. A. Silva), and Valparaíso, Usina, UNIVALEM, 25.x.1990 (Paganelli); **MT:** 7 males, 7 females, including female, Cuiabá, 7.iii.1990 (BPF Group), 5 males, 3 females, Cuiabá, São Gerônimo, 4.iv. (4-0), 10.v (0-2), and 12.v. (1-1) 1990 (BPF Group), female, Nossa Senhora do Livramento, 2.i.1991 (BPF Group), female, Nova Mutum, 19.ii.1990 (BPF Group), male, Poconé, Centro, 16.v.1990 (BPF Group), female, Poconé, 17.xi.1990, bait (Paganelli), male, Várzea Grande, Vila Artur, Jardim Glória, 18.xi.1990 (Paganelli). Also **Bolivia, Santa Cruz:** 2 females, Ichilo-Yapacaní, 11.ii.1971 (L. E. Peña).

Not paratypes.—11 males, 20 females, of the same localities, plus **MT:** Santo Antônio do Leverger, and **PE:** Fazenda Amapá Agrestina.

Etymology.—The specific name is a noun compounded from the Latin adjective *parvus,* small, and noun *calcar,* spur.

This is the only species of *Hippelates* with a very short spur that was taken in the survey. It belongs to a group of species that was at one time considered a separate genus, *Olcanabates* Enderlein, but the species appear to us to be *Hippelates* with very reduced spur. They are eye gnats and the male genitalia agree with those of *Hippelates.*

4. *Hippelates pseudodorsalis,* N. Sp.

Diagnosis.—Densely gray-microtomentose frontal triangle and thorax, the humeral calli, scutellum (except at base), and pleuron in part reddish yellow; legs entirely yellow; spur on hind tibia preapical, stout, curved, the tibia distally excised.

Male, female.—*Color:* Head chiefly yellow, the frontal triangle chiefly blackish centrally, occiput broadly black across middle from eye to eye, yellow above and below; 3rd antennal segment infuscate anterodorsally. Dorsum of thorax chiefly black, with humeral calli, notopleura and scutellum (except at base) reddish yellow; mesoscutum densely gray microtomentose; mediotergite of postnotum glossy black; pleuron reddish yellow anteriorly and above, the sternopleuron, except sometimes a weak reddening along posterodorsal margin, and adjacent anteroventral area of mesopleuron black, almost entirely gray microtomentose. Abdomen yellow toward base, tergites 3–5 with broad infuscate bands anteriorly, posteriorly yellow, the yellow bands wider in males than in females; male genitalia shining yellow. Legs entirely yellow, only spur on hind tibia glossy black. Wing clear, veins brownish.

Frons of moderate width, at vertex 1.4

times width of eye as viewed from above, and over ¾ its own length; frontal triangle approximately equilateral, apex midway of frons, sometimes with traces of tiny glossy black spots beside each ocellus; cheek not broad, subequal to breadth of 3rd antennal segment and over ¼ eye height; proboscis slender and geniculate, exceptionally long, each section longer than length of lower margin of head, projecting in advance of head as seen in profile. Mesoscutum with numerous hairs set in fine punctures, typically 2–3 somewhat irregular rows of intermediate acrostichals on each side of median row. Spur on hind tibia stout, strongly curved, preapical, about equal to tibial diameter, inserted half its length before apex of tibia, the tibia excised and angulate. Wing with 2nd costal section only 1.7 times 3rd section.

Male genitalia: Very similar to *H. coxipo* (cf. Fig. 10). Cerci very long and curved, more slender than in *coxipo*. Surstyli longer and curved.

Length: 2–2.5 mm.

Holotype male and allotype.—**Brazil, RJ:** Saquarema, 5.xii.1982 (Paganelli). Paratypes.—All **Brazil,** 6 males, 27 females, same data as holotype; **MT:** 2 males, 3 females, Cuiabá, São Gerônimo, 10.v. (2-2) and 12.v.1990 (BPF Group); **MT:** 2 males, Nossa Senhora do Livramento, 2.i.1991 (BPF Group); **RJ:** male, Grajaú (H. S. Lopes); **RJ:** female, Taquara, Petrópolis, 15.ii.1971 (H. S. Lopes); **SP:** male, 16 females, Araçoiaba, 26.iv.1981, bait (Paganelli); **SP:** 10 females, Guatapará, i.1945 (M. Carrera); **SP:** female, São Paulo, iv. 1960 (Forattini).

Not paratypes.—2 males, 43 females, **SP:** Guatapará.

Etymology.—The species is very suggestive of the Caribbean *H. dorsalis* Loew, hence the name *pseudodorsalis.*

The yellow legs and stout preapical spur on the hind tibia resemble those of *H. dorsalis* Loew, but *dorsalis* is a much paler species with more restricted black coloration. The extent of black areas on the frontal triangle and mesopleuron in *pseudodorsalis* varies, possibly depending on the degree of maturity of the specimens.

5. *Hippelates coxipo,* N. Sp.

Diagnosis.—Densely gray-microtomentose frontal triangle and thorax, the humeral calli, scutellum (except disk in part), and propleuron reddish yellow; legs predominantly yellow; hind femur and hind tibia strongly infuscate mesally; spur on hind tibia stout, preapical, the tibia excised.

Male, female.—*Color:* Head predominantly yellow, occiput chiefly and frontal triangle black, densely dark gray microtomentose; frons dark yellow, contrasting with narrow whitish yellow parafrontals, parafacials and cheeks; 3rd antennal segment dorsally infuscate. Thorax predominantly black in ground color, the humeral calli, scutellum except much of disk, and propleural area reddish yellow; mesopleuron often partly reddish yellow dorsally, narrowly glossy black anteroventrally; sternopleuron partly gray microtomentose, partly glossy black especially ventrally; mediotergite of postnotum glossy black. Abdomen yellow toward base, tergites 3–5 broadly yellow on hind margins in male, in female entirely brown or occasionally with linear traces of yellow, and tergite 5 yellow distally in female. Fore and mid legs yellow; hind femur and hind tibia strongly infuscate mesally, that on tibia a definite band; spur on hind tibia glossy black. Wing veins yellowish to brown; halter knob whitish yellow, stalk yellow.

Frons moderately broad, at vertex 1.5–1.6 times width of eye as viewed from above, and ¾ its own length; frontal triangle approximately equilateral, apex about at middle of frons, usually with tiny glossy black area beside each ocellus; cheek similar to that of *pseudodorsalis,* not broad, 0.70 times breadth of 3rd antennal segment and 0.20–0.30 times height of eye; proboscis as described for *pseudodorsalis,* each section longer than length of lower margin of head.

Dorsum of thorax with numerous short and inconspicuous hairs set in fine punctures, 2–3 somewhat irregular rows of intermediate acrostichals on each side of median row. Spur on hind tibia stout, strongly curved and preapical, inserted half its length before apex of tibia; tibia excised and distally angulate. Wing with 2nd costal section slightly over 1.5 times 3rd section.

Male genitalia (Fig. 10, 10a): Cerci very long and curved, each longer than a surstylus, and with slightly curved tips. Surstyli slightly convex, short and blunt, with a row of long internal setae mesally (Fig. 10a).

Length: 1.75 mm.

Holotype and allotype.—**Brazil, MT:** Coxipó do Ouro, 17.xi.1990 (Paganelli). Paratypes (all **Brazil**): **MT:** 7 males, 2 females, same data as holotype; **MT:** 2 males, 1 female, Cuiabá, Bela Vista, 17.xi.1990 (Paganelli); **MT:** male, Cuiabá, São Gerônimo, 4.iv.1990 (BPF Group); **PE:** 5 males, 19 females, Fazenda Amapá, Agrestina, 11–17.vi.1971 [Expediçao do Museu de Zoologia]; **RJ:** 2 males, 1 female, Saquarema, 5.xii.1982 (Paganelli); **RJ:** 4 females, Manguinhos, 18.i.1971 (S. Pacheco); **SP:** Cotia, 1986 (Paganelli); **SP:** 2 females, Balneário Flórida, Praia Grande, 7–8.ii.1981 (Paganelli); **SP:** male, 3 females, Guatapará, i.1945 (M. Carrera).

Not paratypes.—4 males, 22 females of the preceding localities, plus **SP:** Praia de Juquehy, Município São Sebastião, 29.x.1972 (F. C. Val).

Etymology.—The specific name is a noun in apposition, from the name of the type locality, one of the localities of cases of Brazilian Purpuric Fever.

Most specimens show the distinct male–female difference in the color pattern of the abdomen, but two specimens, not paratypes, are exceptions. A male of the Pernambuco series has a female-patterned abdomen, and a female from Praia de Juquehy in the state of São Paulo has the abdominal pattern of a male.

The stout preapical spur on the hind tibia and the gray-microtomentose frontal triangle will distinguish *H. coxipo* from other new species in the group with partly reddish yellow thorax, and in addition the infuscation on hind femur and hind tibia will distinguish it from the already described *H. dorsalis* Loew.

ACKNOWLEDGMENTS

We extend our gratitude to the Instituto Adolfo Lutz in the person of their directors, Dr. Anísio de Moura (General Director), José Eduardo Tolezzano (Division of Medical Biology), Dr. Vera Simonsen Dias Vieira (Dept. of Bacteriology), Luiza T. M. de Souza (Dept. of Virology), and many of their staff members, for providing working space, facilities, and assistance during the development of this research; to Dr. Paulo E. Vanzolini and Dr. Francisca C. do Val, Museu de Zoologia da Universidade de São Paulo, for the loan of specimens and for providing a technician to mount part of the specimens collected; and to Mrs. Linda Lawrence, Systematic Entomology Laboratory, U.S. Department of Agriculture, for inking and arranging the drawings. The senior author is also indebted to Dr. Wagner A. Costa and Dr. Graziela A. Silva, Centro de Vigilancia Epidemiológica da Secretaria da Saúde de São Paulo, for providing funds for the indentification period (Proc. 233/91 – FESIMA); to Dr. Claire V. Broome and Bradley A. Perkins, M.D., Centers for Disease Control, Atlanta, Georgia, for supporting one of the trips to Mato Grosso, and contributing in many ways; and to Dr. Ione M. Bortolotto (Divisao de Vigilancia, Secretaria da Saúde de Mato Grosso) and Dr. Olga A. Takano (Fundaçao Universidade Federal de Mato Grosso) for their help and facilities during the field work in Mato Grosso; and to Dr. Sergio A. Vanin, Dept. Zoology, Instituto de Biociências, Universidade de São Paulo, for permission to prepare the drawings of male genitalia under his microscopes with camera lucida.

LITERATURE CITED

Brazilian Purpuric Fever Study Group. 1992. Brazilian Purpuric Fever identified in a new region of Brazil (report prepared by Bradley A. Perkins and Claire V. Broome). Journal of Infectious Diseases 165(Suppl. 1): 516–519.

Harrison, L. H., et al. 1989. Epidemiology and clinical spectrum of Brazilian Purpuric Fever. Journal of Clinical Microbiology 27: 599–604.

McAlpine, J. F. 1981. Morphology and terminology—Adults, pp. 9–63. *In* McAlpine, J. F., et al., eds., Manual of Nearctic Diptera, Volume 1. Ottawa, Research Branch, Agriculture Canada, Monograph 27: 674 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. Museu de Zoologia, Universidade de São Paulo.

Tondella, M. L. C., et al. 1991. Isolamento do clone invasor de *Haemophilus aegyptius* (Hae), responsável pela Febre Purpúrica Brasileira (FPB), de chloropideos (Diptera) dos gêneros *Hippelates* e *Liohippelates.* Revista Brasileira de Microbiologia 22(3)(Suppl. 1): 157. (*In* Resumos do XVI Congresso Brasileiro de Microbiologia e IX Simpósio Nacional de Fermentaçoes.)

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 175–181

SIMULIUM (*PSILOPELMIA*) *TRAVISI* (DIPTERA: SIMULIIDAE), A NEW BLACK FLY SPECIES FROM COSTA RICA

MARIO VARGAS V., J. V. VARGAS, AND J. RAMÍREZ-PÉREZ

(MVV and JVV) School of Microbiology and CIDPA, University of Costa Rica; (JRP) Instituto de Biomedicina, P. O. Box 4043, Caracas, Venezuela.

Abstract.—The male and female (pharate), pupa and larva of ***Simulium* (*Psilopelmia*) *travisi*,** new species, are described and illustrated. The new species is separated from its closest relative, *S.* (*Ps.*) *pseudocallidum* Díaz Nájera, by the form of the pupal respiratory organ.

Key Words: Diptera, Simuliidae, black fly, Costa Rica

The subgenus *Psilopelmia* is well represented in the Neotropical Region, especially in the Central American and Mexican subregions. It consists of 31 species: eight Nearctic (two in common with Central America), 23 from Central America, and 5 from South America (three in common with Central America), (Díaz-Nájera 1979, Coscarón 1987, 1990, Peterson 1992 personal comm.).

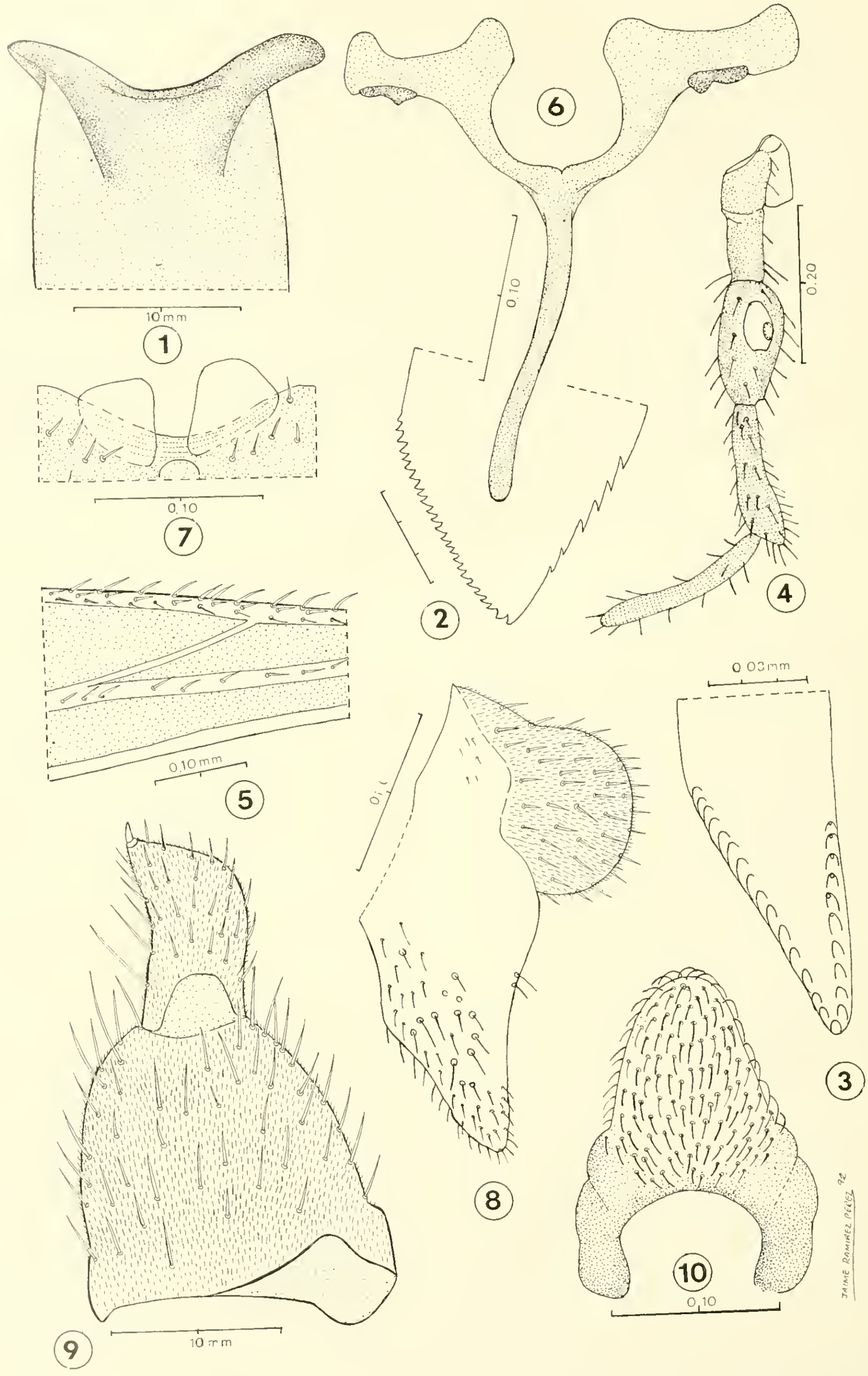
Simulium travisi, NEW SPECIES

Description.—Female (pharate; preserved in alcohol).— General body color: apparently yellowish but faded because of the alcohol. *Length:* body, ? mm; wing, 2.9 mm, 1.15 mm at maximum width.

Frons with an interocular distance of 0.13 mm. Mandible (Fig. 2) with 25 teeth on inside margin and 6 larger teeth on outside margin. Blade of maxilla (Fig. 3) slender, with 25 retrorse teeth. Palpus (Fig. 4) with basal segment quadrate, 0.07 mm; second palpomere rectangular, 0.07 mm; third dilated, 0.15 mm; fourth, slender, 0.18 mm with apical portion directed to one side; fifth elongated, 0.22 mm long. Sensory vesicle moderately large, ovoid, with a small, round mouth. Palpal index about 1:1.1:2.2:2.6:3.3. Cibarium (Fig. 1) with medioproximal space shallow, broadly concave, with a sclerotized margin, smooth at medial region; dorsolateral arm short, ending in an expanded, rugose lobe; inner surface of each arm with a patch of minute denticles arising from a slight prominence.

Sc and R_{2+3} without setae ventrally, R_1 bare on basal half, apical half with a mixture of setae and spines (Fig. 5). Antenna 0.54 mm in length.

Terminalia as in Figs. 6–8. Anal lobe (Fig. 8) subtriangular, external margin slightly concave, inner margin with a convexity at middle; anterodistal margin sinuous, covered with scattered setae of median size and fine pilosity. Cercus (Fig. 8) subrectangular, with round posterior margin, moderately covered with fine pilosity and stronger setae. Hypogynial valves (Fig. 7) very short, lobe shaped, barely reaching bases of cerci. Stem of genital fork (sternite 9) (Fig. 6) long and sclerotized, sinuous, longer than arms; each arm weakly sclerotized and ending in an expanded area, inner margin of arm with a slight concave area towards median line and a small convex area at each side. Spermatheca large, sclerotized, roundish, with-



Figs. 1–10. *Simulium travisi.* Figs. 1–8, female. 1, Median proximal space of cibarium. 2, Tip of mandible showing serrations. 3, Blade of maxilla showing retrorse teeth. 4, Maxillary palpus. 5, Portion of wing showing venation. 6, Genital fork. 7, Hypogynial valves. 8, Anal lobe and cercus. Figs. 9–10, male. 9, Gonocoxite and gonostylus (dorsal [inner] surface). 10, Ventral plate of aedeagus, ventral view.

out a reticulose pattern, with a few internal spicules, and a clear area at junction with spermathecal duct.

Male (pharate).—Terminalia as in Figs. 9, 10. Gonocoxite (Fig. 9) subquadrangular, with scattered long setae along distal and lateral areas. Gonostylus (Fig. 9) short, tubular, two times as long as wide, outer apical margin rounded, inner distal angle produced, with 1 moderately developed pointed apical spine; with scattered setae. Body of ventral plate of aedeagus (Fig. 10) pyramidal, densely covered with reclinate setae; in ventral view, with straight apical margin; basal arms well developed, sclerotized, spatula-like. Plate of endoparameral organ membranous, with marked striations, arms with 4 long, sclerotized spines.

Pupa.—Length, 3 mm. Respiratory organ (gill) (Fig. 16) consisting of 8 dark, slightly corrugated and granulose tubular filaments; dorsal filament more robust than others, ornamented; 7 mm long, 5 times as long as others that average about 1.5 mm. Branching pattern as follows: with 3 primary trunks, dorsal trunk wide at base, and with a ventral subbasal branch; and 2 other more ventral branches bifurcated at same level, medial trunk with same arrangement as dorsal trunk, and a ventral trunk with 2 filaments bifurcated at same level as dorsal bifurcation. The distal portion of each filament with fine annuli.

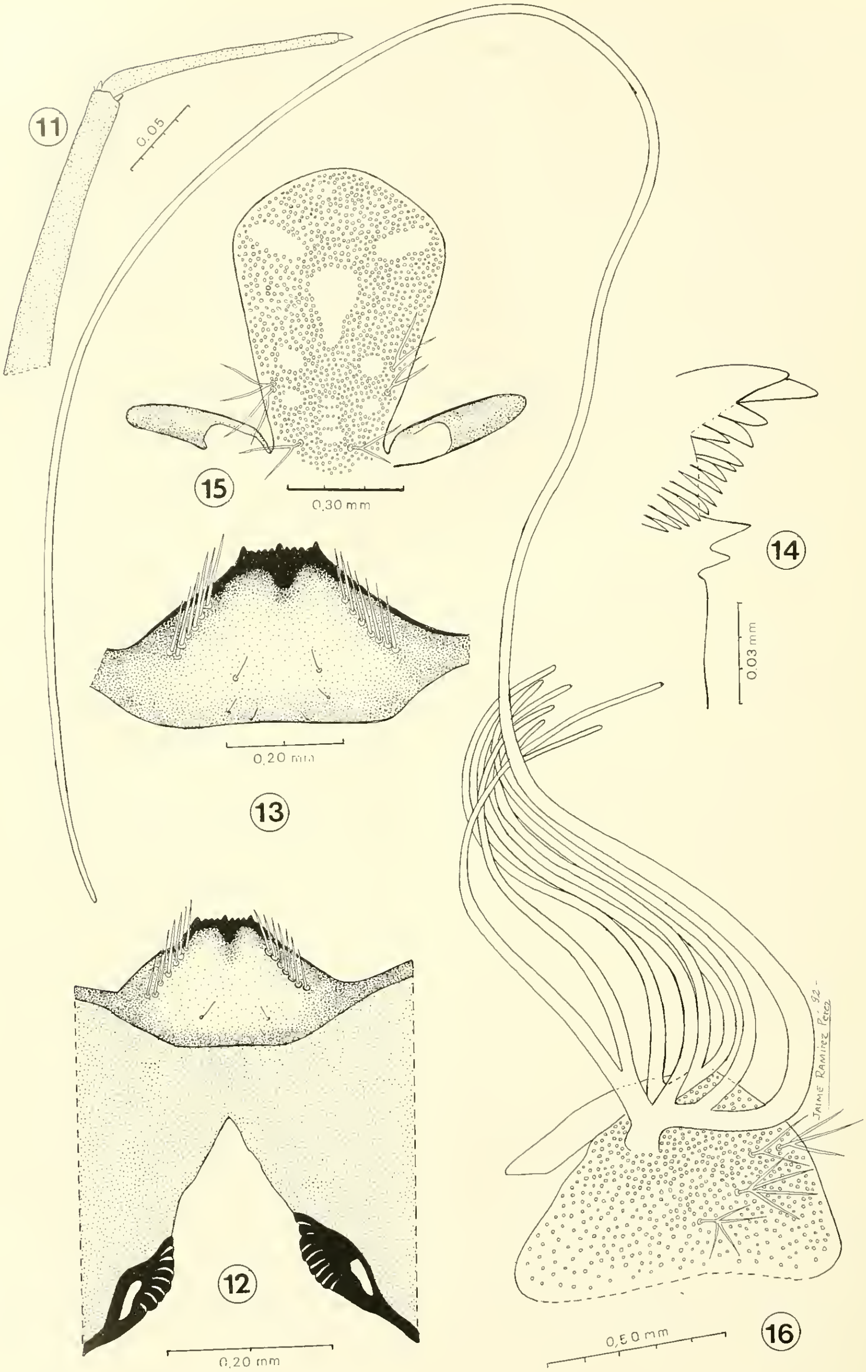
Head and thoracic integument covered by numerous microprotuberances and with some bare areas on frons distributed as follows: one slightly inclined pair of bands in upper part of cephalic region, a subtriangular medial area, ovoid spots on each side in basal region, and 4 ovoid medial areas.

Frons of male pupa (Fig. 15) elongate, 1.5 times longer than wide, and with a convex posterior border. Frons of female not so elevated, mushroom shaped. Antennal envelopes of female reach posterior margin of head, male antennal envelopes reach only about half distance to posterior margin of head. Labral envelope of female pupa shorter, wider and more roundish than that of male. Two pairs of long, bifid, submedial frontal trichomes and one pair of bifid basal trichomes. Female pupa with a single short, spine-like trichome towards midline at level of base of respiratory organ, and at side of respiratory organ there are 4 long tetrafid trichomes; 1 bifid trichome in line with respiratory organ and 1 long, simple, medial trichome ventral to base of respiratory organ.

Chaetotaxy of each lateral half of abdominal tergites as follows (from midline to lateral margin of abdomen): segment 0 = 1 long bifid seta. Segment I = 1 long simple seta. Segment II = 2 spiniform setae near midline, and anterior to them 5 small, single setae in a straight line, and 1 long, simple seta in front of external spiniform seta. Segment III = 4 single sclerotized hooks; 1 small seta in front of external pair of hooks. Segment IV = 4 single sclerotized hooks, 2 small simple setae, 1 in front and 1 beyond external pair of hooks, 4 simple setae and 1 bifid, lateral to external hook. Segment V = 1 simple lateral seta. Segment VI = 1 simple lateral seta. Segment VII = ?. Segment VIII = with a comb of 9 scales. Segment IX = with a rudimentary comb.

Chaetotaxy of each lateral half of sternites: segment III = 3 simple lateral setae, forming a triangle. Segment IV = bare. Segment V = 2 hooks, outer bifid, inner trifid, and 2 submedial and 2 submarginal simple setae. Segment VI = 2 bifid submedian hooks. Segment VII = 2 bifid submedian hooks. Segment VIII = bare. Segment IX = bare. Apex with 2 tiny terminal hooks on a wide lobe.

Larva (mature, with fully developed respiratory histoblasts).—Length, 6 mm. Antenna (Fig. 11), with first and second segments dark brown, third, pale brown, proportions of segments (basal to apical) 1:1.5:2.0. Labral fan with 40–43 primary rays. Hypostoma as in Fig. 13, with 9 teeth arranged as follows: 1 prominent central tooth, 2 lateral groups of 3 teeth each, and



Figs. 11–16. *Simulium travisi.* Figs. 11–14, larva. 11, Antenna. 12, Hypostomal cleft. 13, Hypostoma. 14, Inner distal and subapical margins of mandible showing dentation. Figs. 15–16, pupa. 15, Frons. 16, Respiratory organ (gill).

1 outer tooth followed by a prominence. Lateral margin of the hypostoma with 7–9 minute weak serrations; a row of 7 lateral hypostomal setae, 1 pair of submedian setae and 2 pair of subbasal setae; there is 1 pair of basal setae in line with laterals. Hypostomal cleft (Fig. 12) an inverted V-shape, deep, reaching 0.11 mm from base of hypostoma.

Mandible (Fig. 14) with 1 large, sclerotized apical tooth, 2 stout subapical teeth that are less developed than the apical, 3 moderately sclerotized outer teeth, followed by a series of 10 toothlike setae, 2 outer teeth with a minute tooth in between; mediobasal region of mandible with a patch of about 20 small spines; basoventral margin with 7 very large setae divided at apex into 3 points. Maxillary palpus stout, dark brown, with scattered setae, about 3.3 times as long as wide at base, distal end membranous, ending in a group of triangular spinules. Lateral plate of proleg extended about ½ length of apical segment, subtriangular, slightly sclerotized, wider than its height; proleg with about 24 rows of apical hooks, each row with about 12 hooks; distal end of proleg with about 24 double pointed spines placed near base of rows of hooks. Anal papillae in 3 groups of about 11 lobes each. Anterodorsal arm of anal sclerite strongly sclerotized, hornshaped, reaching posterior end of rings of hooks; posteroventral arm platelike, slightly sclerotized and rugose; a band of non sclerotized scales encloses posterior arm, posterior circlet of hooks, consisting of about 15 hooks in about 100 rows.

Type data.—Holotype and paratypes deposited in the entomological collections, Department of Parasitology, School of Microbiology, University of Costa Rica. Holotype, ♀ (mounted on four slides) Río El Angel. Permanent stream (#66) located 4.1 km beyond Cinchona, on route from Vara Blanca to Puerto Viejo, Provincia Heredia, Costa Rica, November 16, 1970, C.R. R. Echeverri.

Paratypes.—1 ♀, same data as type (mounted on 2 slides); 1 ♀ (mounted on 4 slides), 2 ♂ (one mounted on 3 slides, other on 2 slides), permanent stream (#68) located 8.0 km beyond Tapezco, on route from Naranjo to Ciudad Quesada, Lajas, Cantón San Carlos, Provincia Alajuela, Costa Rica, August 4, 1969, C.R. M. Vargas, G. Zúñiga, R. Echeverri; 2 pupal skins (males) with larval cephalic capsule (mounted on 2 slides each), permanent stream (#67), located 6.7 km beyond Vara Blanca, on route from Vara Blanca to Puerto Viejo, Cantón Central, Provincia Heredia, C.R. January 30, 1992. M. Vargas, J. V. Vargas, J. Ramírez, S. Alfaro. One larva (mounted on 3 slides), temporary stream (#65), located 1.0 km beyond Cariblanco, on route from Vara Blanca to Puerto Viejo.

This species is named after, and dedicated to, the late Dr. Bernard V. Travis, first leader of the black fly bionomics project in Costa Rica.

Biological notes: All available specimens of *S. travisi* came from the central plateau of the Province of Heredia, and San Carlos, Province of Alajuela. This area is about 250 km^2 and is located between 84°10′00″ and 84°25′32″ and 10°12′41″ and 10°17′31″. Four streams in this area were positive for *S. travisi*: Qda. Ujarrás (numbered 65), Rio el Angel (Numbered 66), Qda. Paz Chiquita (numbered 67) and Qda. Las Lajas (numbered 68).

According to Vargas and Travis (1973), these streams range between 800–1325 m above sea level, have temperatures between 14–26°C, depths between 0.20–0.50 m, widths from 2–10 m, have stream velocities varying from fast and turbulent (two streams), fast and with intermitent turbulence (one stream), and fast and nonturbulent (one stream). Three streams are clean and unpolluted, but stream number 65 is contaminated with organic material. Three of the streams are open-shaded, and one is partially shaded. Both rocks and vegetation are used as substrates for larvae and pupae.

Remarks: Until now, only three species of the subgenus *Psilopelmia* have been reported in Costa Rica: *S. callidum* (Dyar and Shannon), *S. haematopotum* Malloch (Travis et al. 1974), and *S. panamense* Fairchild (Zeledón and Vieto 1957).

Of the 23 species of *Psilopelmia* in the Mexican and Central American regions, there are two in which the pupal stage is unknown: *S. escomeli* Roubaud of which only the male is known, and *S. jacobsi* Dalmat which is known only in the larval stage.

Using the number of filaments of the respiratory organ as a means of dividing the species of *Psilopelmia* into groups, *S. panamense* Fairchild, 1940, has twenty, *S. mangabeirai* Vargas, 1945, has four, while *S. dandrettai* Vargas, Martínez and Díaz Nájera, 1946, *S. zempoalense* Vargas, Martínez and Díaz Nájera, 1946, and *S. mazzottii* Díaz Nájera, 1979 have six. In the other 16 species, the respiratory organ has eight filaments, and *S. travisi* belongs to this group. Of these latter 16 species, only *S. callidum* and *S. pseudocallidum* Díaz Nájera have the outer dorsal filament more enlarged than the others. The filaments of all species are arranged in an archlike manner. However, in *S. callidum* and *S. pseudocallidum* the outer dorsal filament is about 1.7 times longer than the other filaments, and in *S. travisi* the same filament is about five times longer than the others.

A striking difference in the branching pattern of *S. callidum* and *S. pseudocallidum* is the bifurcation of the outer dorsal filament at some distance from the level of bifurcation of the ventral filaments, while in *S. travisi* the bifurcation of both the dorsal and ventral filament groups is almost at the same level.

The ventral plate of the aedeagus of *S. callidum* is bare, in *S. pseudocallidum* it is pilose, and that of *S. travisi* is pilose and longer than the former species.

On the other hand, the cibarium of *S. callidum* has a patch of spines on low prominences at each side; that of *S. pseudocallidum* is smooth and without denticles, and in *S. travisi* there are slight prominences and patches of very minute spines (visible at 400×).

Finally, *S. travisi* is closely related to *S. callidum* and *S. pseudocallidum* but all three species can be separated from each other. The characters given by Díaz-Nájera (1965) to separate *S. callidum* from *S. pseudocallidum*, will separate *S. travisi* and *S. callidum*. Besides the slope of the respiratory organ, the shape of the ventral plate of the aedeagus, the number of rays of the labral fan, the number of rows in the posterior circlet of hooks of the larva, and the number of hypostomal setae will distinguish *S. pseudocallidum* and *S. travisi*.

ACKNOWLEDGMENTS

We thank M. Roberto Echeverri, Mr. Guillermo Zúñiga and Mr. Sergio Alfaro, Centro de Investigación y Diagnóstico en Parasitología, U.C.R. for their help with field collections. Financial and logistic support was provided by the Vicerrectoría de Investigación, U.C.R., and the International Committee of Migrations (C.I.M.) gave facilities to J. Ramírez Pérez for travel to Costa Rica. Dr. R. V. Peterson, Systematic Entomology Laboratory, PSI, ARS, U.S.D.A. % National Museum of Natural History, Washington, D.C., critically reviewed the manuscript and made helpful editorial suggestions.

LITERATURE CITED

Coscarón, S. 1987. El género *Simulium* Latreille en la región Neotropical: Análisis de los grupos supraespecíficos, especies que los integran y distribución geográfica. Museo Paraense Emilio Goeldi, Belem. 112pp.

———. 1990. Taxonomía y distribución del subgénero *Simulium* (*Ectemnaspis*) Enderlein (Simuliidae, Diptera, Insecta). IHERINGIA, serie Zoología Porto Alegre. 70: 109–170.

Dalmat, H. T. 1955. The black flies (Diptera, Simuliidae) of Guatemala and their role as vectors of onchocerciasis. Smithsonian Miscellaneous Collections 125(1): 1–425.

Díaz-Nájera, A. 1965. Acerca de un nuevo simúlido mexicano. Revista del Instituto de Salubridad y Enfermedades tropicales. (Méx.) 25: 24–45.

———. 1969. Simúlidos de Aguascalientes y Zacatecas. Descripción de seis especies del subgénero *Psilopelmia* y datos de dimorfismo. Revista del Instituto de Salud Pública (Méx.) 29: 21–63.

———. 1979. Una nueva especie del género *Simulium* (Diptera: Simuliidae) del Estado de Coahuila, México. Anales del Instituto de Biología, Universidad Nacional Autónoma de México. Serie Zoología 1: 553–561.

Travis, B. V., M. Vargas, and J. C. Swartzwelder. 1974. Bionomics of black flies (Diptera: Simuliidae) in Costa Rica. I. Species biting man, with an epidemiological summary for the Western Hemisphere. Revista de Biología Tropical 22: 187–200.

Vargas, L. and A. Díaz-Nájera. 1957. Simúlidos Mexicanos. Revista del Instituto de Salubridad y Enfermedades tropicales (Méx.). 17: 143–399.

Vargas, M. and B. V. Travis. 1973. Bionomía de los simúlidos (Diptera: Simuliidae) en Costa Rica. IV. Localización y descripción de los lugares de recolección. Revista de Biología Tropical 21: 143–175.

Zeledón, R and P. L. Vieto. 1957. Contribución al estudio de los Simúlidos de Costa Rica (Diptera: Nematocera) I. Sobre el *Simulium panamense* Fairchild, 1940. Revista de Biología Tropical 5: 19–25.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 182–188

A REMARKABLE NEW SPECIES OF *PARADEJEANIA* FROM THE DOMINICAN REPUBLIC (DIPTERA: TACHINIDAE)

NORMAN E. WOODLEY

Systematic Entomology Laboratory—USDA, ARS, PSI, % U.S. National Museum NHB 168, Washington, D.C. 20560.

Abstract.—The first species of *Paradejeania* from the Caribbean is described and illustrated (***P. xenisma***, type locality: Dominican Republic, Independencia Province, 1 km E of El Aguacate, 18°20′N, 71°42′W). A key to the three known species, and habitus photographs of each, are included.

Key Words: *Paradejeania*, Tachinidae, Caribbean, taxonomy

Paradejeania is a New World genus of Tachinidae, with two previously known species from western North America south to Costa Rica, and Colombia. Arnaud (1951) provided an excellent review of the genus. While collecting in the Dominican Republic in 1984, I encountered a third species that is described here. A single specimen had been collected previously by my colleagues Jason D. Weintraub and Francis M. Harrington during an earlier collecting excursion to the Dominican Republic. In 1989, Stephen A. Marshall and John E. Swann collected an additional three females. The species is being described here because it is quite different in general appearance from the previously known species and because its presence in the Greater Antilles is a significant extension of the range of the genus.

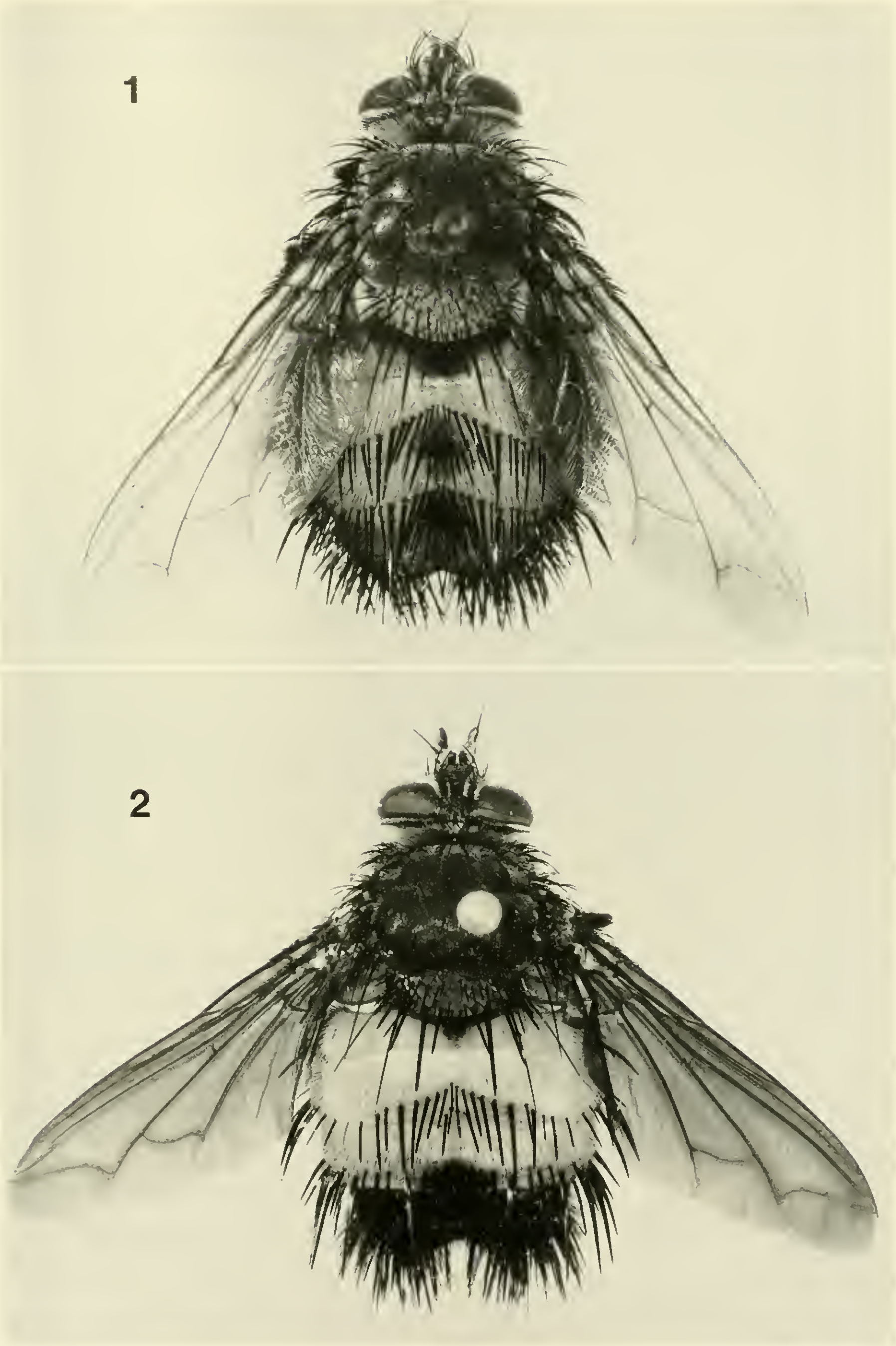
GENUS *PARADEJEANIA* BRAUER AND BERGENSTAMM

Paradejeania Brauer & Bergenstamm, 1893: 147, 184 (as subgenus of *Jurinia*). Type species, *Dejeania rutilioides* Jaennicke (by designation of Coquillett, 1910: 584).

Diagnosis.—The bare prosternum, pilosity on the posterior margin of the hind coxae, and well-developed palpi place *Paradejeania* in the tribe Dejeaniini. Within the tribe, the genus is unique in having a complete, sagittate row of marginal setae on abdominal tergites three and four that encloses a small patch of setae between it and the posterior margin of each tergite. This character state is considered autapomorphic for the genus.

Remarks.—The three species now known to compose this genus are very distinctive in appearance (see Figs. 1–3). A full generic description was given by Arnaud (1951), and as the new species described here conforms closely to it there is no reason to formulate a new one. Because the genera of Tachininae have not been reviewed on a worldwide basis, and the species of the largely New World Dejeaniini have not been comprehensively reviewed, it is impossible to comment on the phylogenetic relationships between *Paradejeania* and other members of the tribe.

Paradejeania rutilioides (Jaennicke) is known to range from Vancouver Island, British Columbia south to Costa Rica. In the United States it occurs mostly west of the continental divide, the easternmost records being from Colorado, New Mexico, and



Figs. 1–2. Dorsal habitus photographs of *Paradejeania* spp. 1, *P. rutilioides*. 2, *P. xenisma* (paratype).

3

Fig. 3. Dorsal habitus photograph of *Paradejeania colombiae* (holotype).

Texas. Specimens from the Pacific Coast states and British Columbia average darker in coloration than those occurring further inland, and were named *P. rutilioides nigrescens* Arnaud (Arnaud 1951). *Paradejeania colombiae* Arnaud remains known only from the male holotype from Colombia.

The biology of *Paradejeania* is poorly known. Arnaud (1951, 1968) has provided some notes on the habits of adult *P. rutilioides,* which are usually collected on flowers. He later (1974) reported the first host information for the genus, recording *P. rutilioides nigrescens* as being reared from a species of *Hemihyalea* (Lepidoptera: Arctiidae). More recently, Hsu and Powell (1992) gave a more detailed account of rearing *P. rutilioides* from *Hemihyalea edwardsii* (Packard) in California.

KEY TO SPECIES OF *PARADEJEANIA*

1. Upper and lower calypters yellowish; abdomen with pale portions tannish-yellow, blackish color variable in extent but not distinctly confined to apical region; general habitus in Fig. 1; British Columbia south to Costa Rica .... *P. rutilioides* (Jaennicke)

– Upper and lower calypters blackish; abdomen distinctly bicolored with yellow and black or mostly reddish brown 2

2. Abdomen with tergites 1–4 mostly bright yellow, black only on dorsomedial portion of syntergite 1 + 2 and with a medial spot posteriorly on tergite 4, tergite 5 nearly entirely black; wing with basicosta dark; scutellum appearing dark and concolorous with scutum to the naked eye; general habitus in Fig. 2; Dominican Republic .... ***P. xenisma*, new species**

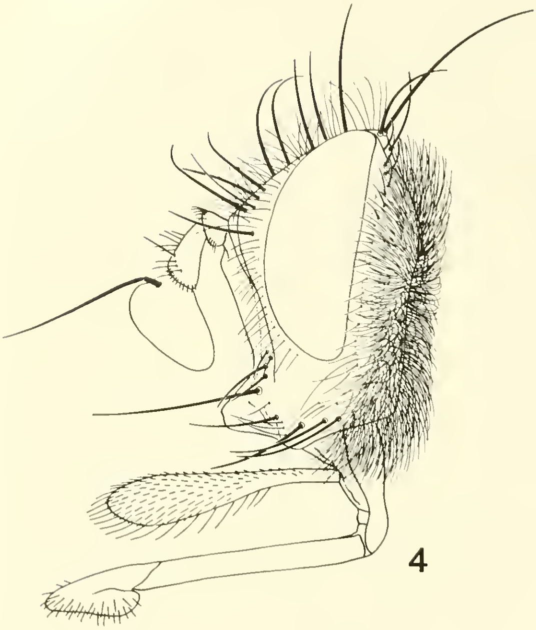
– Abdomen mostly reddish brown, with very limited, weakly contrasted blackish coloration on medial portion of syntergite 1 + 2, and small, posteromedial spots on tergites 3, 4, and 5; wing with basicosta yellow; scutellum brownish, nearly concolorous with abdomen; general habitus in Fig. 3; Colombia .... *P. colombiae* Arnaud

Paradejeania xenisma, New Species

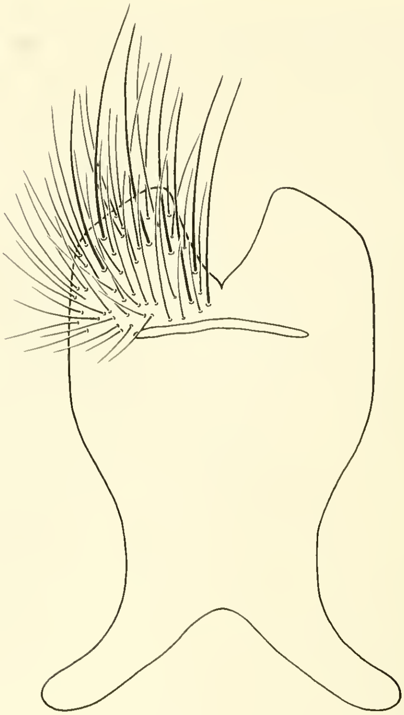
Description.—*Male:* Head (Fig. 4) and appendages brownish black to black, densely covered with silvery tomentum except along facial ridge, tomentum of frontal region more blackish and not shiny; hairs and setae of head black, except for dense white pilosity on occiput and postgena and a few pale hairs on lower part of genal dilation; frons at vertex 0.23 to 0.25 head width; antenna with first flagellomere strongly lobed posteriorly; arista with first segment about as long as wide, second 1.5 to 2.0 times longer than wide, third gradually tapered from base to apex; palpus 0.94 to 1.0 as long as eye height, strongly narrowed in basal third, terminal two-thirds spatulate, laterally compressed; setulae of palpus present on outer side, longest marginally, absent from inner side; prementum 0.97 to 1.03 as long as eye height; labella with short yellowish hairs. Thorax brownish black, with lateral areas of postsutural scutum, especially postalar calli, and more ventral areas of pleura more brownish; scutellum becoming distinctly brownish yellow apically; thorax entirely brownish gray tomentose, with faint indications of vittae on scutum, especially presuturally; fine hairs and setae of thorax entirely black; posterior katepisternal seta absent; wings strongly infuscated (darker than in other known species) dark brownish; tegula and basicosta both brownish, but the latter is slightly yellower posteriorly; upper and lower calypters very darkly infuscated, with concolorous, dense fringe of short marginal hairs; halter brownish, becoming yellowish on knob; legs mostly black, coxae somewhat more brownish; pulvilli yellowish, claws of tarsi brownish basally. Abdomen bright yellow, excepting the extreme anterior, declivous portions of syntergite 1 + 2 brownish black, a posteromedial black spot on tergite 4 that usually extends slightly anterior of the anteriorly displaced marginal setae, tergite five entirely black except for narrow posterior margin, and entire postabdomen black; hairs and major setae black; patch of setae behind marginal row on tergites three and four with fewer setae than in other known species, 4–5 on tergite three, 5–7 on tergite four; marginal row of setae on tergite three incomplete ventrally, a small gap occurring between those in lateral region and those at posteroventral corner of tergite; on tergite four the row is complete, uniserial to weakly biserial; both tergites three and four with more or less uniserial marginals laterally, thus the outline of the abdomen appears less spinose in dorsal view than in other known species; sternite four with a single row of setae. Terminalia very similar to those of *P. rutilioides*; epandrium (Fig. 6) short and deep, evenly rounded posteriorly in lateral view, densely setose dorsally; surstyli (Figs. 6, 7) long, slender, apex slightly expanded; cerci long, almost entirely fused except at extreme apices (Fig. 7), very broad in dorsal two-thirds, strongly narrowed ventrally, nearly parallel-sided but slightly expanded subapically, the separated, apical lobes parallel in posterior view, recurved anteriorly in lateral view (Fig. 6), strongly setose on dorsal two-thirds; fifth sternite (Fig. 5) with V-shaped medial emargination posteriorly, the resultant lobes truncately rounded, strongly setose. Length, 14.5 to 16.2 mm.

Female: Very similar to male in most respects, differing as follows: Head with frons 0.28 head width, with two proclinate orbital setae; first flagellomere more ovate, not as strongly lobed posteriorly. Thorax with tarsomeres 2–4 of front leg flattened and expanded laterally. Abdomen with fifth sternite and terminalia black, with black hairs. Length, 13.8 to 15.1 mm.

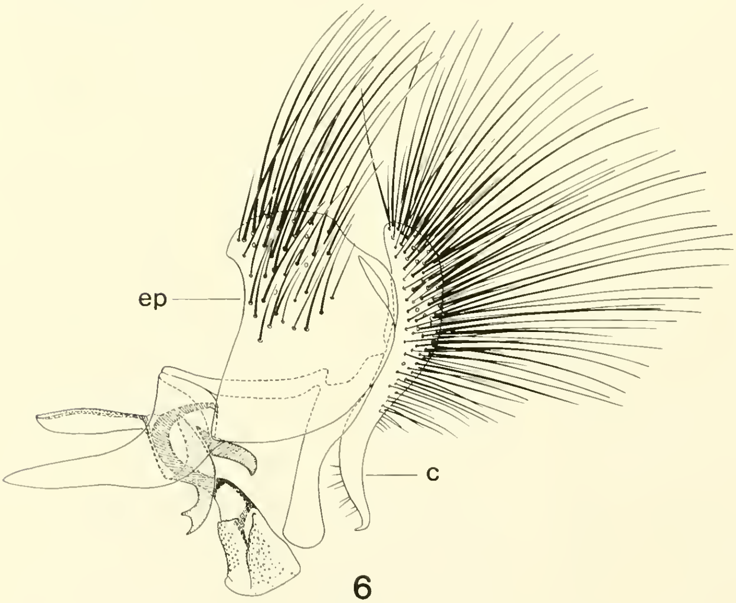
Material examined.—♂ holotype (USNM),



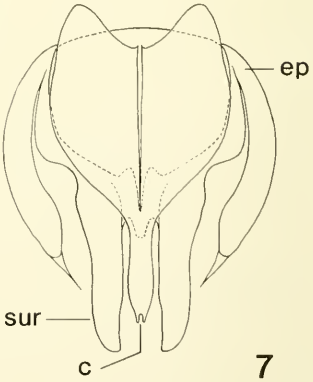
4



5



6



7

Figs. 4–7. Features of *Paradejeania xenisma.* 4, left lateral view of male head. 5, ventral view of fifth abdominal tergite. 6, left lateral view of male terminalia. 7, posterior view, in outline, of male terminalia. Abbreviations: c, cercus; ep, epandrium; sur, surstylus.

5 ♂ paratypes (USNM, CNC, GUE): DOMINICAN REPUBLIC: Independencia Province, 1 km E of El Aguacate, 18°20′N, 71°42′W, 950 m, 26 March 1984, F. M. Harrington, J. D. Weintraub, and N. E. Woodley; ♀ allotype (CNC), 2 ♀ paratypes (USNM, GUE): Pedernales Province, "Las Abejas," 7.3 km NNE of Las Mercedes, 18°09′N, 71°38′W, 1300 m, 19 January 1989, S. A. Marshall, J. E. Swann; ♂ paratype (USNM): Pedernales Province, "Las Abejas," 7.3 km NNE of Las Mercedes, 18°09′N, 71°38′W, 1100–1150 m, 23 August 1983, F. M. Harrington, J. D. Weintraub.

Etymology.—The species name, a noun in apposition, is from Greek, meaning amazement or surprise. This refers to the unexpected discovery of a *Paradejeania* in the Caribbean.

Remarks.—The discovery of this remarkable species on Hispanola extends the known range of *Paradejeania* several hundreds of miles. It is further remarkable in that its yellow and black color pattern is very similar to that found in some other tachinine genera in the Dejeaniini (e.g. *Adejeania* Townsend, *Protodejeania* Townsend) and Juriniini (e.g. *Xanthoepalpus* Townsend), but previously unknown in *Paradejeania*. The origin of this convergent color pattern is not known, but as not all species in some of the genera in which it occurs are so colored, some sort of mimicry is suggested. Because of its similar coloration, it was initially thought that *P. xenisma* might have been *Adejeania armata* (Wiedemann), which has a type locality of "Cuba." However, the type of *A. armata* has been discovered to be a well-known Brazilian species (D. M. Wood, from J. Butze, personal communication) of *Adejeania*, and the genus is not otherwise known to occur in the Caribbean.

The two localities at which *P. xenisma* was collected are in the Sierra de Baoruco in southwestern Dominican Republic. Both localities are in premontane wet forest areas that occur below the extensive pine forests found at higher elevations. The type locality is along the road just east of El Aguacate (which is very near the Haitian border) leading toward Duvergé. At the time of collection, this site consisted of a small patch of remnant forest vegetation along a south facing hillside paralleling the road. *Paradejeania xenisma* was found flying very rapidly along the ground and around low shrubs, rarely alighting. Individuals were very difficult to capture; numerous individuals were observed but not caught. It is likely that they frequent flowers as do other Dejeaniini. The "Las Abejas" locality in Pedernales Province is described floristically by Fisher-Meerow and Judd (1989).

ACKNOWLEDGMENTS

I am very grateful to the staff of the Alcoa Exploration Company (now Ideal Dominicana), particularly Srs. Garcia, Reyes, and Kelly, for hospitality and use of the guest house at Cabo Rojo, Dominican Republic, during two collecting trips to the region. Jason Weintraub and Mimi Harrington were pleasant field colleagues during the 1984 trip, and provided a specimen of *P. xenisma* from an earlier trip. Stephen A. Marshall at the University of Guelph, Ontario, Canada (GUE) kindly loaned the specimens from his collecting trip. I thank Randall T. Schuh for the loan of the holotype of *P. colombiae* from the American Museum of Natural History, New York. Linda Lawrence of the Systematic Entomology Laboratory rendered Fig. 4 and inked Figs. 6 and 7. T. Britt Griswold provided the habitus photographs. Wayne N. Mathis, D. M. Wood, R. J. Gagné, and John Kingsolver kindly read the manuscript, providing useful criticism.

LITERATURE CITED

Arnaud, P. H., Jr. 1951. A study of the genus *Paradejeania* Brauer and Bergenstamm (Diptera: Tachinidae or Larvaevoridae). Canadian Entomologist 83: 317–329.

———. 1968. Occurrence of *Paradejeania rutilioides nigrescens* (Diptera: Tachinidae) in San Francisco, California. Pan-Pacific Entomologist 44: 85–86.

———. 1974. *Paradejeania rutilioides nigrescens* Arnaud reared from *Hemihyalea* sp. (Diptera: Tachinidae; Lepidoptera: Arctiidae). Pan-Pacific Entomologist 50: 93.

Brauer, F. and J. E. von Bergenstamm. 1893. Die Zweiflügler des Kaiserlichen Museums zu Wien. VI. Vorarbeiten zu einer Monographie der Muscaria Schizometopa (exclusive Anthomyidae). Pars III. Denkschriften der Mathematische-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften (Wien) 60: 89–240.

Coquillett, D. W. 1910. The type-species of the North American genera of Diptera. Proceedings of the United States National Museum 37: 499–647.

Fisher-Meerow, L. L. and W. S. Judd. 1989. A floristic study of five sites along an elevational transect in the Sierra de Baoruco, Prov. Pedernales, Dominican Republic. Moscosoa 5: 159–185.

Hsu, Y. and J. A. Powell. 1992. *Hemihyalea edwardsii* (Packard) (Lepidoptera: Arctiidae) is the host of *Paradejeania rutilioides* (Jaennicke) (Diptera: Tachinidae) in central coastal California. Pan-Pacific Entomologist 68: 64–65.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 189–194

NEW SYNONYMY OF *EPOCHRA* LOEW WITH *EUPHRANTA* (*RHACOCHLAENA* LOEW) (DIPTERA: TEPHRITIDAE) AND DESCRIPTION OF A NEW SPECIES FROM MEXICO

Allen L. Norrbom

Systematic Entomology Laboratory, USDA, ARS, PSI, % U.S. National Museum, NHB 168, Washington, D.C. 20560, U.S.A.

Abstract.—The generic name *Epochra* Loew (1873) is synonymized with *Rhacochlaena* Loew (1862), a subgenus of *Euphranta* Loew. A new species, ***Euphranta mexicana,*** is described from specimens reared from fruit of *Ribes pringlei* Rose in Morelos, Mexico. The male and female terminalia of *Euphranta canadensis* (Loew), n. comb., are also described. A species of *Biosteres* (Braconidae) is reported to parasitize *E. mexicana.*

Resumen.—El nombre genérico *Epochra* Loew (1873) se sinonimiza con *Rhacochlaena* Loew (1862), un subgénero de *Euphranta* Loew. Se describe una nueva especie, ***Euphranta mexicana,*** con especímenes criados de frutos de *Ribes pringlei* Rose en Morelos, México. También, se describen las terminalia del macho y de la hembra de *Euphranta canadensis* (Loew), comb. n. Además, se registra una especie de *Biosteres* (Braconidae) que parasita *E. mexicana.*

Key words: *Euphranta, Epochra,* Tephritidae, fruit flies, *Ribes*

Most genera of the tribe Euphrantini (Diptera: Tephritidae) are restricted to the Old World tropics, although at least 12 of the approximately 90 known species of *Euphranta* Loew occur in the Palearctic Region. Until recently the tribe was thought not to occur in the New World, but A. Freidberg (pers. comm.) and Foote et al. (in press) discovered that the Nearctic genus *Epochra* Loew has a setulose anatergite and therefore belongs in the Euphrantini. Upon further examination, Freidberg and I found no significant differences between it and *Euphranta* subgenus *Rhacochlaena* Loew, so I therefore consider *Epochra* a subjective junior synonym of *Rhacochlaena.*

Hardy (1983), White (1988), Korneyev (1990), and White and Elson-Harris (1992) summarized the limited but diverse biological data that are known for the species of *Euphranta.* Both Nearctic species, including the new central Mexican species described in this paper, breed in fruit of species of *Ribes* L. (Saxifragaceae).

The terminology used in this paper follows McAlpine (1981), and for the wing bands, Foote (1981, Fig. 71).

Euphranta subgenus *Rhacochlaena* Loew

Rhacochlaena Loew 1862: 50 (type species *Trypeta toxoneura* Loew, by monotypy); see Hardy 1983 and White 1986 for additional synonymy.

Epochra Loew 1873: 238 (type species *Trypeta canadensis* Loew, by monotypy). **New Synonymy.**

Diagnosis.—The two New World species of *Euphranta* can be distinguished from all other American genera of Tephritidae by their setulose anatergite. Their lack of presutural supra-alar and posterior orbital setae are also useful diagnostic characters.

Remarks.—The type species of *Rhacochlaena* and *Epochra* do not differ in chaetotaxy, wing venation or other characters that Hardy (1983) and Hancock (1986) use to separate the genera of Euphrantini. In particular, the acrostichal (prescutellar) setae are present, which is the main character used to distinguish *Rhacochlaena* from the subgenus *Euphranta*. Phylogenetic relationships among the species of *Euphranta* have not been analyzed, but *E. toxoneura* and *E. canadensis* appear to be relatively closely related. They are among the species with short aristal hairs and with the subapical wing band interrupted in cell r$_{2+3}$. Their distiphalli and aculei also are very similar (compare Fig. 2E–F with White 1988, Figs. 33–34). I therefore see no reason to recognize *Epochra* as a separate taxon.

Key to the Nearctic Species of *Euphranta* (*Rhacochlaena*)

Wing (Fig. 1C) with discal band (band across r-m) interrupted in cell r$_{2+3}$, its anterior part equidistant from its posterior part and subapical band (band across dm-cu). Apical band not connected to discal band along Costa, not extended into cell r$_1$. Discal and subapical bands broadly connected posteriorly, no hyaline space between them in cell cu$_1$. Scutum mostly dark brown or bluish gray. [Central Mexico.] . . . . *mexicana* Norrbom, n. sp.

Wing (Fig. 1A, B) with discal band (band across r-m) uninterrupted and anteriorly well separated from subapical band (band across dm-cu). Apical band narrowly connected to discal band along Costa in cell r$_1$. Discal and subapical bands usually separated by hyaline space in cell cu$_1$. Scutum orange brown. [Canada, northern and western U.S.A. south to mountains of California and New Mexico.] . . . . *canadensis* (Loew)

Euphranta* (*Rhacochlaena*) *mexicana
Norrbom, New Species
(Fig. 1C, 2A, C)

Holotype.—♂ (USNM), MEXICO: Morelos: Lagunas de Zempoala, reared ex. fruits of *Ribes pringlei* Rose (89M13) collected 10–11.VIII.1989, emerged 5.X.1989, A. L. Norrbom.

Paratype.—♂ (USNM), same data as holotype (teneral, wings not expanded).

Diagnosis.—*E. mexicana* can be recognized from *E. canadensis* by the characters given in the key, by its wider apical spot in cell r$_{4+5}$ (Fig. 1C), and by its shorter inner surstylus (Fig. 2A, C) and aedeagus. Although the female of *E. mexicana* is unknown, its syntergosternite 7 probably is shorter than that of *E. canadensis*, because the length of that structure is usually correlated with that of the aedeagus. Of the nine Palearctic species of the subgenus *Rhacochlaena*, *E. toxoneura* (Loew), *E. licenti* Zia, *E. japonica* (Ito), and *E. transmontana* (Ito) have wing patterns most similar to *E. mexicana*, with the discal band interrupted and the subapical band not extended anteriorly through cell r$_{2+3}$. They differ from *E. mexicana* in that the apical band is extended into cell r$_1$, and the discal and subapical bands are separated posteriorly. Also, in some of these species, the subbasal band is interrupted in cells r$_1$ and r$_{2+3}$.

Description.—*Head:* Ocellar seta absent; 1 orbital seta, posterior seta absent; 3 frontal setae, middle one closer to anterior than to posterior seta; arista short pubescent. *Thorax:* Generally pale brown; scutum mostly dark bluish gray or dark brown, sides and broad medial postsutural stripe pale brown; scutellum pale brown; mediotergite and subscutellum dark brown; mesonotum 2.00 mm long; thorax entirely microtrichose (except scutum medially, anterior to scapular setae), scutum with 2 paired stripes that appear shiny or darker at some angles because of microtrichia of different density or shape—these include 1 submedial stripe from anterior margin to about halfway between transverse and scuto-scutellar sutures, and 1 sublateral stripe, interrupted at transverse suture but extended to intra-alar seta; inner and outer scapular setae present; presutural supra-alar seta absent; 1 post-

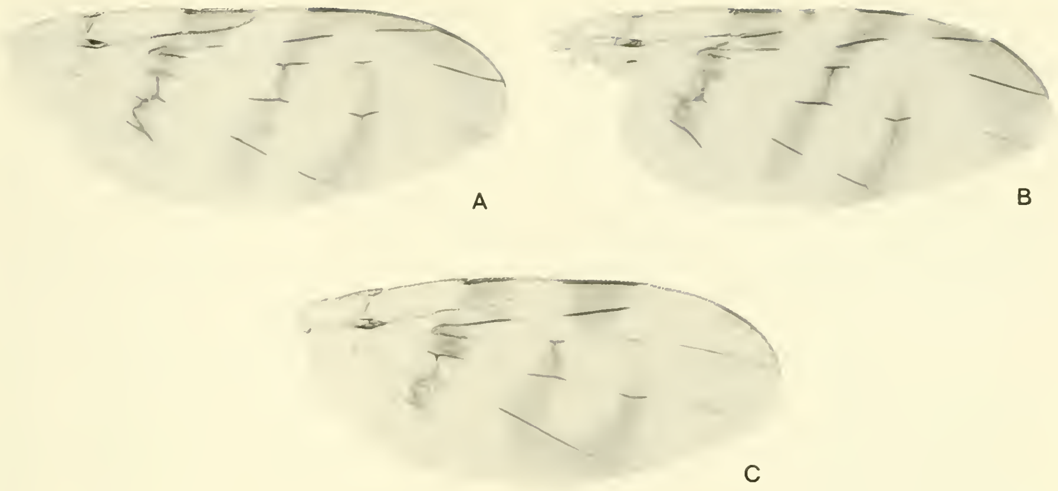


Fig. 1. Wings: A, *E. canadensis*, Chaffee Co., Colorado; B, same, Modoc Co., California; C, *E. mexicana*, holotype.

pronotal, 2 notopleural, 1 postsutural supra-alar, 1 intra-alar, 1 postalar, 1 acrostichal, 1 dorsocentral, 2 scutellar, 1–2 large anepisternal, 1 anepimeral, and 1 katepisternal seta present; dorsocentral seta closer to acrostichal seta than to postsutural supra-alar seta; anatergite with long fine setae. *Legs:* entirely pale brown; femora without ventral spines; mid tibia with 1 large ventroapical spinelike seta. *Wing* (Fig. 1C): Length 4.99 mm; subbasal band complete, extended anteriorly into stigma, separated from discal band; discal band interrupted in cell r_{2+3}, its anterior part broad and equidistant from its posterior part and anterior end of subapical band; discal and subapical bands broadly connected posteriorly, hyaline area between them in cell dm not extended across vein Cu_1; apical band not extended into cell r_1, and isolated from discal band, in cell r_{4+5} very broad, extended more than halfway to dm-cu. *Abdomen:* Terga dark brown, except terga 3 and 4 yellow medially, and terga 1 + 2 and 5 yellow posteromedially. *Male terminalia:* Surstyli (Fig. 2A, C) very long, outer surstylus 0.45 mm long; inner surstylus 0.78 times as long as outer surstylus; aedeagus 1.12 mm long, 0.56 times as long as mesonotum; distiphallus similar to *E. canadensis.*

Biology.—*Ribes pringlei* is a shrub or understory tree at Lagunas de Zempoala, a site at approximately 3000 m altitude. Approximately 20 percent of the fruits collected were infested. The larvae were heavily parasitized by a braconid wasp (*Biosteres* n. sp. near *sanguineus* (Ashmead)); 50 wasp adults, but only two adults of *E. mexicana,* emerged from the sample of fly puparia.

Euphranta (*Rhacochlaena*) *canadensis,*
New Combination
(Fig. 1A, B, 2B, D–G)

Trypeta canadensis Loew 1873: 235.
Epochra canadensis: Loew 1873: 238; see Foote et al. (in press) for full synonymy, distribution, host and type data.

Description.—*Head:* Ocellar seta minute or absent; 1 orbital seta, posterior seta absent; 3 (rarely 4) frontal setae, middle one usually closer to anterior than to posterior seta; arista short pubescent. *Thorax:* Generally pale brown; scutum mostly orange or

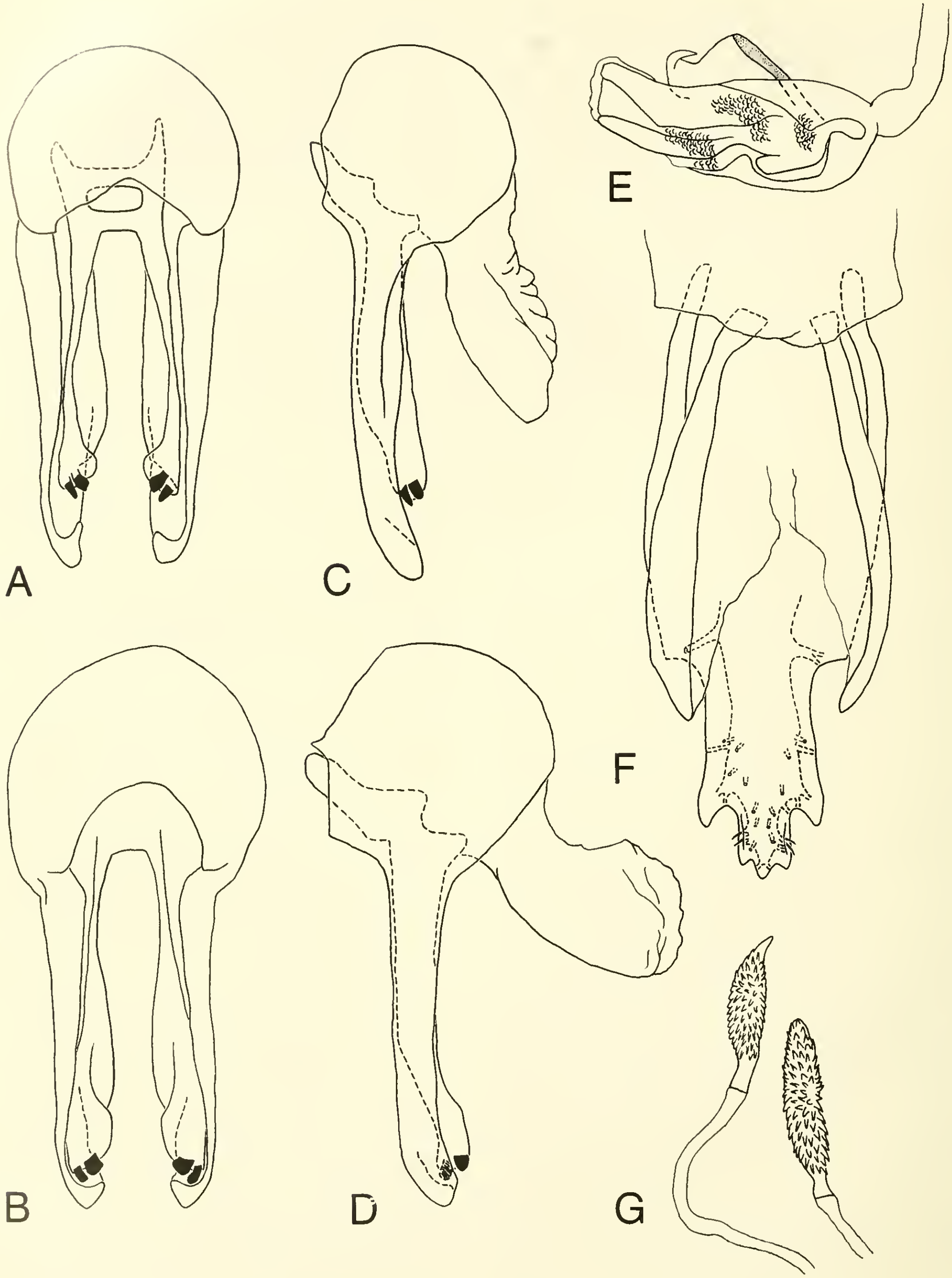


Fig. 2. Terminalia: A, C, *E. mexicana*; B, D–G, *E. canadensis*; A, B, epandrium, surstyli and proctiger, posterior view; C, D, epandrium and surstyli, lateral view; E, distiphallus, lateral view; F, aculeus, ventral view; G, spermathecae (2 of 3).

pale brown, with grayish microtrichia, rarely with brown postsutural sublateral stripe; scutellum pale brown, often with broad medial brown spot; mediotergite and subscutellum typically yellow with T-shaped dark-brown mark, but sometimes more extensively yellow or brown; mesonotum 1.83–2.70 mm long; thoracic chaetotaxy and scutal microtrichia as in *E. mexicana,* with stripes appearing shiny or darker than rest of scutum at some angles. *Legs:* Orange, other characters as in *E. mexicana. Wing* (Fig. 1A, B): Length 4.94–6.17 mm; discal and subapical bands usually separated posteriorly (connected in posterior half of cell cu_1 in only 1♀ from Maine and 1♂ from Alberta among 83 specimens examined); apical band extended into cell r_1 and narrowly connected to discal band, in cell r_{4+5}, extended at most halfway to dm-cu. *Abdomen:* Terga yellow, each especially terga 4 and 5, often with mediolateral dark brown spot or band of varying size. *Male terminalia:* Surstyli (Fig. 2B, D) very long, outer surstylus 0.40–0.45 mm long; inner surstylus 0.90–0.95 times as long as outer surstylus; aedeagus 2.08–2.54 mm long, 0.93–1.08 times as long as mesonotum; distiphallus (Fig. 2E) stout, surface largely covered with minute platelike or scalelike sculpture (extent of this difficult to determine). *Female terminalia:* Syntergosternite 7 1.49–1.74 mm long, 0.75–0.79 times as long as mesonotum; aculeus relatively short and broad, 0.59–0.65 mm long, 0.35–0.38 times as broad as long, tip (Fig. 2F) with 3 pairs of strong steps or lobes; 3 spermathecae (Fig. 2G) long and slender.

Remarks.—Specimens of *E. canadensis* from the Pacific Coast states generally have an apical hyaline spot in cell r_{4+5} (Fig. 1B) that is usually absent in specimens from farther east (Fig. 1A). The presence of this spot is variable in series of specimens from the same localities in Maine, Idaho, and Washington, however, and I found no correlation between it and other variable characters. The connection of the apical band with the discal band distinguishes *E. canadensis* from the nine Palearctic species of *Rhacochlaena* as well as from *E. mexicana*; *E. incompleta* Hardy, from Borneo, perhaps has the most similar wing pattern. White and Elson-Harris (1992: 344) recently redescribed the third-instar larva of *E. canadensis.*

Specimens examined.—83 specimens from Alberta, British Columbia, California, Colorado, Idaho, Maine, New Mexico, Oregon, Utah, Washington, and Wyoming.

ACKNOWLEDGMENTS

I am grateful to A. Freidberg (Tel Aviv University) for permission to include information about the relationships of *Epochra* that we discovered jointly. S. F. Smith (Dept. of Botany, Smithsonian Institution) kindly identified the specimens of *Ribes pringlei,* and P. M. Marsh (Systematic Entomology Lab.) and R. A. Wharton (Texas A&M University) identified the braconid wasps. T. B. Griswold prepared the wing illustrations. R. J. Gagné, A. Freidberg, V. Hernández, A. S. Menke, H. Y. Han, and I. M. White provided useful suggestions in their reviews of the manuscript.

LITERATURE CITED

Foote, R. H. 1981. The genus *Rhagoletis* Loew south of the United States (Diptera: Tephritidae). United States Department of Agriculture, Technical Bulletin no. 1607, 75 pp.

Foote, R. H., F. L. Blanc, and A. L. Norrbom. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Cornell University Press, Ithaca. (In press.)

Hancock, D. L. 1986. Classification of the Trypetinae (Diptera: Tephritidae), with a discussion of the Afrotropical fauna. Journal of the Entomological Society of Southern Africa 49:275–305.

Hardy, D. E. 1983. The fruit flies of the tribe Euphrantini of Indonesia, New Guinea, and adjacent islands (Tephritidae: Diptera). International Journal of Entomology 25: 152–205.

Korneyev, V. A. 1990. Fruit flies of the subfamilies Phytalmiinae, Acanthonevrinae and Adraminae (Diptera, Tephritidae) from Soviet Far East. pp. 116–125. *In* Lelej, A. S., S. Y. Storozhenko, and N. A. Storozheva, eds., News of Insects Systematics of Soviet Far East. Far East Branch of the USSR Academy of Sciences, Vladivostok, 136 pp.

Loew, H. 1862. Die Europäischen Bohrfliegen (Trypetidae). W. Junk, Vienna. 128 pp.

———. 1873. Monographs of the Diptera of North America, pt. III. Smithsonian Miscellaneous Collections 11 (no. 256): 1–351.

McAlpine, J. F. 1981. Morphology and terminology—Adults, pp. 9–63. *In* J. F. McAlpine et al., coordinators, Manual of Nearctic Diptera, vol. 1, Agriculture Canada, Monograph No. 27. Ottawa.

White, I. M. 1986. A new species of *Paroxyna* Hendel and notes on the nomenclature of other British Tephritidae (Diptera). Entomologist's Monthly Magazine 122: 145–163.

———. 1988. Tephritid flies, Diptera: Tephritidae. Handbooks for the Identification of British Insects 10(5a): 1–134.

White, I. M. and M. M. Elson-Harris. 1992. Fruit Flies of Economic Significance: Their Identification and Bionomics. C.A.B. International, Wallingford, U.K. 601 pp.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 195–209

NEW SPECIES AND PHYLOGENETIC ANALYSIS OF *EUARESTA* LOEW (DIPTERA: TEPHRITIDAE), WITH A KEY TO THE SPECIES FROM THE AMERICAS SOUTH OF MEXICO

Allen L. Norrbom

Systematic Entomology Laboratory, USDA, ARS, PSI, % U.S. National Museum, NHB 168, Washington, D.C. 20560, U.S.A.

Abstract.—***Euaresta regularis***, n. sp., and ***E. versicolor***, n. sp., are described based on specimens from southern Brazil, and *E. toba* (Lindner) and *E. reticulata* (Hendel) are redescribed. A lectotype is designated for *E. toba*, and *Tephritis apicata* Becker is considered a new synonym of *E. reticulata*. A key to species of *Euaresta* south of Mexico is provided, and a preliminary analysis of relationships among all the species of *Euaresta* is presented. New host plant and distribution data are reported for *E. toba* and *E. regularis*.

Resumen.—Se describen ***Euaresta regularis***, sp. n., y ***E. versicolor***, sp. n., de especimenes del sur de Brasil, y también *E. toba* (Lindner) y *E. reticulata* (Hendel). *Tephritis apicata* Becker es un sinónimo nuevo de *E. reticulata*. Se provee una clave a las especies de *Euaresta* del sur de México, y se presenta un análisis de las relaciones entre todas las especies de *Euaresta*. Se avisan registros nuevos de plantas huepedes y de distribución de *E. toba* y *E. regularis*.

Key Words: Fruit flies, Tephritidae, *Euaresta*, *Ambrosia*, *Xanthium*

Species of *Euaresta* Loew breed in ragweeds and cockleburs of the closely related composite genera *Ambrosia* L. and *Xanthium* L. (Asteraceae: Heliantheae) (Foote 1984). Because some of their host plants cause health problems (hayfever and other allergic reactions) and others are agricultural weeds, various *Euaresta* species have been investigated or introduced as biological control agents. In this paper I provide a key to the seven species of *Euaresta* known from Central and South America, only four of which were included in the most recent key (Aczél 1952). I also describe two new species closely related to *E. toba* (Lindner), redescribe the latter species and *E. reticulata* (Hendel), report new host data, and present a preliminary analysis of relationships among all of the species of *Euaresta*.

Materials and Methods

The morphological terminology used in this paper follows McAlpine (1981) and Norrbom and Kim (1988). The length of syntergosternite 7 was measured ventrally on undissected specimens. It may be slightly underestimated because the extreme base of this sclerite is often hidden by sternite 6. The length of the aedeagus, including the distiphallus, was measured (with difficulty) by stretching it to its full extent. Sample sizes included at least 5 males and 5 females, except in *E. versicolor* Norrbom, n. sp. Phylogenetic relationships were analyzed using Henning86 (Farris 1988, Fitzhugh 1989). Additional details are explained in the Relationships section. The following acronyms are used for depositories of specimens:

AMNH—American Museum of Natural History; BMNH—Natural History Museum (formerly British Museum [Natural History]), London; CAS—California Academy of Sciences; CMP—Carnegie Museum of Natural History, Pittsburgh; CNC—Canadian National Collection; DEI—Deutches Entomologisches Institut (formerly Institut für Pflanzenschutzforschung), Eberswalde; IML—Instituto Miguel Lillo, Tucumán; MCZ—Museum of Comparative Zoology, Harvard University; MNHNP—Muséum National d'Histoire Naturelle, Paris; MSUL—Michigan State University; NMW—Naturhistorisches Museum, Wien; SMNS—Staatliches Museum für Naturkunde, Stuttgart; SMT—Statliches Museum für Tierkunde, Dresden; UCD—University of California, Davis; USP—Museu de Zoologia, Universidade de São Paulo; USNM—National Museum of Natural History, Smithsonian Institution; USU—Utah State University, Logan; ZMUM—Zoological Museum, University of Moscow.

Taxonomic Synopsis of *Euaresta*

Species of *Euaresta* may be distinguished from other Tephritidae by the following combination of characters: postocular setae mixed short acuminate and long, swollen, white; scutal setulae swollen, white; 2 orbital setae, posterior one reclinate; dorsocentral seta closer to transverse suture than to level of postsutural supra-alar seta; parafacial spot absent; 1–2 scutellar setae (if 1, anterior notopleural seta absent); 2 frontal setae (1 in male of *E. versicolor*); head higher than long; mouthparts not geniculate, labella short; wing reticulate, with extensive markings on basal half; hind femur with anterodorsal and posterodorsal preapical setae; male fore femur swollen (except in *E. versicolor*); epandrium broad, often (*bullans* group) with striations on posterior surface.

Foote (1980) and Foote et al. (in press) provide keys by which *Euaresta* may be separated from other American genera. In *E. toba, E. regularis* Norrbom, n. sp., and *E. versicolor,* the apical pair of scutellar setae are small or absent, which may cause them to be misidentified as species of *Lamproxynella* Hering or *Dyseuaresta* Hendel. These three species may be be distinguished from all other American tephritid taxa by the absence of the anterior notopleural seta. Males of *Euaresta* may be recognized from other Tephritini by their swollen fore femur (except in *E. versicolor*) and by their broad, often posteriorly striate epandrium. Foote's (1980: 28) comment that these characters occur elsewhere in the Tephritini to my knowledge is incorrect. The species to which he referred in his discussion of *Plaumannimyia* belong in *Euaresta.* The male of *E. versicolor* is unusual in having only one frontal seta and small ocellar and orbital setae.

Euaresta is endemic to the Americas, although several species have been introduced into the Old World. With the addition of the two species described here, it includes a total of 14, although there are probably additional cryptic species in the *E. bellula* complex (Berlocher 1984). Some species have been placed in *Camaromyia* Hendel, now generally recognized as a synonym of *Euaresta.* Foote et al. (in press) reviewed the Nearctic species. In South America, seven species are now recognized. The most recent revision, by Aczél (1952), included *E. bullans, E. meridionalis* Aczél, *E. philodema* (Hendel), and *E. toba.* Steyskal (1972) transferred *E. reticulata* (Hendel) to *Euaresta* from *Plaumannimyia* Hering, and *E. versicolor* Norrbom, n. sp., and *E. regularis* Norrbom, n. sp., are described here.

Biology and Economic Importance

Species of *Euaresta* breed in the female flowers or developing seeds of their hosts. Foote (1984) summarized the known host data for the North American species. Those that have been released as biological control agents in the Old World include: *E. aequalis* (Loew), introduced to Australia and Fiji to control common cocklebur, or Noogoora burr, *X. strumarium* L. (= *pungens* Wallr.); *E. bella* (Loew), released in eastern Europe to control common ragweed, *A. artemisiifolia* L.; and *Euaresta bullans* (Wiedemann), introduced, in some cases accidentally (Currie 1940), from South America to California, Europe, the Middle East, South Africa, and Australia, where it attacks spiny cocklebur, or Bathurst burr, *X. spinosum* L.

Host plant information is not as complete for the Neotropical species as for the Nearctic species of *Euaresta*, but hosts are known for four of the South American species. *Euaresta regularis* has been reared from *Ambrosia polystachya* DC. (C. Garcia, pers. comm.), and *E. toba* from *Ambrosia elatior* L. (R. McFadyen, pers. comm.), *A. tenuifolia* (H. Cordo, pers. comm.), and *A. cumanensis* H.B.K. (C. Garcia, pers. comm.). Both *E. bullans* and *E. philodema* breed in *Xanthium spinosum* and *X. catharticum* (Frias, in press; H. Cordo, pers. comm.). Aczél (1952) also erroneously listed *X. pungens* (a synonym of *X. strumarium*, the host of *E. aequalis*) as a host of *E. bullans*. In the book edited by Whyte that Aczél cited for this record, only the paper by Currie (1940) deals with *Euaresta*, and in that article, only *E. aequalis* is stated to attack *X. strumarium* (as *pungens*), and the only host given for *E. bullans* is *X. spinosum*.

PHYLOGENETIC RELATIONSHIPS

This project originally concentrated on the four Neotropical species of *Euaresta* treated in the Taxonomy section, but because some characters were observed that seemed to have phylogenetic significance throughout the genus, the study was expanded to include a preliminary analysis of relationships among all of the species. Table 1 lists the 13 characters used in the analysis, and the distributions of their states are shown in Table 2.

The following character states are considered autapomorphies for individual species and were not included in the analysis: the broad, orange frons, the dark legs and abdomen, the straight margin of male sternite 5, and the unusual male chaetotaxy and microtrichial patterns in *E. versicolor* (see description); the nonmicrotrichose male sternite 5 in *E. toba*; the elongate syntergosternite 7 in *E. regularis*; the reduced eye size, and the orange syntergosternite 7 in *E. aequalis*; the arista color and shape, and the male antenna color in *E. bullans* (see key); and the bicolored wing pattern, and the even distribution and small size of the reticulations in the proximal ⅔ of the wing in *E. reticulata* (see key and Foote 1980, Fig. 66).

Euaresta belongs to the tribe Tephritini (Foote et al., in press), but its exact relationships within the tribe remain unclear. Because its sister group is uncertain, I examined representative species of all other New World genera of Tephritini to determine character polarities by outgroup comparison. For characters for which only one state occurs in all other Tephritini (i.e. characters 1, 2, 3, 5, 10, 13), polarities within *Euaresta* were easily hypothesized. For characters that vary among other Tephritini (e.g. characters 6, 7, 9 and 12), where possible I hypothesized the polarity that makes the character state distribution most congruent with those of characters of unequivocal polarity. For example, with character 7 polarized as in Table 1, the distribution of its states is congruent with that of character 5; reversing its polarity would cause homoplasy in regard to character 5. For these characters, it is interesting to note that the state coded plesiomorphic by the above method also is the more common state among other Tephritini, although I do not mean to imply that the common equals primitive method of determining character polarity should be used to support the character analysis. The polarities of several characters (4, 8, 11) could not be determined. These were coded with alternate states in the outgroup in a variety of preliminary analyses with little effect on the resulting trees (e.g. two steps are required for

Table 1. Characters used in phylogenetic analysis of species of *Euaresta*. State 0 is considered plesiomorphic, and transformation series are linear unless otherwise stated.

1. Epandrium width: 0) not broader than high; 1) broader than high.
2. Male fore femur: 0) similar to that of female; 1) much broader than that of female.
3. Anterior notopleural seta: 0) present; 1) absent.
4. Apical scutellar seta: 0) distinctly differentiated; 1) small or absent. Presence of the apical seta varies among other Tephritini.
5. Epandrium shape: 0) posterior side convex, without distinct ridges; 1) posterior side flattened or concave, with distinct ridges.
6. Syntergosternite 7 setulae: 0) slender, yellow; 1) swollen, white. Both states occur among other Tephritini, but with this polarity the character state distribution is congruent with that of character 5.
7. Epandrium color: 0) dark brown to black; 1) light brown or orange. State 1 occurs rarely in other Tephritini, but with this polarity the character state distribution is congruent with that of character 5.
8. Thorax ground color: 0) dark brown; 1) orange. State 1 occurs rarely in other Tephritini. The character state distribution is incongruent with those of several other characters and causes homoplasy when either state is coded plesiomorphic.
9. Cell r_{2+3}, number of apical hyaline spots: 0) 2; 1) 1. Wing pattern is highly variable among other Tephritini, but with this polarity the character state distribution is congruent with that of character 5.
10. Cell br basal spot: 0) small or absent; 1) large.
11. Apical dark rays: 0) very broad; 1) narrow to moderately broad. This character is difficult to code for *E. aequalis*, *E. versicolor*, *E. toba*, and *E. regularis*. Its polarity is uncertain because wing pattern is highly variable among other Tephritini (see text).
12. Bulla (i.e. small, dark dorsal concave area) in middle of cell r_{4+5}: 0) absent; 1) sometimes weakly present; 2) distinctly present. Occurrence of a bulla is rare in other Tephritini, and with this polarity the character state distribution is congruent with that of character 5.
13. Abdominal tergite microtrichia: 0) entirely microtrichose; 1) only male tergite 5 and female tergites 5–6 largely bare of microtrichia; 2) tergites 3–4 bare laterally in addition to most of tergites 5–6; 3) only male tergite 5 bare of microtrichia, female tergites entirely microtrichose. Nonmicrotrichose abdominal areas are rare in other Tephritini (e.g. in *Lamproxyna* Hendel, some *Pseudoedaspis* Hendel, some Old World genera) and where present they occur in different patterns, suggesting that states 1–3 are independently derived in *Euaresta*. State 3 and states 1–2 probably are independently derived from state 0.

Host: Amb = hosts are species of *Ambrosia*; Xan = hosts are species of *Xanthium*. Hosts are not included as a character in the phylogenetic analysis, but are listed in Table 2 and in Fig. 1 for convenience of comparison.

Biogeographic region: Ne = Nearctic; Nt = Neotropical. Distributions are not included as a character in the phylogenetic analysis, but are listed in Table 2 and in Fig. 1 for convenience of comparison.

character 8 no matter which polarity is hypothesized for it because in both cases it is incongruent with several other characters). These are further discussed below.

Analysis of the matrix in Table 2 by the implicit enumeration option (ie*) of Hennig86 resulted in four trees of 20 steps (consistency index = 80, retention index = 88). Successive weighting did not reduce the number of trees. The original trees differ from the Nelson consensus tree (Fig. 1) in having either *E. aequalis*, *E. reticulata*, or both grouped with *E. bullans*, *E. philodema*, and *E. meridionalis*, depending upon the interpretation of characters #6 and #7. The Nelson tree therefore is one step longer (length = 21 steps, consistency index = 76, retention index = 86).

The following are the significant results of the analysis. The broad epandrium (character #1) is a synapomorphy for *Euaresta*. This state does not occur in any other Tephritini. The swollen male fore femur (#2) is probably another synapomorphy of the genus, with reversal to the plesiomorphic state in *E. versicolor*, but it also may be interpreted as a synapomorphy for *E. toba* + *E. regularis*, and another for the bullans group.

Euaresta includes two monophyletic

Table 2. Matrix of character state distributions, hosts, and biogeographical regions (Reg.) of species of *Euaresta*. Numbers and abbreviations refer to characters, states, hosts, and regions listed in Table 1.

Species	Character													Host	Reg.
	1	2	3	4	5	6	7	8	9	10	11	12	13		
toba	1	1	1	1	0	0	0	0	0	0	1?	0	0	Amb	Nt
regularis	1	1	1	1	0	0	0	0	0	0	1?	0	0	Amb	Nt
versicolor	1	0	1	1	0	0	0	0	0	0	0?	0	3	?	Nt
reticulata	1	1	0	0	1	1	0	0	0	0	0	0	0	?	Nt
aequalis	1	1	0	0	1	0	1	1	0	0	0?	0	0	Xan	Ne
philodema	1	1	0	0	1	1	1	0	1	0	0	0	0	Xan	Nt
bullans	1	1	0	0	1	1	1	0	1	1	0	0	0	Xan	Nt
meridionalis	1	1	0	0	1	1	1	0	1	1	0	0	0	?	Nt
tapetis	1	1	0	0	1	0	0	0	0	0	0	1	0	?	Ne
festiva	1	1	0	0	1	0	0	1	0	0	1	2	0	Amb	Ne
bella	1	1	0	0	1	0	0	0	0	0	1	2	0	Amb	Ne
stigmatica	1	1	0	0	1	0	0	0	0	0	1	2	1	Amb	Ne
bellula	1	1	0	0	1	0	0	0	0	0	1	2	2	Amb	Ne
jonesi	1	1	0	0	1	0	0	0	0	0	1	2	2	Amb	Ne

groups, the *toba* group and the *bullans* group. The *toba* group includes *E. toba, E. regularis,* and *E. versicolor,* for which the loss of the anterior notopleural seta (#3) and the reduced apical scutellar seta (#4) are synapomorphies. The relationships among *E. toba, E. regularis,* and *E. versicolor* are poorly resolved. The closer relationship of *E. toba* and *E. regularis* is weakly supported only by character #11, which is difficult to

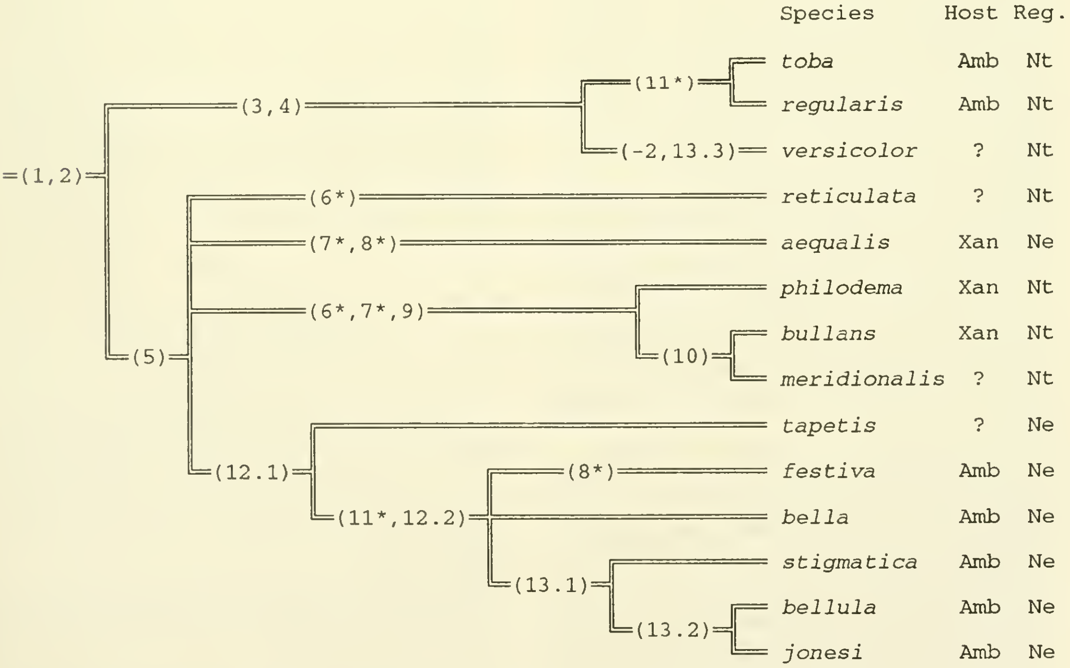


Fig. 1. Cladistic relationships among the species of *Euaresta*. Numbers and abbreviations refer to characters, states, hosts and distributions listed in Tables 1 and 2.

analyze (see below) and by one interpretation of character #2 (see above). Most characters that differentiate these three species are autapomorphies for one of them.

The *bullans* group includes all of the species of *Euaresta* other than *E. toba, E. regularis,* and *E. versicolor.* Its monophyly is supported by the shape of the epandrium, which is flattened or concave posteriorly, with strong ridges or striations (#5). Within the *bullans* group there are two monophyletic subgroups: *E. philodema, E. bullans,* and *E. meridionalis* form the *bullans* subgroup; and *E. tapetis, E. festiva, E. bella, E. stigmatica, E. bullula,* and *E. jonesi* comprise the *bella* subgroup. As stated above, *E. reticulata* is grouped most closely with the *bullans* subgroup by character #6, whereas *E. aequalis* is placed in this position by character #7.

The relationship of *E. tapetis* with the rest of the *bella* subgroup is based only on character state #12.1, which may not be reliable because the presence of a weak bulla in cell r_{4+5} is intraspecifically variable in *E. tapetis.* Also, if the polarity is reversed for character #11, which was difficult to code and polarize, some of the resulting trees group *E. tapetis* with the *bullans* subgroup, *E. aequalis,* and *E. reticulata.* A Hennig86 analysis of the matrix with the polarity reversed for character #11 produced 16 trees of 21 steps (consistency index = 0.76, retention index = 0.86). Except for sometimes placing *E. tapetis* with the *bullans* subgroup, they otherwise are similar to the trees of the first analysis except that the three species of the *toba* group sometimes form an unresolved trichotomy.

The hypotheses of phylogenetic relationships within *Euaresta* discussed above permit limited analysis of the biogeography of the genus. It should be noted that the introduction of *E. bullans* to California was presumably by man, sometime prior to 1903 when the types of *E. adspersa* Coquillett (= *bullans*) were collected. If the sister group of *Euaresta* is Neotropical, it is most parsimonious to assume that the genus originated in that region with two dispersals to North America, by the ancestor of the *bella* subgroup, and by *E. aequalis* or its ancestor. If the sister group is Nearctic or occurs in both regions, that hypothesis is equally likely to the following, that *Euaresta* originated in North America, with dispersals to South America by the ancestors of the *toba* group and *bullans* subgroup. Another dispersal event would be required if *E. aequalis,* rather than *E. reticulata,* is the sister group of the *bullans* subgroup.

The fact that all of the known hosts for *E. toba, E. regularis,* and the species of the *bella* subgroup are *Ambrosia* suggests that species of this plant genus may have been the original hosts of the common ancestor of *Euaresta.* Interesting questions that remain to be answered include whether all of the species that breed in *Xanthium* form a monophyletic group, and what the hosts are of the other species. If there has been only one shift from *Ambrosia* to *Xanthium* by *Euaresta,* the cladogram suggests that *E. versicolor* breeds in *Ambrosia,* and that *E. meridionalis* breeds in *Xanthium.* If *E. reticulata* is more closely related to the *bullans* subgroup than is *E. aequalis,* it probably also breeds in *Xanthium,* although if *E. aequalis* is closer, no host prediction can be made from the cladogram.

TAXONOMY

Euaresta toba (Lindner)
(Fig. 2A, 3A)

Camaromyia toba Lindner 1928: 29 (Lectotype [here designated] ♂ (SMNS), ARGENTINA: [FORMOSA: Puesto] Misión Tacaaglé [Cué (24°56′S, 58°46′W)], XI.1925, E. Lindner); Aczél 1950: 296 [catalog].

Euaresta toba: Aczél 1952: 165 [taxonomy, distribution, additional references]; Foote 1967: 24 [catalog].

Diagnosis.—The male of *E. toba* is distinguished from those of all of the other species of *Euaresta* south of Mexico by its shiny, nonmicrotrichose sternite 5. The female resembles that of *E. regularis,* but differs in having a shorter syntergosternite 7 and a less uniform wing pattern.

Description.—Body length 1.85–3.50 mm. Setae yellow. *Head:* Face white microtrichose. Frons yellow or gray, usually with distinct yellow ptilinal mark; at vertex 1.80–2.30 times as wide as eye. 2 frontal setae. 2 orbital setae. *Thorax:* Ground color mostly brown. Microtrichia dense, giving bluegray appearance. Mesonotum 0.69–1.09 mm long. Scutal microtrichia evenly white or gray. Scutal setulae all white or rarely all with orange tinge, evenly distributed except sometimes slightly denser along posterior margin. Anterior notopleural seta absent. Scutellum with setulae sometimes clustered; apical scutellar setae small, never longer than distance between basal setae, or sometimes absent. *Legs:* Entirely yellow. Male fore femur approximately 3 times as broad as fore tibia (distinctly broader than that of female). *Wing* (Fig. 2A): Extensively hyaline; cells br and dm more hyaline than brown, and with large basal hyaline areas; hyaline spots in cells br and dm, medial hyaline spots in cell r_{2+3}, and basal hyaline spot in cell r_{4+5} usually quadrate and as wide as cells containing them. Pattern of brown marks not uniform, marks uneven in size and distribution; cell cu_1 usually with basal brown mark large; brown mark in stigma and cells r_1, r_{2+3}, and br at least as wide as stigma. Stigma with large basal hyaline spot. Cell r_{2+3} with 2 marginal hyaline spots. Cell r_{4+5} with 2 subapical hyaline spots. *Male abdomen:* Tergites mostly yellow, often with large brown spot (usually paired), especially on tergite 5, occasionally mostly or entirely brown; setulae white, swollen, not clustered; microtrichia white, moderately dense, evenly distributed. Sternites 2–4 microtrichose. Sternite 5 (Fig. 3A) short trapezoidal, shiny, without microtrichia; posterior margin concave. Epandrium brown, similar in shape to *E. versicolor,* broad in posterior view (also see Aczél 1952, Fig. 29), but not strongly concave and without distinct ridges on posterior side. Aedeagus 0.91–0.95 mm long, 1.02–1.05 times as long as mesonotum. *Female abdomen:* Tergites yellow, often with large brown spot (usually paired), especially on tergites 4–6; setulae as in male. Tergites and sternites with moderately dense, evenly distributed, white microtrichia. Syntergosternite 7 brown, 0.59–0.83 mm long, 0.65–0.76 times as long as mesonotum; setulae yellow, acuminate. Aculeus tip (see Aczél 1952, Fig. 32) very slender, acute.

Remarks.—This is the most widespread Neotropical species of *Euaresta.* The record from El Salvador is the first for the genus from Central America. *Ambrosia cumanensis, A. tenuifolia,* and *A. elatior* are host plants (C. Garcia, H. Cordo, and R. McFadyen, pers. comm.). McFadyen (1976) also reported *A. tenuifolia* as a host, but this was a misidentification of *A. elatior* (R. McFadyen, pers. comm.).

Specimens examined.—Lectotype (see synonymy). ARGENTINA: Buenos Aires: Buenos Aires, 1♂1♀ (USNM); La Plata, Punta Lara, 30.XII.1969, Vardy, 1♀ (BMNH); San Isidro (Delta), S Bolle, I.1976, 4♂3♀ (CNC) 2♂1♀ (USNM). Chaco: Colonia Benitez, 7.XII.1949, R. Golbach, 2♂2♀ (IML). Cordoba: 19 mi N Taninga, emerged from seed head *Ambrosia tenuifolia,* 29.I.1990. 1♀ (USNM). Corrientes: 7 km SW Bella Vista, Hwy. 12, 16.I.1989, C. W. O'Brien, 1♀ (CAS). Entre Rios: La Paz, 14.XI (various years 1948–1961), M. Aczél, 2♂3♀ (IML) 2♀ (USNM). Formosa: Clorinda, XI.1947, I. Morel, 1♂ (IML); Isla de Cuba, 3.XII.1949, F. Monrós, 1♀ (IML); Lapango, XII.1926, E. Lindner, 1♀ paralectotype (SMNS); Puesto Misión Tacaaglé Cué, XI.1925, E. Lindner, 2♀ paralectotypes (SMNS). Misiones: Alto Parana, Bemberg, 1.XII.1933, K. J. Hayward, 1♀ (BMNH). Tucumán: Alpachiri, 29.XII.1949, Golbach, 2♂ (IML) 1♂1♀ (USNM); Cacavera, 23–28.XI.1951, Aczél, 1♂ (IML); Tucumán, fl. buds *Ambrosia ten-*

uifolia [misid. of *A. elatior*], XII.1975, R. E. McFadyen, 4♂4♀ (USNM). BRAZIL: Espirito Santo: Guaraparí, 25.I.1973, H. S. Lopes, 1♂ (USP). Para: Boca do Cuminá, Miri Oriximiná, Exp. Perm. Amaz., I.1968, 26♂17♀ (USP) 3♂4♀ (USNM). CHILE: Llanquihue, Casa Pangue, XII.1926, R. Shannon, 1♂ (USNM). Santiago, Cord. de la Costa, Cantillana, 2000 m, XII.1969, L. E. Peña, 9♂5♀ (USP) 3♂2♀ (USNM). COLOMBIA: Antioquia: Baranquilla, 5.X.1971, G. E. Bohart, 1♂1♀ (USU) 1♂ (USNM); Medellin, 2.X.1971, G. E. Bohart, 2♂2♀ (USU) 1♂1♀ (USNM). Boyacá: V. de Leiva, on flowers *A. cumanensis,* 30.VII.1991, C. Garcia, 1♂ (USNM). Cundinamarca: Fusagasugá, 1500 m, 15.X.1972, R. T. Schuh, 3♀ (AMNH) 1♀ (USNM). Tolima: Fresno, from seeds *Ambrosia cumanensis,* 3.VIII.1991, C. Garcia, 2♂2♀ (USNM). EL SALVADOR: San Salvador, X.1959, N. L. H. Krauss, 1♂ (USNM). PERU: 53 km N Chimbote, 16.III.1951, Ross, 1♀ (CAS); Chancay, river valley, 15.III.1951, Ross, 2♂ (CAS). URUGUAY: Montevideo: Montevideo, 15.I.1925, J. Tresnaleros, 1♂ (USNM). San José: Libertad, 4.III.1975, A. R. Wells, 3♂3♀ (MSUL) 1♂1♀ (USNM). VENEZUELA: Trujillo: La Mesa, 11.IX.1973, B. Villegas, 2♀ (UCD) 1♀ (USNM).

***Euaresta regularis* Norrbom, New Species**

(Fig. 2B, 3B)

Holotype.—♀ (USP), BRAZIL: São Paulo: Barueri, 4.XII.1965, K. Lenko.

Paratypes.—BRAZIL: Minas Gerais: Sapucai mirim Cidade Azul, 1400 m, 7.XI.1953, L. Trav., 1♀ (USP). Paraná: Curitiba, from seeds of *Ambrosia polystachya,* 12.VI.1992, C. Garcia, 1♀ (USNM); Jaquariaiva, 29.I.1974, J. G. Rozen, 1♀ (AMNH). São Paulo: Barueri, 4.XII.1965, K. Lenko, 2♂ (USP, USNM); same, 5.II.1966, 1♀ (USP); same, 3.II.1968, 7♂7♀ (USP, USNM); Barão de Antonina, Itaporanga, I.1946, M. P. Barreto, 3♀ (USP, USNM); Camp. do Jordão, III.1953, L. Travassos & E. Rabello, 1♂ (USP); Eug. Lefevre, 1.XI.1937, Travassos, 1♀ (USNM); Monte Alegre, Faz. N. S. Incarnacão, 750 m, 14–27.X.1942, L. Trav. & Almeida, 3♀ (USP, USNM): Osasco, Vulcanoe Martinez, 20.XI.1955, 1♀ (USP); São Jose dos Campos, X.1933, H. S. Lopes, 1♀ (USNM); Sumaré, 5.I.1941, M. Carrera, 1♂1♀ (USP).

Diagnosis.—*E. regularis* closely resembles *E. toba,* but can be distinguished by its more uniform wing pattern. The female can be easily recognized because it is the only species of *Euaresta* in which syntergosternite 7 is longer than the mesonotum.

Description.—Body length 1.85-3.30 mm. Setae yellow. *Head:* Face white microtrichose. Frons yellow or gray, usually with distinct yellow ptilinal mark; at vertex 1.90–2.5 times as wide as eye. 2 frontal setae. 2 orbital setae. *Thorax:* Ground color mostly brown. Microtrichia dense, giving bluegray appearance. Mesonotum 0.79–0.95 mm long. Scutal microtrichia evenly white or gray. Scutal setulae white, evenly distributed. Anterior notopleural seta absent. Scutellum with setulae usually not clustered; apical scutellar setae small, never longer than distance between basal setae, or sometimes absent. *Legs:* Entirely yellow. Male fore femur approximately 3 times as broad as fore tibia (distinctly broader than that of female). *Wing* (Fig. 2B): Extensively hyaline; cells br and dm more hyaline than brown, and with large basal hyaline areas; hyaline spots in cells br and dm, medial hyaline spots in cell r_{2+3}, and basal hyaline spot in cell r_{4+5} usually quadrate and as wide as cells containing them. Most brown marks similar in size, giving more or less uniform appearance to pattern; cell cu_1 with basal brown mark small; brown mark in stigma and cells r_1 and r_{2+3} narrower than stigma. Stigma with large basal hyaline spot. Cell r_{2+3} with 2 marginal hyaline spots. Cell r_{4+5} with 2 subapical hyaline spots. *Male abdomen:* Tergites usually mostly yellow or light brown, except tergite 5 often predominantly dark brown; setulae white, swollen, not clus-

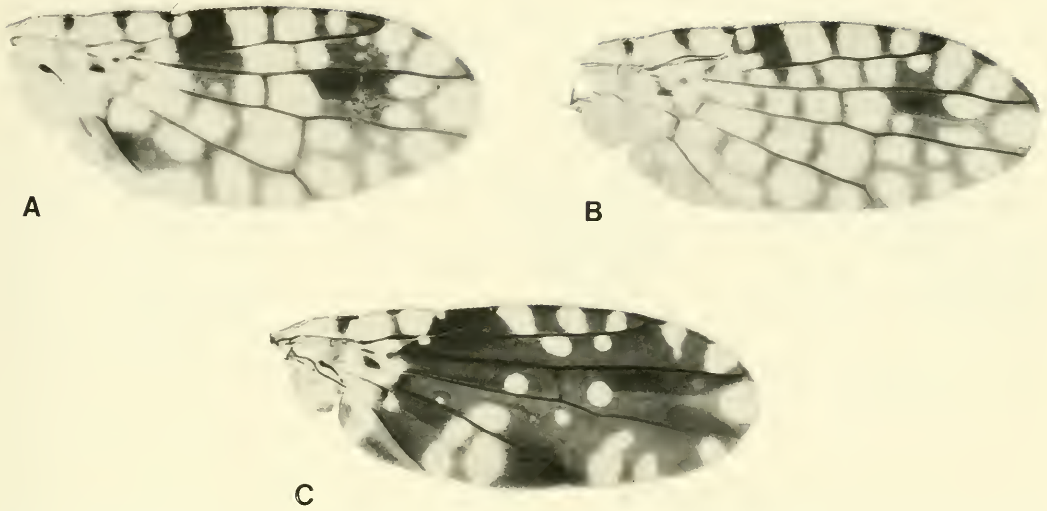


Fig. 2. Wings: A, *E. toba*, Brazil, Paraná, Boca do Cuminá; B, *E. regularis*, paratype, Brazil, São Paulo, Barueri; C, *E. versicolor*, holotype.

tered; microtrichia white, moderately dense, evenly distributed. Sternites 2–5 microtrichose. Sternite 5 (Fig. 3B) short trapezoidal; posterior margin concave. Epandrium brown, similar in shape to *E. versicolor*, broad in posterior view, but not strongly concave and without distinct ridges on posterior side. Aedeagus 1.11–1.41 mm long, 1.37–1.45 times as long as mesonotum. *Female abdomen:* Tergites yellow, often with large brown spot (usually paired). Setulae and microtrichia as in male. Syntergosternite 7 brown, 0.93–1.05 mm long, 1.09–1.20 times as long as mesonotum; setulae yellow, acuminate. Aculeus tip similar to *E. toba*, very slender, acute.

Remarks.—*Ambrosia polystachya* DC. is the only known host (C. Garcia, pers. comm.).

Etymology.—From the Latin, in reference to the uniform wing pattern.

Euaresta versicolor **Norrbom,**
New Species
(Fig. 2C, 3C–G)

Holotype.—♂ (USP), BRAZIL: São Paulo: Barueri, 25.X.1955, K. Lenko, 3528.

Paratypes.—Same data as holotype, 1♂ (USP); same except 6.XII.1965, 1♀ (USNM). BRAZIL: São Paulo: Cipó, 15.X.1976, V. Alin, 1♀ (ZMUM); Monte Alegre, Faz. N. S. Incarnacão, 750 m, 14–27.X.1942, L. Trav. & Almeida, 1♂ (USNM).

Diagnosis.—Both the male and female of *E. versicolor* can be distinguished from all other species of *Euaresta* by their dark femora and extremely broad, orange frons. The male also is easily distinguished by its orange presutural scutal setulae, its unusual microtrichial pattern on the abdomen, its single frontal seta and reduced ocellar and orbital setae, and by its relatively unswollen fore femur (similar in width to that of female). The presutural scutal setulae are also denser in both the male and female of *E. versicolor* than in other species. The abdominal tergites are entirely brown, whereas they usually are at least partially yellow in other species.

Description.—Body length 2.70–3.20 mm. Setae yellow to brown. *Head:* Face bright white microtrichose. Frons with broad medial orange band or mostly orange, in addition to yellow ptilinal mark; at vertex 2.95–3.39 times as wide as eye. 1 frontal seta in male, 2 in female. 2 orbital setae,

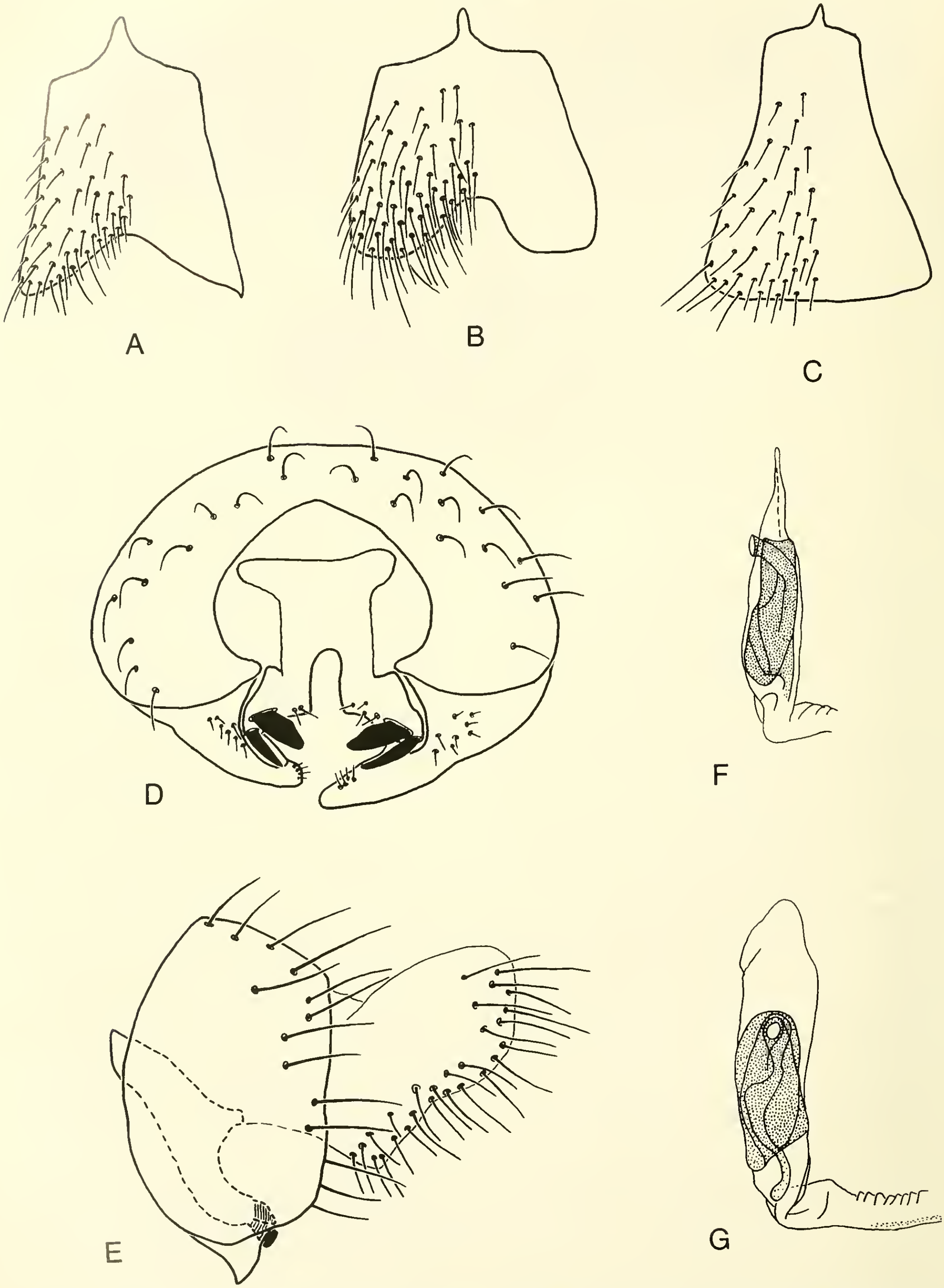


Fig. 3. Male terminalia: A, *E. toba,* Chile, Cordillera de la Costa; B, *E. regularis,* paratype, Brazil, São Paulo, Barueri; C–G, *E. versicolor,* paratype, Brazil, São Paulo, Barueri; A–C, sternite 5; D, epandrium and surstyli, posterior view; E, same, lateral view; F, distiphallus, ventral view; G, same, lateral view.

those and ocellar seta small in male. *Thorax:* Ground color mostly brown. Microtrichia dense, giving bluegray or brown appearance. Mesonotum 0.93–1.09 mm long. Scutal microtrichia white anteriorly; in female, gradually turned to gray posteriorly; in male, sharply turned to dark brown on posterior third of scutum and on scutellum. Scutal setulae small and dense anteriorly, sparse posteriorly except for row of larger setulae along margin; in male, presutural setulae bright orange. Anterior notopleural seta absent. Scutellum with cluster of small swollen white setulae; apical scutellar setae absent. *Legs:* Femora dark brown except apical ⅕–¼. Male fore femur approximately 2 times as broad as fore tibia and similar in width to that of female (in males of other species, it is 3 or more times as wide as the fore tibia). *Wing* (Fig. 2C): Mostly dark brown; cells br and dm more brown than hyaline; broad subbasal brown area from stigma to cell a_1 uninterrupted (in one specimen with small subbasal hyaline spots in cell dm); hyaline medial spots in cell r_{2+3}, basal hyaline spot in cell r_{4+5}, and all hyaline spots in cells br and dm usually ovoid and narrower than cell containing them. Stigma entirely brown or with small or large basal hyaline spot. Cell r_{2+3} with 2 marginal hyaline spots. Cell r_{4+5} with or without 1–2 subapical hyaline spots. *Male abdomen:* Tergites entirely brown; setulae yellow, acuminate except for subapical lateral tuft of small slightly swollen white setulae on syntergite 1 + 2. Syntergite 1 + 2 with dense black microtrichia in broad M-shaped pattern. Tergites 3–4 sparsely microtrichose, subshiny, except for narrow medial area of dense microtrichia. Tergite 5 without microtrichia. Sternites 2–5 microtrichose. Sternite 5 (Fig. 3C) elongate trapezoidal; posterior margin straight. Epandrium (Fig. 3D, E) brown, broad in posterior view, but not strongly concave and without distinct ridges on posterior side. Aedeagus 1.05 mm long, 1.13 times as long as mesonotum. *Female abdomen:* Tergites entirely brown; entirely and evenly lightly microtrichose; setulae all small, acuminate, yellow. Syntergosternite 7 brown, 0.71–0.75 mm long, 0.65–0.74 times as long as mesonotum; setulae yellow, acuminate. Aculeus tip similar to *E. toba,* very slender, acute.

Remarks.—The orbital setae may be difficult to recognize as such in the male because of their small size and location close to the eye due to the broad width of the frons in this species.

Etymology.—From the Latin, in reference to the colorful frons, microtrichia and setulae.

Euaresta reticulata (Hendel)

Trypanea reticulata Hendel 1914: 81 (Syntypes 10♂♀ (SMT, NMW), PERU: Lares Valley, 2000 m, 9.VIII; Cuzco, 3300 m, 19.VI; Tarma, 3000 m, 20.I; Sicuani, 19.VI; Arequipa, 19.XI; and Callabamba, 3000 m).

Tephritis apicata Becker 1919: 195 (Syntypes 5♂♀ (MNHNP, USP?), ECUADOR: environs of Tulcan; Riobamba, 2754 m; and Troya, 3513 m; 1902, Rivet). **New synonym.**

Plaumannimyia reticulata: Hering 1941: 158 [taxonomy; Peru]; Aczél 1950: 284 [catalog]; Foote 1967: 35 [catalog].

Plaumannimyia apicata: Foote 1967: 35 [catalog], 1980: 41.

Euaresta reticulata: Steyskal 1972: 130 [taxonomy; Colombia, Ecuador, Bolivia].

Diagnosis.—*E. reticulata* differs from all other species of *Euaresta* by its bicolored wing pattern, although based on this character alone it might be confused with some species of *Euarestoides* Benjamin and *Trypanaresta* Hering that have similar bicolored wings. Like other species of *Euaresta, E. reticulata* differs from *Euarestoides* in having 2 rather than 3 frontal setae, and from *Trypanaresta* in having a pair of small dorsal preapical setae on the hind femur.

Description.—Body length 2.90–4.40 mm. Setae yellow. *Head:* Face white microtrichose. Frons yellow or gray, usually with distinct yellow ptilinal mark; at vertex 1.75–1.95 times as wide as eye. 2 frontal setae. 2 orbital setae. Arista slender, brown except for slightly swollen basal ⅕ yellow. *Thorax:* Ground color mostly brown. Microtrichia dense, giving bluegray appearance. Mesonotum 1.13–1.76 mm long. Scutal microtrichia evenly white or gray. Scutal setulae white, evenly distributed. Anterior notopleural seta present. Scutellar setulae not clustered; apical scutellar seta present, usually at least as long as distance between basal setae. *Legs:* Entirely yellow. Male fore femur at least 3 times as broad as fore tibia (distinctly broader than that of female). *Wing* (see Foote 1980, Fig. 66): Almost entirely infuscated gray or light brown, with evenly distributed small hyaline spots, except for large dark brown subapical spot extended from apex of cell r_1 into cell m; apical rays extended from subapical spot also often darker than more basal infuscation. Hyaline spots in cells br, r_{2+3}, r_{4+5}, and dm usually ovoid and narrower than cells containing them. Cell dm with 6–9 hyaline spots. Stigma usually with 2 small hyaline spots. Cell r_{2+3} with 2 or rarely 3 marginal hyaline spots. Cell r_{4+5} with 2 subapical hyaline spots. *Male abdomen:* Tergites usually mostly brown (usually appearing bluegrey due to microtrichia) with yellow posterior margin, syntergite 1 + 2 and tergites 3–4 often more yellow with large brown spot (usually paired); setulae white, swollen, not clustered; microtrichia white, moderately dense, evenly distributed. Sternites 2–5 microtrichose. Sternite 5 short trapezoidal; posterior margin concave. Epandrium brown, strongly flattened or concave posteriorly, with distinct oblique ridges. *Female abdomen:* Tergites usually brown except posterior margin usually and middle sometimes yellow; setulae and microtrichia as in male. Syntergosternite 7 brown, 0.88–1.11 mm long, 0.60–0.79 times as long as mesonotum; setulae swollen, white. Aculeus tip very slender, acute.

Remarks.—I am formalizing the synonymy of *Tephritis apicata* Becker with *E. reticulata.* This action was suggested by Foote (1980), who nevertheless continued to classify *T. apicata* in *Plaumannimyia.* I see no significant differences from *E. reticulata* in Becker's description of *T. apicata* and his Fig. 5 of the wing, nor between specimens from the same collections series as the syntypes of these two nominal species. The male in the USP collection from Ecuador, "env. de Tulcan" may be a syntype or at least is from the same collection series as some of the syntypes of *T. apicata.* It has a handwritten label with "Tephritis apicata Bck." and its locality data are on a "MUSEUM PARIS" label. The Schnuse specimens from Arequipa, Cuzco, Sicuani, and Tarma, Peru in the AMNH and DEI collections are not syntypes of *T. reticulata,* but they come from the same large collection series.

Specimens examined.—BOLIVIA: La Paz: Estr. de Quitina, 30.IX.1972, G. E. Bohart, 2♂2♀ (USU) 1♂1♀ (USNM); La Paz, 4.X.1972, G. E. Bohart, 3♂2♀ (USU) 1♂ (USNM). COLOMBIA: La Combre, 18.V.1914, H. S. Parish, 1♀ (USNM). Cundinamarca: Fusagasugá, 1500 m, 15.X.1972, R. T. Schuh, 1♂ (AMNH). Nariño: Pasto, 28.IX.1954, M. Revelo, 1♀ (USNM); Pasto, 14–15.VII.1955, R. F. Ruppel, 2♂2♀ (USNM); Pasto, 2700 m, 9.XII.1955, L. Posada, 1♂2♀ (USNM); Pasto, 6.X.1958, A. Unigarro, 8♂7♀ (USNM); Pasto, 6.IX.1960, G. Bravo, 2♂2♀ (USNM); Pasto, 2600 m, 1969, 1♂ (USNM). ECUADOR: Baños, 19–20.II.1937, S. W. Frost, 1♂2♀ (USNM). Moya, E. de Alausi, 2500 m, XI.1970, L. E. Peña, 1♀ (USP). San Miguel, 30.XI.1955, H. R. Yust, 1♀ (USNM). Bolívar: Guaranda, 18.XI.1957, G. Marino, 9♂9♀ (USNM). Cañar: 1 km SE Cañar, 10,200 ft., [collected on] *Polymnia fruticosa* (USNM #6621), 30.I.1974, R. M. King, 1♂2♀ (USNM). Carchi: env. de Tulcan, 1902, G. Rivet, 1♂ [possibly a syntype of *T. apicata*] (USP). Chimborazo: Riobamba, 2700 m, 20.IV.1939, F. M. Brown, 1♂1♀ (USNM). Cuenca: Azuay, 25.II.1939, F. M. Brown, 1♂1♀ (AMNH). Loja: Loja, 2500 m, 23–25.III.1965, L. E.

Pena, 1♂1♀ (CNC). Napo: Pastaza, Pambay, Levi-Castillo, 1♀ (USNM). Pichincha: 20 km S Quito, 9200 ft., [collected on] *Ambrosia artemisioides* (USNM #6515), 18.I.1974, R. M. King, 1♂1♀ (USNM); 2 km S Aloag, 10,300 ft., [collected on] *Ambrosia artemisioides* (USNM #6515), 18.I.1974, R. M. King, 1♂ (USNM). Tungurahua: Ambato, 2555 m, 7.II.1955, E. S. Ross, 1♂3♀ (CAS); Tunga Farm, 6.III.1969, G. Merino, 3♂3♀ (USNM). PERU: Tia Baya, Cockerell, 1♂ (USNM). Apurímac: Abancay, 11.VII.1960, Young, 1♀ (USNM); 5 mi N Andahuaylas, 7.III.1951, Ross, 1♀ (CAS). Arequipa: Arequipa, 13.XI.1902, Schnuse, 1♀ (DEI). Cuzco: Cuzco, VIII.1973, B. V. Ridout, 3♀ (BMNH); Cuzco, 3500 m, 5.VII.1905, Schnuse, 1♂ (AMNH): Cuzco, 3300 m, 5–12.VIII.1965, P. Wygodzinsky, 1♂ (AMNH); Cuzco, 12,000 ft, 19.II.1947, J. C. Pallister, 2♀ (USNM); Cuzco, 20.II.1968, A. Garcia, 1♀ (MCZ); Cuzco, Quebradas Salineras, 3500 m, 3.VIII.1971, C. Vardy, 1♂1♀ (BMNH) 1♂ (USNM); 8 km S Cuzco, 3500 m, 6.VIII.1971, C. Vardy, 1♂2♀ (BMNH); NW Cuzco, Barrio Magisterial, 3500 m, 8.VIII.1971, C. Vardy, 3♂ (BMNH); 30 km S Cuzco, Lucre, 3550 m, 4.VIII.1971, C. Vardy, 1♂ (BMNH); Quispicamchis, Huamputio, 2900 m, 1.IX.1988, A. Freidberg, 1♀ (USNM); Sacsayhuaman, 3900 m, 5.VIII.1971, C. Vardy, 1♂3♀ (BMNH); Sicuani, 22.VI.1902, Schnuse, 1♂1♀ (DEI); Urubamba, 2900 m, 9.VIII.1971, C. Vardy, 1♂1♀ (BMNH) 1♂ (USNM). Huánuco: Huánuco, 16.IX.1954, E. S. Ross, 1♀ (CAS). Junín: 4 mi E Acobambo, 31.XII.1954, E. S. Ross, 1♀ (CAS); Tarma, 3000 m, 20.I.1904, Schnuse, 1♂ (DEI) 1♀ (AMNH); Tarma, 10,000 ft, 13.VII.1928, R. C. Shannon, 1♀ (USNM); Tarma, 30–31.V.1920, 1♀ (AMNH). Lima: Matucana, 14.VI.1914, H. S. Parish, 3♂1♀ (USNM). Piura: Huancabamba, 13.VIII.1945, P. A. Berry, 1♂ (USNM).

Euaresta sp.

Remarks.—A few specimens from Cuba and the Dominican Republic that I examined are very similar to specimens of *E. bella* (Loew) from the United States, but the males usually have most of tergite 5 nonmicrotrichose. Whether they are conspecific with United States populations requires further investigation. None of the Antillean specimens have a second hyaline spot or an isolated medial brown spot in the pterostigma as often occurs in *E. stigmatica* (Coquillett). No host data are known for them.

Specimens examined.—CUBA: Havana, Baker, 1♀ (CAS); San Diego de los Baños, 1♀ (USNM). DOMINICAN REPUBLIC: Pedernales: 30 km N Cabo Rojo, 1070 m, 23–24.VII.1990, C. Young, 4♂5♀ (CMP); 37 km N Cabo Rojo, 1500 m, 11.VII.1987, R. Davidson, 1♂1♀ (CMP); 7.3 km NNE Las Mercedes, Las Abejas, 1100–1150 m, 20.VIII.1983, F. M. Harrington, 3♂ (USNM).

KEY TO SPECIES OF *EUARESTA* OF AMERICA SOUTH OF MEXICO

I have included couplet 5 in this key in case any of the seven North American species that would run to the second alternative of the couplet are eventually found south of Mexico. None of them is currently known from Central or South America, although *E. bella* (Loew) was reported from the Bahamas and Lesser Antilles (Foote 1967) and specimens that may be *E. bella* are known from Cuba and the Dominican Republic (see "*Euaresta* sp."). Couplets 6 and 7 of this key are based on characters given by Aczél (1952). Some specimens I examined were difficult to identify in couplet 7 as either *E. philodema* or *E. meridionalis.* These species may have variable wing patterns or may be part of a species complex.

1. Anterior notopleural seta absent. Apex of cell r_{2+3} with 2 marginal hyaline spots. Apical scutellar seta absent or small, often white. Small species, mesonotum length less than 1.20 mm 2

– Anterior notopleural seta present. Apex of cell r_{2+3} with 1–2 marginal hyaline spots. Apical scutellar seta present, usually large and yellow. Large species (at least those that occur south of Mexico), mesonotum length usually more than 1.30 mm 4

2. Femora largely brown. Wing (Fig. 2C) mostly dark brown, with broad subbasal dark band from stigma to cell a_1; hyaline medial spots in cell r_{2+3}, basal hyaline spot in cell r_{4+5}, and all hyaline spots in cells br and dm small, none as wide as cell containing them. Frons mostly orange, at vertex at least 2.9 times as wide as eye .... *versicolor* Norrbom, n. sp.
– Femora entirely yellow. Wing (Fig. 2A, B) with hyaline areas in total as extensive as dark brown areas, without subbasal dark band (if large dark marks present on stigma and basally in cell cu_1, separated by largely hyaline basal areas in cells br and dm); most hyaline spots in cells br, r_{2+3}, r_{4+5}, and dm as wide as cells containing them. Frons yellow and gray, at vertex no more than 2.5 times as wide as eye 3

3. Wing (Fig. 2A) with dark marks on stigma, base of cell cu_1, and middle of cells r_{2+3} and r_{4+5} much larger than other dark marks giving uneven appearance to pattern; basal dark mark in cells r_1 and r_{2+3} as wide as stigma. Female syntergosternite 7 length 0.59–0.83 mm, 0.65–0.76 times length of mesonotum. Male sternite 5 without microtrichia, shiny ..... *toba* (Lindner)
– Wing (Fig. 2B) with most dark marks similar in size, giving more or less uniform appearance to pattern; basal dark mark in cells r_1 and r_{2+3} narrower than stigma. Female syntergosternite 7 length 0.93–1.05 mm, 1.09–1.20 times length of mesonotum. Male sternite 5 microtrichose, matte .... *regularis* Norrbom, n. sp.

4. Wing (see Foote 1980, Fig. 66) with infuscated areas faint except for large dark brown subapical spot extended from apex of cell r_1 into cell m; most hyaline spots much narrower than cells containing them; cell dm with 6–9 hyaline spots; apex of cell r_{2+3} with 2 marginal hyaline spots .... *reticulata* (Hendel)
– Wing (see Aczél 1952, Figs. 1–6) with more proximal infuscated areas as dark as subapical spot; most hyaline spots as wide as cells containing them; cell dm with 2–3 hyaline spots; apex of cell r_{2+3} with 1–2 marginal hyaline spots 5

5. Apex of cell r_{2+3} with 1 marginal hyaline spot; cell r_{4+5} without medial bulla 6
– Apex of cell r_{2+3} with 2 marginal hyaline spots; cell r_{4+5} often with medial bulla (North America and Antilles) see key of Foote et al. (in press)

6. Wing (See Aczél 1952, Figs. 1, 2) with subapical dark spot broader in cell r_{4+5} than in cells r_1 and r_{2+3}. Arista with basal half swollen and white; male with pedicel and first flagellomere dark brown .... *bullans* (Wiedemann)
– Wing with subapical spot narrower in cell r_{4+5} than in cells r_1 and r_{2+3}. Arista with only basal ⅛ or less swollen and yellow; male antenna entirely yellow 7

7. Wing (see Aczél 1952, Figs. 3, 4) with basal dark spot in cell br large, oval, extended well into cell bm .... *meridionalis* Aczél
– Wing (see Aczél 1952, Figs. 5, 6) with basal dark spot in cell br small, usually quadrate or linear, at most extended slightly into cell bm .... *philodema* (Hendel)

ACKNOWLEDGMENTS

I am grateful to H. Cordo, R. E. McFadyen, and C. Garcia for allowing me to include their unpublished host data for *E. toba* and *E. regularis*. The following kindly arranged the loan of specimens: D. Grimaldi (AMNH), N. P. Wyatt (BMNH), N. Penny (CAS), C. W. Young (CMP), J. M. Cumming (CNC), J. Zeigler (DEI), G. Claps (IML), D. Furth (MCZ), H.-P. Tschorsnig (SMNS), U. Kallweit (SMT), R. O. Schuster (UCD), F. do Val (USP), W. Hanson (USU), A. L. Ozerov (ZMUM). I. M. White, S. H. Berlocher, D. R. Smith and F. C. Thompson kindly reviewed the manuscript, and T. B. Griswold prepared the wing illustrations.

LITERATURE CITED

Aczél, M. L. 1950. Catalogo de la familia "Trypetidae" (Dipt. Acalypt.) de la region neotropical. Acta Zoologica Lilloana (1949) 7: 177–328.

———. 1952. El género *Euaresta* Loew (= *Camaromyia* Hendel) en la región neotropical (Diptera Trypetidae). Revista Chilena de Entomologiá 2: 147–172.

Becker, T. 1919. Dipteres, Brachyceres, pp. 191–196. *In* Mission du Service geographique de l'Armee. Mesure d'un Arc de Meridien Equatorial en Amerique du Sud 10: 163–214.

Berlocher, S. H. 1984. Electrophoretic evidence for the validity of *Euaresta stelligera* Coquillett (Diptera: Tephritidae). Journal of the Kansas Entomological Society 57: 354–357.

Currie, G. A. 1940. Some Australian weed problems, pp. 113–130. *In* Whyte, R. O., ed., The Control of Weeds. Imperial Bureau of Pastures and Forage Crops, Aberystwith, Bulletin 27, 168 pp.

Farris, J. S. 1988. Hennig86 reference. Documentation for version 1.5.

Fitzhugh, K. 1989. Cladistics in the fast lane. Journal of the New York Entomological Society 97: 234–241.

Foote, B. A. 1984. Host plant records for North American ragweed flies (Diptera: Tephritidae). Entomological News 95: 51–54.

Foote, R. H. 1967. Family Tephritidae (Trypetidae, Trupaneidae). *In* Vanzolini, P. E., and N. Papavero, eds., A Catalogue of the Diptera of the Americas South of the United States. Departmento de Zoologia, Secretaria da Agricultura, São Paulo. Fasc. 57, 91 pp.

———. 1980. Fruit fly genera south of the United States. United States Department of Agriculture, Technical Bulletin No. 1600, 79 pp.

Foote, R. H., F. L. Blanc, and A. L. Norrbom. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Cornell University Press, Ithaca. (In press.)

Frias, D. Aspectos de la biología evolutiva de especies de Tephritidae de distribución chilena. Revista Chilena de Entomologia. (In press.)

Hendel, F. 1914. Die Bohrfliegen Südamerikas. Abhandlungen und Berichte des Königlich Zoologischen und Anthropologisch-Ethnographischen Museums zu Dresden (1912) 14: 1–84.

Hering, E. M. 1941. Beitrag zur Kenntnis der Trypetidae, pp. 121–176. *In* Titschack, E., ed., Beitrage zur Fauna Perus, Band 1. Hamburg.

Lindner, E. 1928. Die Ausbeute der Deutschen Chaco-Expedition. Diptera. Einleitung, I. Trypetidae und II. Pterocallidae. Konowia 7: 24–36.

McAlpine, J. F. 1981. Morphology and terminology—Adults, pp. 9–63. *In* J. F. McAlpine, et al., coordinators, Manual of Nearctic Diptera, vol. 1, Agriculture Canada, Monograph No. 27. Ottawa.

McFayden, R. E. 1976. Report on a survey of the insects attacking *Ambrosia tenuifolia* in Tucuman, Argentina. Commonwealth Institute for Biological Control, West Indian Station, unpublished report, 4 pp.

Norrbom, A. L. and K. C. Kim. 1988. Revision of the *schausi* group of *Anastrepha* Schiner (Diptera: Tephritidae), with a discussion of the terminology of the female terminalia in the Tephritoidea. Annals of the Entomological Society of America 81: 164–173.

Steyskal, G. C. 1972. *Euaresta reticulata* (Hendel), new combination (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 74: 130.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 210–222

LIFE HISTORY AND DESCRIPTIONS OF IMMATURE STAGES OF *TEPHRITIS ARIZONAENSIS* QUISENBERRY (DIPTERA: TEPHRITIDAE) ON *BACCHARIS SAROTHROIDES* GRAY IN SOUTHERN CALIFORNIA

Richard D. Goeden, David H. Headrick, and Jeffrey A. Teerink

Department of Entomology, University of California, Riverside, California 92521.

Abstract.—*Tephritis arizonaensis* Quisenberry is bivoltine and monophagous, or nearly so, on *Baccharis sarothroides* Gray (Asteraceae). The F_1 larvae feed and develop in non-galled, branch-tip mines, the only Nearctic Tephritidae known to do so; whereas, the F_2 larvae develop singly in male or female flower heads. Eggs and ova, second and third instars, and the puparium of this tephritid are described for the first time. The discovery of a laterally striated, membraneous sheath covering each ovum is reported. The median oral lobe of second and third instars is attached to the floor of the mouth lumen, as reported to date for only one other, noncongeneric, nonfrugivorous, North American tephritid. The puparium is tightly girdled by a cylinder of host-plant epidermis inside the branch tip mine, which bears a characteristic vent hole basally. Adult behaviors, including courtship and copulation, are described. Hymenopterous parasitoids of *T. arizonaensis* include two species of solitary, primary endoparasitoids, *Pteromalus* sp. and *Dinarmus* sp. (Pteromalidae), and two species of solitary, primary, endoparasitic *Eupelmus* (Eupelmidae). This tephritid may be worth evaluating further as a candidate agent to export for the biological control of weedy *Baccharis*.

Key Words: Insecta, *Tephritis*, *Baccharis*, biology, biological weed control, gall evolution, monophagy, phytophagy, taxonomy of immature stages, mating behavior, parasitoids

Eighteen species of *Tephritis* indigenous to North America have been described (Foote 1960, Stolzfus 1977, Foote and Blanc 1979, Jenkins and Turner 1989), but the biologies of only two of these are known in great detail, i.e. *T. stigmatica* (Coquillett) on *Senecio* spp. (Tauber and Toschi 1965, Goeden 1988a) and *T. baccharis* (Coquillett) on *Baccharis salicifolia* (Ruiz and Pavon) Persoon (Goeden and Headrick 1991a). This paper describes the life history of a third Nearctic species, *T. arizonaensis* Quisenberry, on *B. sarothroides* Gray in southern California.

Materials and Methods

Two locations in San Diego Co. in southern California were used as primary study sites: Otay Mesa overlooking San Ysidro just north of Tijuana, Mexico, at 45-m elevation, and near Loveland Reservoir, 5 km south of Alpine at 480-m elevation. Field observations on the F_1, branch-mining generation were principally made at these two locations during 1989–91. Flower heads containing F_2 larvae and puparia also were sampled at several additional locations reported below. Samples of branch mines and flower heads containing larvae and puparia were returned to the laboratory for dissection, photography, description, and measurement. All larvae and three puparia dissected from these mines were preserved in 70% EtOH for scanning electron microscopy (SEM). All other puparia were placed in separate glass rearing vials stoppered with absorbant cotton and held in humidity chambers for adult emergence. Specimens for SEM later were rehydrated to distilled water in a decreasing series of acidulated EtOH. They were osmicated for 24 h, dehydrated through an increasing series of acidulated EtOH, critically point dried, mounted on stubs, sputter-coated with a gold-palladium alloy, and studied with a JEOL JSM C-35 SEM in the Department of Nematology, University of California, Riverside.

Most adults reared from isolated puparia, as well as overwintered adults swept from *B. sarothroides,* were individually caged in 850-ml, clear-plastic, screened-top cages fitted with a cotton wick and basal water reservoir and provisioned with a strip of paper toweling impregnated with yeast hydrolyzate and sucrose. These cagings were used for longevity studies and oviposition tests. Virgin male and female flies obtained from emergence vials, as well as field-collected adults, were paired in clear-plastic petri dishes provisioned with a flattened, water-moistened pad of absorbant cotton (Headrick and Goeden 1991) for direct observations, videorecording, and still-photography of their general behavior, courtship, and copulation. Pairs were held together for at least 1 week, and observations were made throughout the day.

Plant names used follow Boldt (1989); tephritid names follow Jenkins and Turner (1989). Voucher specimens of *T. arizonaensis* from each study site are located in the research collection of RDG (Department of Entomology, University of California, Riverside). RDG also maintains a separate collection of hymenopterous parasitoids of California Tephritidae; DHH has established a separate collection of immature Tephritidae. Means ± SE are provided throughout this paper.

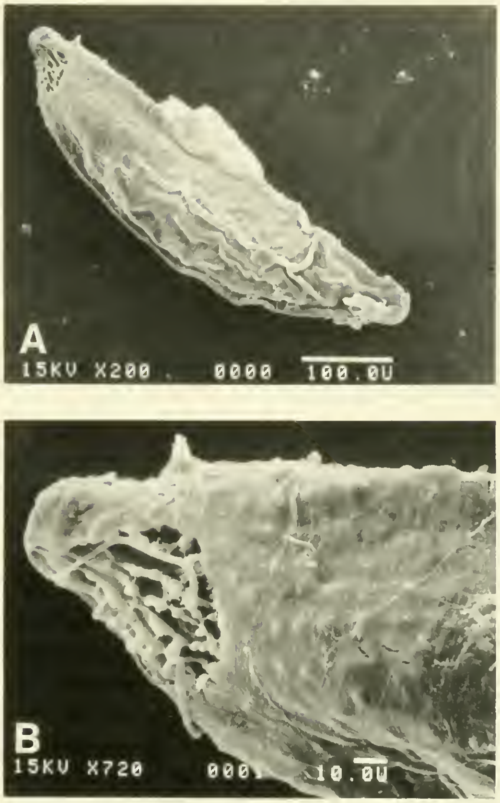


Fig. 1. Egg of *T. arizonaensis*: (A) habitus, dissected from gravid female; (B) detail of pedicel, showing membranous sheath and polygonal reticulation.

RESULTS AND DISCUSSION

TAXONOMY

Quisenberry (1951) described *T. arizonaensis.* In their revision of the *Baccharis*-infesting *Tephritis* species of North America, Jenkins and Turner (1989) reviewed the taxonomy, measured ova, described and illustrated the male genitalia, and described the light and dark morphs of *T. arizonaensis* adults.

Egg.—Ova white, fusiform-ellipsoidal; 16 averaged 0.64 ± 0.01 mm long, 0.28 ± 0.01 mm wide (Fig. 1A); anterior end bears a short pedicel 0.02 mm long, 0.01 mm wide; ovum covered by a laterally striated, membranous sheath.

These means differed only slightly from means of 0.69 and 0.24 mm for lengths and widths, respectively, of five ova measured by Jenkins and Turner (1989). The eggs of *T. baccharis* (Coquillett) are very close in size to both sets of measurements (Goeden and Headrick 1991a), but both of these species have smaller ova than *T. californica* Doane and *T. rufipennis* Doane, also measured by Jenkins and Turner (1989). The ovum examined with SEM was found to be covered by a laterally striated, membranous sheath. The sheath is either partially or fully removed during oviposition thus exposing the aeropyle and polygonal reticulation. Reexamination of *T. baccharis* eggs illustrated by Goeden and Headrick (1991a) showed a similar sheath rolled back to the middle of the egg body where it entered the stem. The nature of this sheath and its function remain unclear, as it has never been described or illustrated for any other insect (Hinton 1981). The polygonal reticulation typical of *Tephritis* eggs was seen beneath this sheath in *T. arizonaensis* (Fig. 1B).

Third instar.—Third instar superficially smooth, elongate, cylindrical, tapered anteriorly and truncated posteriorly; gnathocephalon conical with many small rugose pads; anterior sensory lobes flattened, separated by a medial depression (Fig. 2A); paired dorsal sensory organs dorsad of anterior sensory lobes and consist of a single dome-shaped papilla (Fig. 2A-1); anterior sensory lobes bear lateral sensory organ (Fig. 2A-2), pit sensory organ (Fig. 2A-3), and terminal sensory organ (Fig. 2A-4); stomal sense organs lie ventrad of anterior sensory lobes, near lateral aspect of mouth lumen (Fig. 2A-5); two distinct lobes lie laterally and ventrolaterally on the gnathocephalon (Fig. 2B-3); each bears small, dome-shaped, smooth, verrucate papilla with a central pore; mouth hooks tridentate, teeth stout and bluntly conical (Fig. 2A-6, 2B-1); median oral lobe smooth ventrally, laterally flattened, attached to floor of mouth lumen (Fig. 2B-2); labial lobe bears paired sensilla (Fig. 2B-4); prothorax smooth, bearing several stelex sensilla; anterior thoracic spiracle located dorsolaterally on the posterior margin bearing three or four papillae (Fig. 2C); mesothorax, metathorax and abdominal segments superficially smooth and circumscribed by shallow, longitudinal depressions; intersegmental area bears rows of minute acanthae; lateral spiracular complex located near anterior margins of segments T-II to A-VII composed of an open lateral spiracle (Fig. 2D-1), and two dome-shaped sensilla, each with a central pore (Fig. 2D-2); caudal segment bears posterior spiracular plates; plates bear three, elongate-oval rimae ca. 0.05 mm long (Fig. 2E-1), four interspiracular processes with three to five branches each; the longest process measured 0.01 mm in length (Fig. 2E-2); stelex-type sensilla surround margin of caudal segment in four-dorsal, six-ventral arrangement; additionally, the caudal segment bears a pair of compound sensilla ventrad of the spiracular plates (Fig. 2F); each pair consists of a stelex sensillum (Fig. 2F-1), and a tuberculate, medusoid, chemosensillum resting in a shallow depression (Fig. 2F-2).

Tephritis arizonaensis is very similar to *T. baccharis* in the type of sensory structures and their placement with a few noticeable differences that may be of taxonomic importance. The rugose pads on the gnathocephalon are not dorsoventrally elongated as in *T. baccharis* (Goeden and Headrick 1991a). The lateral spiracular complex is composed of a spiracle and two dome-shaped sensilla in *T. arizonaensis*. The complex is similar to that described for *T. baccharis* (Goeden and Headrick 1991a) and *Neaspilota viridescens* Quisenberry (Goeden and Headrick 1992). However, in *T. baccharis* there are three associated, dome-shaped sensilla, and in *N. viridescens*, there is only one dome-shaped sensillum (Goeden and Headrick 1991a, 1992). The num-

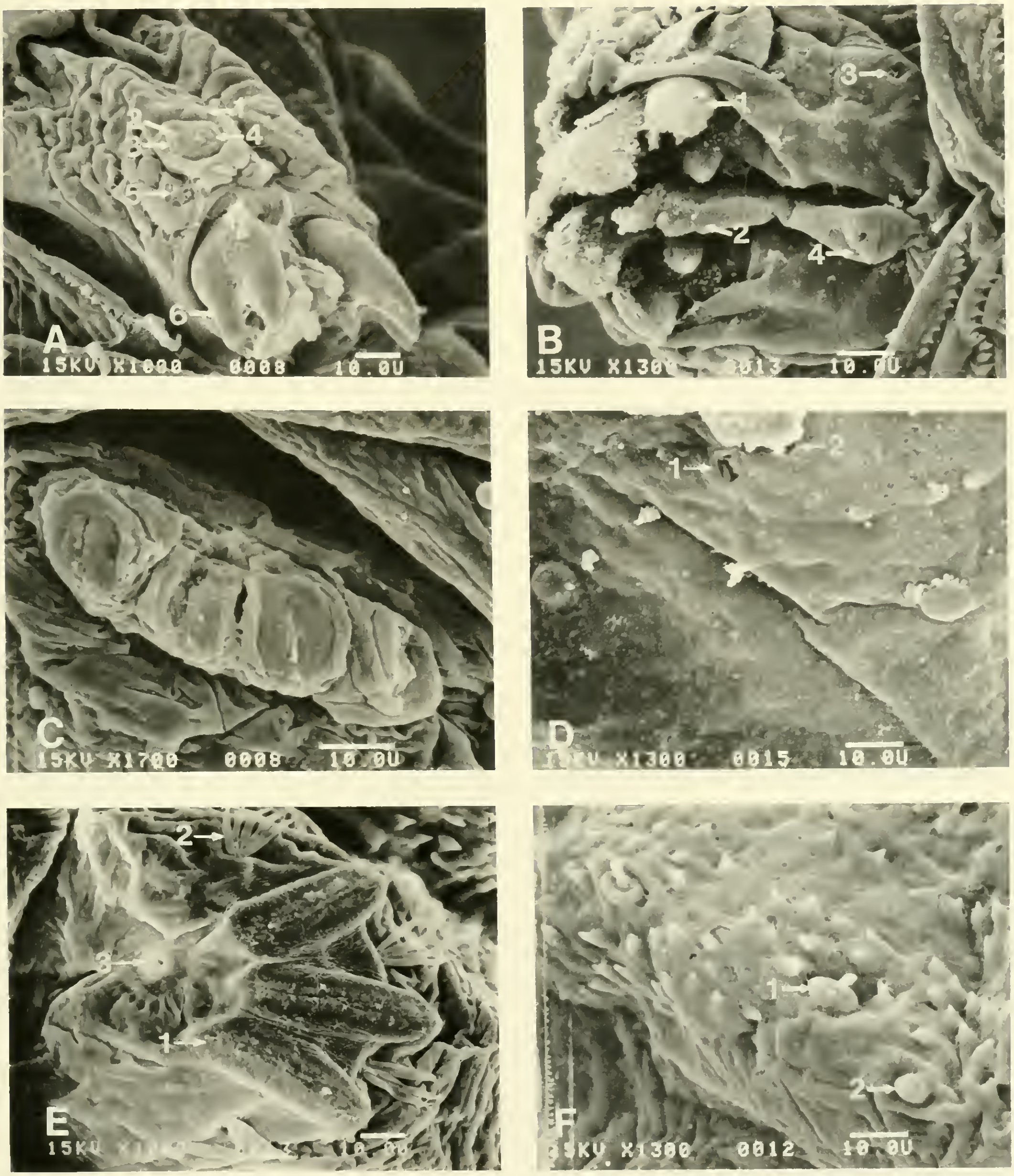


Fig. 2. Third instar larva of *T. arizonaensis*: (A) gnathocephalon, 1—dorsal sensory organ, 2—lateral sensory organ, 3—pit sensory organ, 4—terminal sensory organ, 5—stomal sense organ, 6—mouth hooks; (B) 1—mouth hooks, 2—median oral lobe, 3—ventral sensory organ, 4—labial lobe sensilla; (C) anterior prothoracic spiracle; (D) lateral spiracular complex, first abdominal segment, 1—spiracle, 2—sensilla; (E) posterior spiracular plate (dorsal at top), 1—rima, 2—interspiracular process, 3—median ecdysial scar; (F) caudal segment sensory papillae, 1—stelex sensillum, 2—tuberculate, medusoid chemosensillum.

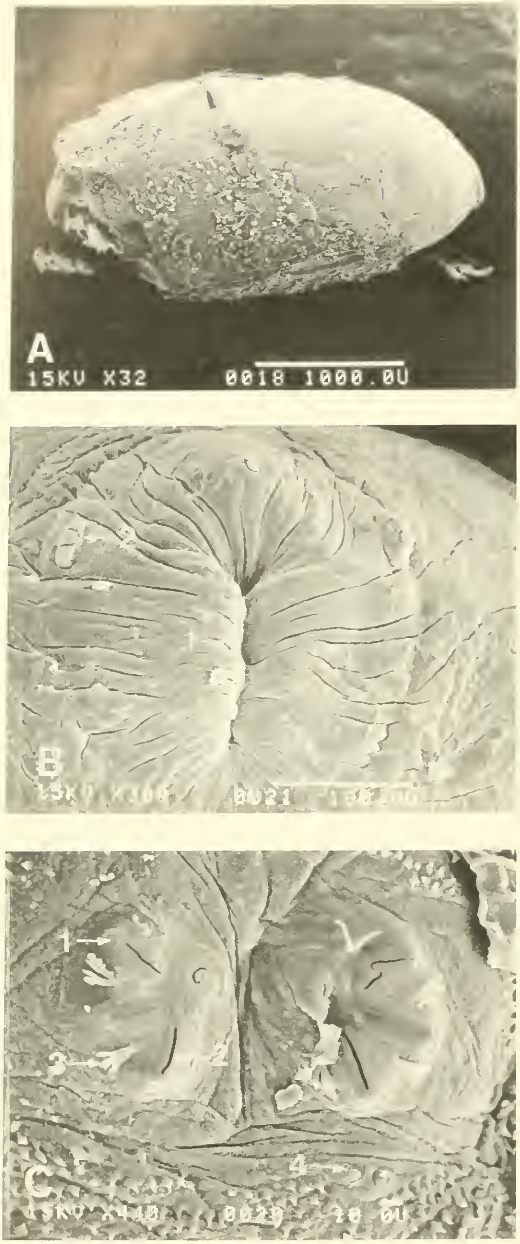


Fig. 3. Puparium of *T. arizonaensis*: (A) habitus, anterior to the right; (B) anterior end, 1—invagination scar, 2—anterior thoracic spiracle; (C) posterior spiracular plates, 1—rima, 2—spiracular slits, 3—interspiracular processes, 4—compound sensilla.

ber of sensilla may be species-specific (Goeden, Headrick, and Teerink, unpublished data). The median oral lobe is attached to the floor of the mouth lumen, as in *N. viridescens* (Goeden and Headrick 1992). To date, these are the only two Nearctic species of Tephritidae reported to have attached median oral lobes (DHH, unpublished data).

Second instar.—Second instar cylindrical; gnathocephalon cone-shaped and rounded posteriorly; mouth hooks bidentate; median oral lobe similar to that of third instar and attached to floor of mouth lumen.

Most structures were similar in shape and placement to those of the third instar. Quality specimens of all immature stages were difficult to obtain due to the nature of their feeding habits. Early instars were rarely obtained and unsuitable for SEM except for general observations.

Puparium.—Puparium superficially smooth, elongate-ellipsoidal and rounded anteriorly (Fig. 3A); anterior end bears invagination scar (Fig. 3B-1) and raised anterior thoracic spiracles dorsolaterad of the invagination (Fig. 3B-2); posterior spiracular plates bear slightly raised, oval rimae (Fig. 3C-1), with opened slits measuring 0.04 mm in length (Fig. 3C-2); branches of longest interspiracular processes measured 0.01 mm in length (Fig. 3C-3); compound sensilla ventrad of spiracular plates remained intact and erect (Fig. 3C-4).

Because of plant tissues adhering to the puparia (Fig. 3A), only their ends, which were free of debris, could be examined.

Distribution and Hosts

Jenkins and Turner (1989) described the range of *T. arizonaensis* as "southcentral New Mexico west to southern California and south to northwestern Mexico." The distribution of its only confirmed host plant, *B. sarothroides* (Jenkins and Turner 1989) within this range was described by Boldt et al. (1988) as "common in sand or gravel riparian washes, drainage areas, and low hills at elevations of 300–1500 m above sea level."

Jenkins and Turner (1989) recorded *T. arizonaensis* from terminal galls, stem tip mines (first reported by Foote and Blanc 1963), and female flower heads of *B. sarothroides* in Arizona and California. We add the following rearing records for F_2 males and females of *T. arizonaensis* reared from female and male flower heads of *B. sarothroides,* all collected in San Diego Co., CA: Highland Valley, SE of Escondido at 485 m, male heads, 11 Sep 1989, 3 males and 1 female. Barrett Junction at 274 m, female heads, 21 Sep 1989, 1 female. Lake Hodges Dam at 128 m, male heads, 8, 12, 16 Oct 1990, 5 males and 8 females; female heads, same dates, 12 males and 3 females. Del Mar Heights, W of Rancho Penasquitos at 241 m, male heads, 16 and 29 Oct 1990, 1 male; female heads, 8, 12, and 16 Oct 1990, 2 males and 7 females. Rancho Bernardo, NW of Black Mountain at 165 m, male heads, 12, 16, and 22 Oct 1990, 4 males and 8 females.

The host record for *B. pilularis consanguinea* (deCandolle) C. B. Wolf in Wasbauer (1972) remains unconfirmed. This host record is suspect, and may result from host-plant misidentification, as this species is sometimes very difficult to distinguish from *B. sarothroides* (Munz 1974). Similarly, the record for specimens "taken on" *B. sergiloides* Gray reported in Jenkins and Turner (1989) may be a sweep record, as RDG has reared only *Trupanea* spp. from flower heads of this shrub (Cavender and Goeden 1983, Goeden 1985).

BIOLOGY

Egg.—In laboratory cagings, eggs were inserted singly for all or most of their lengths mainly into apical buds, and a few into distal axillary buds on current season's branches (Fig. 4A). As reported for *T. baccharis* (Goeden and Headrick 1991a), a thin circle of necrotic tissue delimits the oviposition site. The eggs of *T. arizonaensis* are inserted pedicel-last, downward and at a slight angle to the long axis of a branch. Eggs of the F_2 generation of *T. arizonaensis* presumably also are laid singly in both male and female flower heads of *B. sarothroides.* However, the low densities of this generation relative to the abundance of small flower heads produced in the field during our study period precluded our finding eggs in samples. As observed with other non-frugivorous tephritids, e.g. *T. baccharis* (Goeden and Headrick 1991a), the embryo reversed itself 180° just before eclosion, so that it immediately gained access to the plant tissues within which the egg was inserted. Eggs hatched in about 1 week at insectary temperatures of 27 ± 1°C.

Larva.—The newly hatched larva immediately tunnels into the pith of the branch tip (Fig. 4B). Shortly after molting to the second instar, it discontinued its tunneling, confined further pith feeding to excavating an area sufficient to accommodate its growing size, while mainly feeding on sap that accumulated in the cuplike depression at the base of the mine (Fig. 4C). No obvious tissue proliferation or attendant swelling or elongation of the branch tip occurred, as only the epidermis remained uneaten and was stretched to accommodate larval growth (Fig. 4D); therefore, the width of the mine was as wide as the third instar itself. This branch tip-mining habit is unique among Nearctic tephritids, and among the hierarchy of gall types, it may represent the connecting link in the transition from nongalled flowerheads, i.e. the most primitive type of tephritid stem "gall" lacking in tissue proliferation (Freidberg 1984). The next step in this hierarchy may be branch galls of the type formed by the F_1 larva of *Tephritis stigmatica* (Coquillett), which extends its mine farther basally into the branch pith parenchyma, which then proliferates as callous or wound tissue in reaction to continued larval feeding and excavation to form a gall (Freidberg 1984, Goeden 1990). Moreover, *T. stigmatica* also infests, but does not gall, the flower heads of its host plant (Goeden 1990). Likewise, the older, F_2 larvae of *T. arizonaensis* deeply score, but do not gall, the receptacle of the flower heads within which they developed singly and largely fed on sap, as reported for larvae of several other genera and species of florivorous tephritids, i.e. Freidberg (1984), Goeden (1988b); Goeden and Headrick (1991b, 1992); Headrick and Goeden (1990a) (Fig. 4E). Thus, the F_1 and F_2 larvae feed similarly, whether mining branch tips or individual flower heads; again, evidence of the primitive nature of these mines in the hierarchy of tephritid gall types (Freidberg 1984). The lengths of 177 branch-tip mines measured from base to branch apex was 6.6 ± 0.1 (range, 3–8.8) mm. The widest width was 1.3 ± 0.1 (range, 1.0–1.8; n = 138) mm at the base of the mine. Mines were scattered over the crowns of host plants.

An interesting behavioral adaptation exhibited by *T. arizonaensis* was the cutting of a small (ca. 0.1 mm) hole at the base of the feeding tunnel through the epidermis after the larva had ceased feeding, but before it pupariated. This hole always was present and allowed the larva to reverse itself 180° within its tunnel by serving as a vent to insure that suction pressure would not build and prevent the larvae from turning in the otherwise intact, sap-filled, basal part of its feeding cavity. This vent hole was separate from the exit hole of the adult described below. The larvae invariably pupariated with their heads toward the branch apices. The branch tips distal to the puparia always were killed.

Puparium.—The puparia were glued by dried sap to the cup-like feeding depressions basally and were tightly covered by the uneaten branch epidermis that covered them (Fig. 4F). This epidermal covering proved difficult to remove; consequently, the following measurement of the widths of 166 puparia included the thin, host epidermal cylinder, i.e. 1.6 ± 0.1 (range, 1.2–1.9) mm. The mean length of 69 puparia was 2.9 ± 0.02 (range, 2.5–3.6) mm. The distance from the base of the mine to the base of the puparium averaged 0.6 ± 0.01 (range, 0.09–1.04) mm. The adult emerged through a flap of host epidermis at the distal end of the larval chamber (Fig. 4G). F_2 flies pupariated in the center of flower heads (Fig. 4H) and emerged outward through the surrounding pappus hairs from fragile cells fabricated of dried, sap-impregnated achene and pappus fragments.

Adult.—*Tephritis arizonaensis* is among the smallest of the California *Tephritis* species. It is rarely collected as an adult, and the early immature stages are even more rarely observed (Foote and Blanc 1963).

General behaviors: Both sexes were observed to groom throughout the day. Grooming took place during resting, feeding, and copulation. The grooming process is typical for tephritids, i.e. the forelegs are used to clean the head and midlegs, and the hindlegs are used to groom the thorax, wings, and abdomen. The distal parts of the fore tibia were used to clean the antennae and mouthparts. There was no detectable sequence to grooming, and except for females in copula, other activities did not influence which body parts were groomed. Adults were most active in the laboratory between 1000 and 1400 h PST, exhibiting spontaneous wing displays either with or without the presence of other individuals, orienting to movement, forming feeding droplets, and grooming.

Wing displays: Both sexes exhibited all of the typical wing displays known for tephritids including hamation, enantion, and asynchronous supination (Headrick and Goeden 1990b, 1991, J. F. Green, DHH, and RDG, unpublished data). There were no wing displays unique to this species. Males have no courtship displays, and thus, no unique wing displays. Both sexes exhibited wing displays when orienting toward moving objects or when startled, and both rested with their wings held flat over their dorsa.

The wing display most often observed for

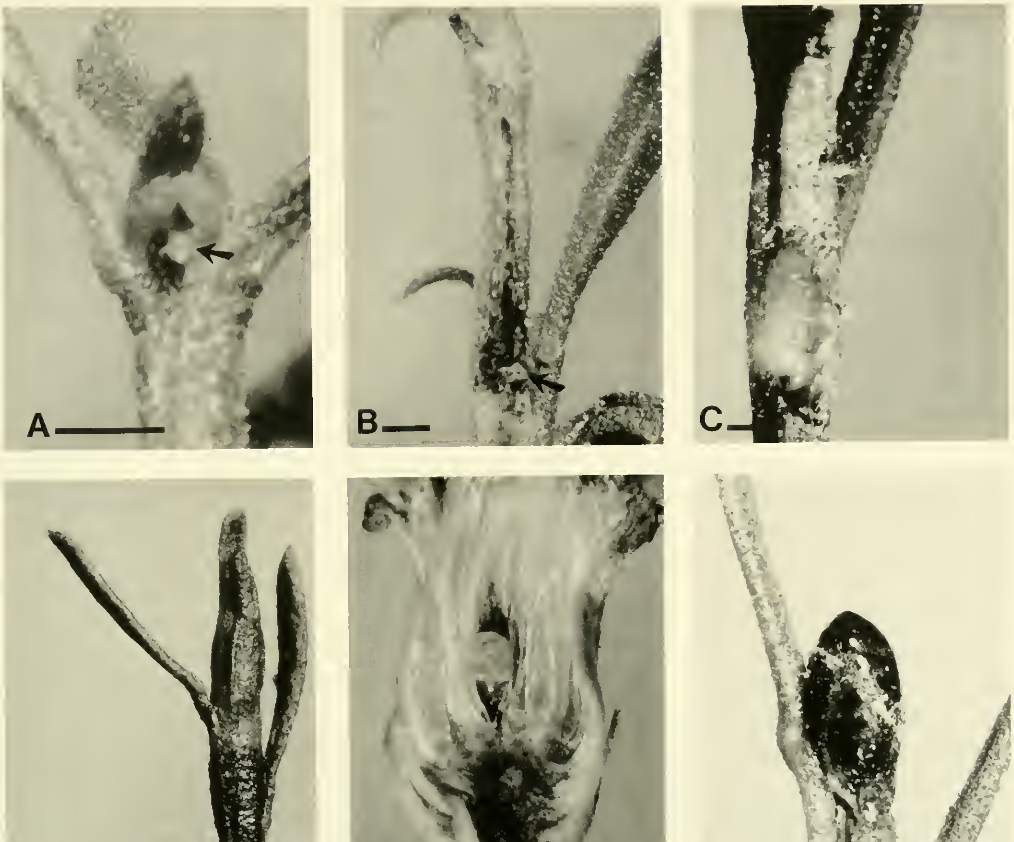


Fig. 4. Life stages of *T. arizonaensis* on *B. sarothroides*: (A) egg inserted in apical bud, (B) second instar in mine at branch apex, (C) last instar exposed, (D) intact branch tip mine, (E) larva in male flower head, (F) empty puparium basally affixed to branch and partly covered by epidermal remnant, (G) exit hole to adult, (H) puparium in male flower head, (I) mating pair.

both sexes was asynchronous supination, as first described for *Trupanea californica* Malloch (Headrick and Goeden 1991). Both sexes displayed asynchronous supinations spontaneously as well as in response to other individuals. The asynchronous supination display was irregular, i.e. one wing was extended more than once, and often held extended for several seconds; or regular, i.e. each wing is extended in turn without pause. Males facing or approaching females often embellished their asynchronous supination display by holding one wing fully extended to 90°, with the other wing held flat over their dorsum, then rotating the extended blade beyond 90° several times. The extended wing was returned and the same motion was repeated with the other wing, and so on.

Females generally were unresponsive to wing displays by males; however, if males moved too closely, the females would jump away. Females did not exhibit any unique wing displays and typically held their wings flat over their dorsa and overlapped. Females displayed aggression by extending both wings forward synchronously to 90° while slightly supinated, e.g. when lunging at an intruder. Males sometimes exhibited synchronous wing extensions without supination, i.e. enantion (J. F. Green, DHH, and RDG, unpublished data), when approaching females; this wing display is typical among *Tephritis* spp. males observed to date (Goeden and Headrick 1991a, DHH and RDG, unpublished data). Both wings are extended while slightly supinated from a resting position at ca. 30°, outward to 90°; this behavior often is followed by swaying. Both sexes swayed during wing displays and both exhibited abdominal flexures during asynchronous wing supinations (Headrick and Goeden 1991).

Male–female interactions: Figure 5 is a flow diagram of male–female interactions prior to and including copulation. Each component is discussed and the number of observations is given for each. During peak activity, there were many encounters between individuals, with approaches initiated by both sexes. Males approached females either passively with their wings flat over their dorsa (n = 3), or with wing displays (n = 26). Males also visually tracked females while remaining still (n = 19), sometimes having to stilt, i.e. rise on their forelegs, to see females as they moved overhead and behind them. Males sometimes exhibited abbreviated wing displays while watching females, i.e. slight supinations to 45°. If a female approached a male, he either sat still, with wings flat over his dorsum, and when she moved away, he remained still (n = 10) or decamped upon approach (n = 11). Males did not exhibit any of the common tephritid courtship displays in the laboratory, i.e. abdominal pleural distension, wing displays, or mouthpart extension (Headrick and Goeden 1990a, 1991, Goeden and Headrick 1992). However, no field observations were conducted, and such behaviors may only be manifested on the host plant with other adults present (Headrick and Goeden 1990b). Males ready to initiate copulation either stalked a female and attempted to jump on her dorsum or did so without stalking. The process of stalking lasted from a few seconds for a single attempt, to ca. 1 h, during which time males intermittantly approached females passively or with wing displays, then turned and moved away. Mounting attempts were not always successful, as females attempted to fly off when males jumped towards them. Males also jumped onto females that passed closely by without any stalking. Thus, males are opportunistic in their attempts to mount females. This opportunistic mating system has evolved several times in different genera of Tephritidae, e.g. *Aciurina* and *Procecidochares,* and is based on the distribution and abundance of the tephritid and the developmental stage of its host plant (DHH, unpublished data). Males that exhibit this mating system have enlarged fore femora for grasping and holding their intended female partner. The enlarged fore femur is a sexually dimorphic character as reported for *Aciurina trixa* (Coquillett), *Valentibulla dodsoni* Foote (Dodson 1987), and *A. thoracica* (Headrick and Goeden, unpublished data). Measurements of the three leg parameters, hind tibial length (HTL), fore femoral length (FFL), and fore femoral width (FFW) from samples of five males and five females from both F_1 and F_2 populations were analyzed for differences in male femoral size. Female FFW averaged 0.21 ± 0.004 (range, 0.19–0.24) mm; male FFW averaged 0.23 ± 0.005 (range, 0.19–0.24) mm. These means were not statistically different (t-statistic = 1.372, $\alpha > 0.05$). The FFL averaged 0.21 ± 0.001 mm for both sexes. Thus, fore femoral size was not sexually dimorphic, because the fore femora were enlarged in both sexes. The middle and hind femora in *T. arizonaensis* are isocylindrical and the fore femora are proximally pyriform. Enlarged fore femora in males of *T. arizonaensis* may provide an advantage in holding potential mates, as confirmed by observing their behavior, but no such use has been elucidated for females.

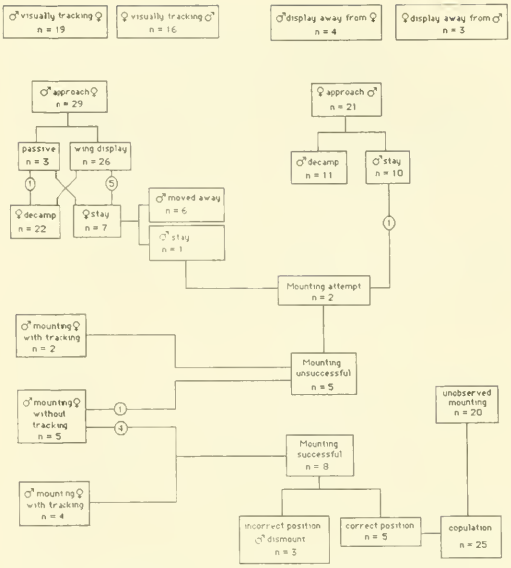


Fig. 5. Flow chart of courtship and copulatory behaviors, with numbers of observations exhibited by *T. arizonaensis* in laboratory arenas.

Copulatory induction behavior and copulation: Males jumped on females to initiate copulation. Once a male mounted a female, he raised her ovipositor ca. 45° with his hindlegs and hind tarsi held flat against her ventrum (Fig. 4I, 6). The male then curled his abdomen under and placed his epandrium against the ovipositor apex and began rubbing his tarsi against the venter of the female's abdomen and oviscape (Fig. 6A). If the female was receptive, she exserted her aculeus after several seconds and its tip was grasped by the surstyli. When the aculeus entered the surstyli, the male's abdomen was moved backward. He then dropped his hindlegs to the substrate, and the ovipositor was lowered. The aculeus was bent upward slightly to expose the ventral flap, and the eversible membrane expanded as the aedeagus entered the cloaca. The fully exserted aculeus slowly retracted as the aedeagus was further inserted. The final copulatory position is typical for tephritids (Fig. 4I, 6B). The head of the male was positioned over the middle of the female's abdomen and behind her scutellum. His hindlegs wrapped around the apex of her ovipositor when first gaining intromission, and then rested on the substrate. His midlegs grasped the middle of her abdomen, and his forelegs rested on top of her abdomen near the thorax, such that his tarsi were parallel with the midline of her body. The wings of the female were held flat at ca. 45° to each other; the wings of the male were flat over his dorsum and spread slightly such that the costal margins were parallel (Fig. 4I). While in copula, the female intermittently used hydrostatic pressure to exert its aculeus against the male, but the male held its abdomen in place, resulting in the eversible membranes ballooning due to increased pressure. Copulation times in the laboratory averaged 5.5 h (range, 2.5–8 h, n = 25).

Territoriality: Male were not observed to be territorial in the laboratory, and no de-

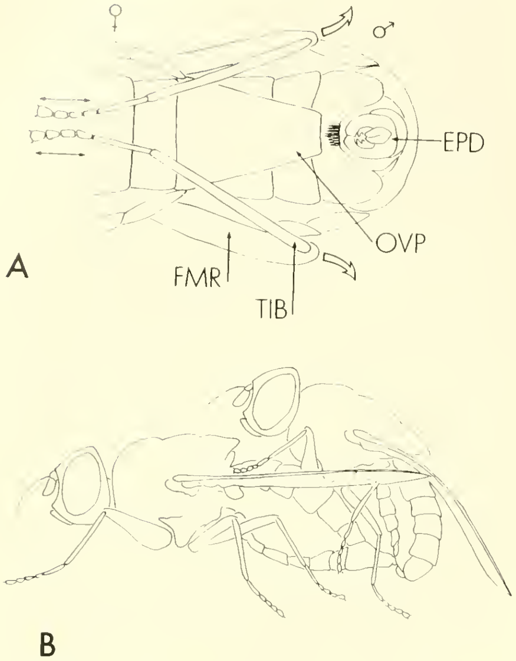


Fig. 6. (A) Ventral view of male mounted on female displaying copulatory induction behavior prior to aculeus exertion. The hindlegs of the male are bent underneath the abdomen of the female. (B) Side view of final copulatory position after insertion of the aedeagus.

tailed field observations have been made on this species. Other tephritid species that have no male courtship, and opportunistic mounting, e.g. *A. trixa,* usually do not establish or defend territories (Dodson 1987, DHH, unpublished data). However, *T. stigmatica* males, which have no courtship displays and mount females opportunistically, have exhibited highly ritualized territorial displays and combat in laboratory cagings. Therefore, we cannot predict from our laboratory studies whether *T. arizonensis* males are territorial in nature.

Seasonal history. — *Tephritis arizonaensis* is bivoltine and synovigenic in southern California. The adults are long-lived, i.e. 13 males lived 165 ± 12.5 days (range, 94–243 days); 13 females, 137 ± 10.0 days (range, 48–199 days) under insectary conditions. Thus, F_2 adults produced in male and female flower heads of *B. sarothroides* overwinter, probably as dispersed, sexually immature, unmated individuals in proximity to sources of fresh water in sheltered locations, e.g. riparian habitats (Goeden 1987, 1988b, Headrick and Goeden 1990b, Goeden and Headrick 1991a). Following resumption of winter rainfall and host-plant vegetative growth, overwintered adults are attracted to and gather on their host plants for mating, copulation, and oviposition in February–April. Our laboratory matings showed that individuals reared from flower heads never mated and remained reproductively immature while they overwintered; whereas, overwintered adults swept from hosts readily mated under laboratory conditions. The F_1 generation develops as branch-tip miners as described above, and emerges as adults in May to oversummer. Larvae were present in March–April; puparia in April–May. *Baccharis sarothroides* flowers in the fall, i.e. August–October, at which time the F_2 generation develops in heads as described above.

The seasonal variation in color of adults reported by Jenkins and Turner (1989) was confirmed, although as they noted, this tends to be less well defined in *T. arizonaensis* than in some other species of *Tephritis* associated with *Baccharis* spp., e.g. *T. californica* Doane. The F_1 generation comprises the dark morphs; the F_2 generation, the light morphs described by Jenkins and Turner (1989). If this color variation somehow is involved in thermal regulation, e.g. as suggested for dark-winged *Eutreta diana* (Osten-Sacken) (Goeden 1990), intuition suggests that the dark morphs which oversummer instead should be lighter to reduce warming than the light morphs that overwinter! The biological significance of this seasonal color variation described by Jenkins and Turner (1989) should be addressed experimentally.

Natural enemies. — Three species of chalcidoid Hymenoptera adults were reared from *T. arizonaensis* during this study.

Eleven specimens of a *Pteromalus* sp. and two specimens of a *Dinarmus* sp. (Pteromalidae) were reared from F_1 puparia as solitary, primary, endoparasitoids. Two *Eupelmus* sp. (Eupelmidae) were reared from F_1 puparia as solitary, primary parasitoids; another specimen was reared from a flower head (F_2 gen. host), as was a male of an unidentified Torymidae. The above named parasitoids of the F_1 flies also parasitized *A. thoracica* on *B. sarothroides* (Headrick and Goeden, unpublished data).

Biological control.—This tephritid may be worth considering as a candidate agent for biological control of groundsel bush, *Baccharis halimifolia* L., which is native to the Southeastern United States, and an introduced weedy shrub in southern Queensland and northern New South Wales, Australia (McFayden 1978), if it can transfer to this plant species. Several insect species, but no tephritids, have been introduced from North America into Australia for biological control of this toxic rangeland weed (McFayden 1978, Julien 1992). Some of these biological control agents were obtained from other species of *Baccharis*, including *B. pilularis* in California (Julien 1992). Russia also has introduced and established three insect species from North America (two of them via Australia) for the biological control of *B. halimifolia* in recent years (Julien 1992).

ACKNOWLEDGMENTS

We thank A. C. Saunders, Curator of the Herbarium, Department of Botany and Plant Sciences, University of California, Riverside, for identification of plants and J. LaSalle, J. Luhman, and J. Beardsley for identification of parasitoids during their visits to or while associated with the Department of Entomology, University of California, Riverside. We also are grateful to F. L. Blanc, A. Freidberg, and A. L. Norrbom for their helpful reviews of earlier drafts of this paper.

LITERATURE CITED

Boldt, P. E. 1989. *Baccharis* (Asteraceae), a review of its taxonomy, phytochemistry, ecology, economic status, natural enemies and the potential for its biological control in the United States. Texas Agricultural Experiment Station Miscellaneous Publication 1674: 1–32.

Boldt, P. E., W. Woods, and T. O. Robbins. 1988. Phytophagous insect fauna of *Baccharis sarothroides* Gray (Asteraceae) in Arizona and New Mexico. Proceedings of the Entomological Society of Washington 90: 207–215.

Cavender, G. L. and R. D. Goeden. 1983. On distinguishing *Trupanea bisetosa* (Coquillett) from *T. nigricornis* (Coquillett) (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 85: 275–281.

Dodson, G. 1987. Biological observations on *Aciurina trixa* and *Valentibula dodsoni* (Diptera: Tephritidae) in New Mexico. Annals of the Entomological Society of America 80: 494–500.

Foote, R. H. 1960. The genus *Tephritis* Latreille in the Nearctic Region north of Mexico: Descriptions of four new species and notes on others. Journal of the Kansas Entomological Society 33: 71–85.

Foote, R. H. and F. L. Blanc. 1963. The fruit flies or Tephritidae of California. Bulletin of the California Insect Survey 7: 1–117.

———. 1979. New species of Tephritidae (Diptera) from the western United States, Mexico, and Guatamala, with revisionary notes. Pan-Pacific Entomologist 55: 161–179.

Freidberg, A. 1984. Gall Tephritidae (Diptera), pp. 129–167. *In* Ananthakrishnan, T. N., ed., Biology of Gall Insects. Oxford and IBH, New Delhi.

Goeden, R. D. 1985. Host-plant relations of *Trupanea* spp. (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 87: 564–571.

———. 1987. Life history of *Trupanea conjuncta* (Adams) on *Trixis californica* Kellogg in southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 63: 284–291.

———. 1988a. Gall formation by the capitulum-infesting fruit fly, *Tephritis stigmatica* (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 90: 37–43.

———. 1988b. Life history of *Trupanea imperfecta* (Coquillett) on *Bebbia juncea* (Bentham) Greene in the Colorado Desert of southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 64: 345–351.

———. 1990. Life history of *Eutreta diana* (Osten Sacken) on *Artemisia tridentata* Nuttall in southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 66: 24–32.

Goeden, R. D. and D. H. Headrick. 1991a. Life history and descriptions of immature stages of *Tephritis baccharis* (Coquillett) on *Baccharis salicifolia* (Ruiz and Pavon) Persoon in southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 67: 86–98.

———. 1991b. Life history and descriptions of immature stages of *Tomoplagia cressoni* Aczél (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 93: 549–558.

———. 1992. Life history and descriptions of immature stages of *Neaspilota viridescens* Quisenberry (Diptera: Tephritidae) on native Asteraceae in southern California. Proceedings of the Entomological Society of Washington 94: 59–77.

Headrick, D. H. and R. D. Goeden 1990a. Resource utilization by larvae of *Paracantha gentilis* (Diptera: Tephritidae) in capitula of *Cirsium californicum* and *C. proteanum* (Asteraceae) in southern California. Proceedings of the Entomological Society of Washington 92: 512–520.

———. 1990b. Life history of *Paracantha gentilis* Hering (Diptera: Tephritidae). Annals of the Entomological Society of America 83: 776–785.

———. 1991. Life history of *Trupanea californica* Malloch (Diptera: Tephritidae) on *Gnaphalium* spp. in southern California. Proceedings of the Entomological Society of Washington 93: 559–570.

Hinton, H. E. 1981. Biology of Insect Eggs. Pergamon Press, New York.

Jenkins, J. and W. J. Turner. 1989. Revision of the *Baccharis*-infesting (Asteraceae) fruit flies of the genus *Tephritis* (Diptera: Tephritidae) in North America. Annals of the Entomological Society of America 82: 674–685.

Julien, M. H. 1992. Biological Control of Weeds: A World Catalogue of Agents and Their Target Weeds. C·A·B International, Wallingford, Oxon, U.K.

McFayden, P. J. 1978. A review of the biocontrol of groundsel-bush (*Baccharis halimifolia* L.) in Queensland. Proceedings of the 1st Conference of the Council of Australian Weed Science Societies, Melbourne, 123–125.

Munz, P. A. 1974. A Flora of Southern California. University of California Press, Berkeley.

Quisenberry, B. F. 1951. A study of the genus *Tephritis* Latrielle in the Nearctic Region north of Mexico. Journal of the Kansas Entomological Society 24: 56–72.

Stolzfus, W. B. 1977. The taxonomy and biology of *Eutreta* (Diptera: Tephritidae). Iowa State Journal Research 51: 369–438.

Tauber, M. J. and C. A. Toschi. 1965. Life history and mating behavior of *Tephritis stigmatica* (Coquillett). Pan-Pacific Entomologist 41: 73–79.

Wasbauer, M. W. 1972. An annotated host catalog of the fruit flies of America north of Mexico (Diptera: Tephritidae). California Department of Agriculture, Bureau of Entomology, Occasional Papers 19: 1–172.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 223–227

REDESCRIPTION OF THE HARPACTORINE GENUS *SOSIUS* CHAMPION 1899, WITH THE DESCRIPTION OF A NEW SPECIES (HETEROPTERA: REDUVIIDAE)

J. MALDONADO CAPRILES AND D. J. CARPINTERO

(JMC) Department of Crop Protection, College of Agricultural Sciences, University of Puerto Rico, Mayagüez, Puerto Rico 00681. Mailing address: Urb. Aponte 6 I 1, Cayey, Puerto Rico 00736; (DJC) Kiernan 822-(1688), Villa Tesei, Partido de Moron, Provincia Buenos Aires, Argentina.

Abstract.—The harpactorine genus *Sosius* Champion is redescribed and illustrated. The male specimen of *S. foliaceus* Champion, from Mexico, is redescribed and the new species, ***Sosius australis***, from Brazil and Argentina, is described. Comparative notes and illustrations are given to distinguish the two known species. The name *S. sierrai* Carpintero, *nomen nudum,* should be dropped.

Key Words: Heteroptera, Reduviidae, *Sosius foliaceus* Champion, *S. sierrai nomen nudum, S. australis* new species, Brazil, Argentina

Sosius is recognized by the conjointly expanded fifth and sixth connexival segments (Figs. 1, 11). Prior to this study, *S. foliaceus* Champion was the only species recognized in the genus (Maldonado 1990). Males belonging to the genus *Sosius* from Brazil and Argentina differ from the male of *S. foliaceus* and are described herein as a new species.

The round lobes on the posterior margin of the pronotum, one each side of the scutellum, are referred to as scutellar lobes (e.g. Maldonado 1987). This terminology was frequently used by Villiers, but has not been followed by American authors. These are not the result of a concavity on the hind margin as is often thought. Instead they are separate structures found at the opposite ends of a usually straight margin (Fig. 13).

The senior author has seen the specimen of what Carpintero (Carpintero 1981: 90) listed, but never described, as *Sosius serrai* nov. sp. The specimen is in very bad condition and we have decided that it does not belong in *Sosius*.

Repositories are mentioned in the corresponding places in the text. All measurements are in mm.

Sosius Champion

1899 *Sosius* Champion, 2: 275.

Type of genus.—*Sosius foliaceus* Champion, 1899, 2: 275. Mexico. By monotypy.

Diagnosis.—*Sosius* is identified by the short genal spines, subequal head lobes, and the foliaceous expansion of connexivum limited to the last two segments.

Description.—Head about half as long as pronotum, head tumid behind eyes (Fig. 12), narrowing posteriorly into a short neck; subantennal spines moderately long, slightly bent forward; genae with a short anteriorly directed spine; eyes not surpassing upper and lower margins of head; interocular suture straight; first rostral segment about as long as second and third together; antenna long and slender. Pronotum as long as wide or slightly longer than wide, subpentagonal, hind margin with two short scutellar lobes; anterior lobe unspined, longitudinal sulcus faint anteriorly, deep posteriorly, reaching posterior lobe; posterior lobe with two submarginal discal spines separated by concave depression, moderately long spine slightly above level of humeral angles; scutellum carinate, with obtuse apical projection, disc depressed. Hemelytra barely reaching apex of abdomen (Fig. 11). Abdomen elongate, narrow basally, gradually widening to apex of fourth segment, fifth and sixth abruptly and conjointly foliaceous in both sexes, fifth produced acutely at apical angle, sixth rapidly narrowing behind, foliaceous expansions horizontal or upcurved; caudal margin of last tergum shallowly indented in both sexes. Legs lacking spines; moderately long, posterior femora reaching beyond fourth segment only; apices of femora with 1 + 1 short, blunt, lateral projections; profemur on dorsal view slightly incurved postbasally, incrassate, gradually narrowing to apex; protibia curved, with small preapical spur and small apical pad of setae; tibia and femur beneath with dense short pubescence. Without plica. Upper surfaces of pronotal lobes at same level (Fig. 3). Claws notched basally. Male genitalia: parameres with longitudinal depression, apical marginal spine of hypopygium broad basally. Thorax and abdomen with small, inconspicuous, scattered, setigerous granules; moderately covered with short, adpressed, silvery pilosity; pilosity of last two legs fine, scattered, about as long as diameter of corresponding segment.

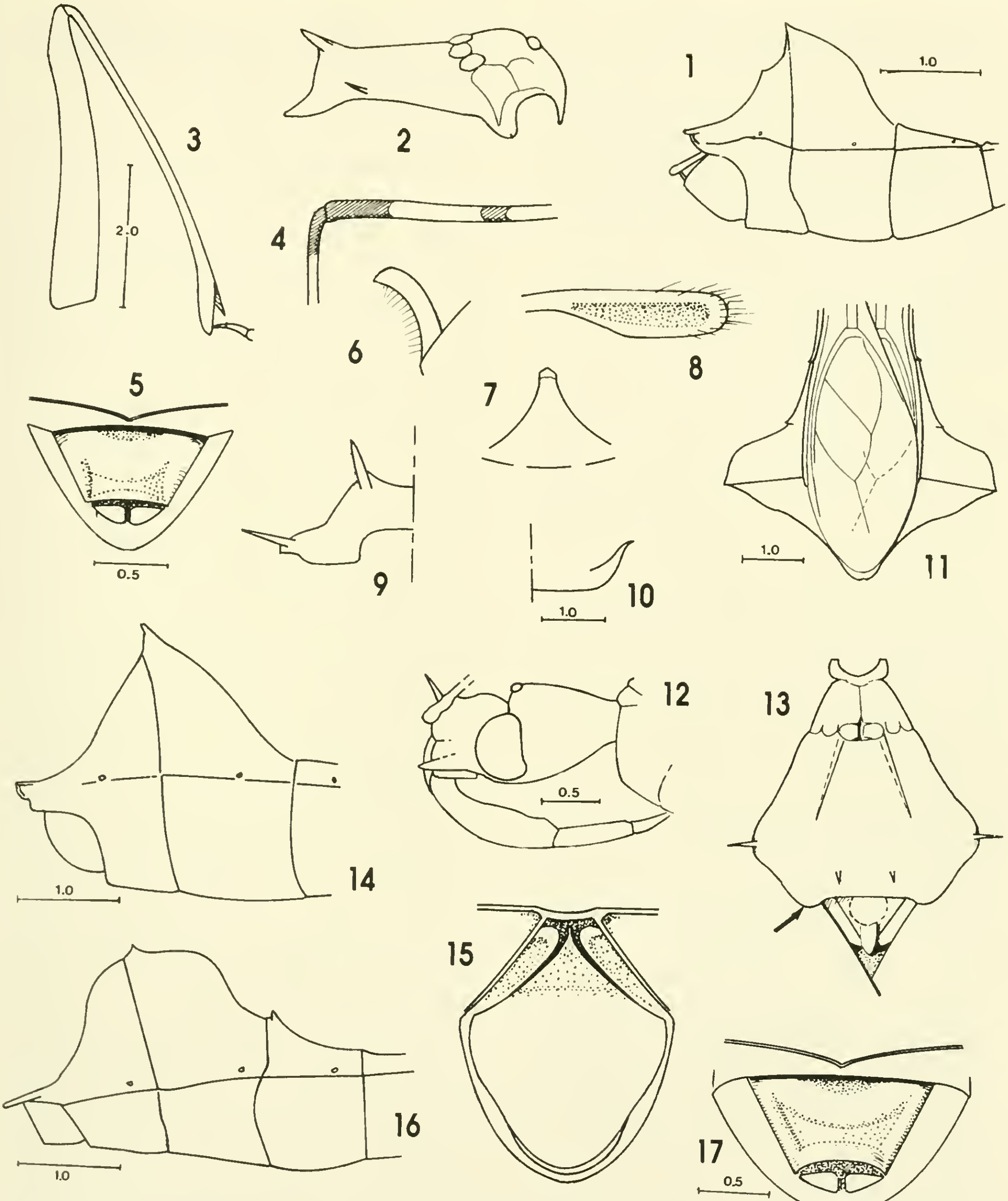
Remarks.—Among genera without plica, *Sosius* Champion belongs with those, such as *Doldina* Stal (Neotropical) and *Serendiba* Distant (African), that have rounded humeri beneath slender, acute spines. This character is usually overlooked. Instead, the humeral angles have been routinely called "spined," a different character. Consequently it is somewhat difficult to determine relationships and to place many harpactorine genera correctly. The foliaceous expansions of several Old World genera, such as *Astinus* Stål, *Austrarcesius* Miller, *Callilestes* Stål, *Cosmolestes* Stål, and *Mastigonomus* Bergroth, include more connexival segments. The upward or almost horizontal position of the foliaceous expansions in *Sosius* seem not to be sex or species related in the two species studied.

Sosius foliaceus Champion
Figs. 14–17

1899 *Sosius foliaceus* Champion, 2: 275. Tab. XVI, figs. 25, 25a, male. Mexico.

Redescription of lectotype: Male.—Dark ferrugineous: head, pronotum after spines, scutellum, hemelytra except membrane, connexivum above and below, last three abdominal sterna. Reddish brown: anterior lobe of pronotum, pleurae, posterior lobe of pronotum to spines. First antennal segment brown, biannulate with fulvous, second and third brown. *Coxae:* Anterior reddish, other two brown. *Fore legs:* Femora dark brown, flavous preapical annulus, poorly defined yellowish area at about midlength; tibia reddish brown, tarsi flavous. Middle and hind legs flavous, black apically (Fig. 4). First abdominal sternum dark ferrugineous, second and third flavous. Pronotal spines black basally and apically, flavous at middle.

Head: Width across eyes 1.31, length 1.81, interocular space 0.68, anterior lobe 1.00, posterior lobe 0.81, anteocular space 0.43. *Antennal segments:* I, 4.50; II, 1.93; III, 3.62; slender, glabrous; subantennal spine as described for genus (Fig. 12), 0.47. Ocelli apart at 4.5 times ocellar diameter (0.13:0.56). *Rostral segments:* I, 1.22; II, 0.74; II, 0.49. *Pronotum:* Anterior lobe width 1.62, length 0.97; posterior lobe width 3.00, length 1.93, disc elevated, limited by diverging longitudinal carinae, surface thinly and faintly



Figs. 1–17. 1–13, *Sosius australis* n. sp. 1, abdomen, lateral, male. 2, fore leg, female. 3, pronotum, lateral, female. 4, hind "knee," female. 5, eighth tergum, caudal, female. 6, hypopygial spine, lateral, male. 7, same, caudal. 8, paramere, outside view. 9, pronotum, caudal view, male. 10, upturned connexival segments, caudal, female. 11, abdomen, dorsal, female. 12, head, lateral. 13, pronotum and scutellum, dorsal, female. 14–17, *Sosius foliaceus* Champion. 14, abdomen, lateral, male. 15, male genital capsule, caudal. 16, abdomen, lateral, female. 17, eighth tergum, lateral.

wrinkled, spines of posterior lobe as in Fig. 9 (same in both species). *Scutellum:* Length 1.25, width 2.18. *Fore legs* (Fig. 2): Profemur slightly longer than posterior (3.87: 3.81), almost 3 × as thick as posterior (0.87: 0.31); tibiae shorter than posterior (3.81: 4.31); abdomen on lateral view as in Fig. 14.

External genitalia: Parameres and hypopygial spine as in *S. australis* n. sp. (Figs. 6–8 and 15). Total length 12.5.

Female.—Above and underneath blackish brown; membrane translucent, with a golden tinge. *Fore leg:* Coxae reddish brown; femur blackish, internal face with two brownish areas; tibia blackish. Mid and hind legs flavous, apex of femur and base of tibiae as in Fig. 4; pronotum laterally brown; eighth tergum as in Fig. 17. Total length 16.5.

Head: Length 2.06, width across eyes 1.40, interocular space 0.75, anteocular space 0.75, anterior lobe 1.12, posterior lobe 0.93, subantennal spine 0.56, genal spine short, not surpassing clypeus; first antennal segment 6.12, glabrous, others missing. *Rostral segments:* I, 1.37; II, 0.93; III, 0.56; ocelli apart at nearly 5 × their diameter (0.13:0.62). *Pronotum:* Anterior lobe length 1.32, width 2.00, anterior angles, sulcus, space between discal spines, surface, posterior margin as in male; posterior lobe length 2.43, width 3.93. Scutellum as in male, width 1.12, length 1.00. *Fore legs:* Femora length 5.31, postbasal width 0.92, about 3.5 × as thick as posterior (0.31); tibiae shorter than posterior (5.31:6.00). Connexival foliaceous expansions almost horizontal (Fig. 16). Abdomen on lateral view as in Fig. 16; eighth tergum as in Fig. 17.

Lectotype (herein designated) male, MEXICO, Atoyac, Vera Cruz. Labeled B.C.A. Rhync. II; *S. foliaceus* [hand written], in British Natural History Museum. Three other specimens seen by Champion, one from Panama, the other two from Mexico, are herein declared paralectotypes, all in the British Museums. Other specimen examined: female, MEXICO, Apuan de Cabañas, Vera Cruz, H. Brailovsky collector, no date, in JMC. See comparative notes and short key under *S. australis.*

Sosius australis
Maldonado and Carpintero, n. sp.
Figs. 1–3

Male.—Dorsally, metapleura, connexivum, and last four abdominal sterna blackish brown; membrane translucent, with golden tinge. Second and basal half of third abdominal sterna gray; pronotum laterally, mesopleura, middle and hind coxae brown. *Rostrum:* First segment black, polished, second reddish and yellow, third pale brown. *Fore legs:* Coxae reddish brown; trochanter, femur, basal ⅔ of tibia black; femur dorsally with two inconspicuous fulvous areas; apical third of tibia reddish; hind legs fulvous, same as in nominate form. Spines of pronotum black, yellow tipped.

Head: Length 1.81, width across eyes 1.25, interocular space 0.62; anterior lobe 1.00, posterior lobe 0.81, anteocular space 0.50; antennae missing; subantennal spine 0.50; ocelli apart at 4 × their diameter (0.125: 0.50). *Rostrum:* I, 1.12; II, 0.68; III, 0.43. *Pronotum:* Anterior lobe length 0.99, width 1.56; posterior lobe length 1.99, width 3.03; posterior lobe with disc elevated, carinae less prominent and shorter than in nominate form, surface more conspicuously wrinkled; scutellum length 1.37, width 2.00, apex longer and sharper than in nominate form. *Fore legs:* Femur slightly shorter than posterior (4.25:4.37), shaped as in nominate form, slightly over 2 × as thick as posterior (0.56:0.25); tibia shorter than posterior (4.31:5.25). Male genitalia as in Figs. 6–8.

Female paratype.—Head and pronotum dark ferrugineous, abdomen above dark brown, abdominal sterna reddish brown, membrane with golden tinge. Fore legs: femur ferrugineous, two inconspicuous pale brown areas above; tibia dark brown. Middle and hind legs fulvous, blackish apically; short incomplete preapical annulus. Tarsi fulvous, blackish apically. Foliaceous part of connexivum upturned (Fig. 10); abdomen on lateral view as in Fig. 1.

Head: Length 2.06, width across eyes 1.37, interocular space 0.68, anteocular space 0.62, anterior lobe 1.06, posterior lobe 1.00, subantennal spine 0.43; genal spine as for genus; antennal segments: I, 6.25; II, 2.25; III, 1.12; others missing, glabrous, slender; ocelli apart about 6.5 × diameter of ocellus. *Rostral segments:* I, 1.50; II, 0.93; III, 0.50. *Pronotum:* Anterior lobe length 1.04, width 1.81; posterior lobe length 2.22, width 4.12, disc flat, slightly elevated inside diverging, poorly defined carinae; surface finely, transversely corrugate; scutellar lobes small; scutellum: length 0.75, width 1.12, apical spine 0.56. *Fore legs:* Femora slightly shorter than posterior (5.00:5.12); postbasal width 0.62, 2 × as thick as posterior (0.31); tibiae shorter than posterior (5.18:5.31). Connexival foliaceous extensions horizontal, 10.0 across. Eighth tergum as in Fig. 5. Total body length 15.5.

Holotype.—BRASIL, Nova Teutonia, Santa Catarina, x.16.1948, collector F. Plauman, Lutz leg., in National Museum of Natural History, Washington, D.C. Paratype female, ARGENTINA, R. N. Iguazu, Misiones, Nov. 7–9, 19??, D. J. In Carpintero's personal collection.

Comparative notes: The thorax is relatively more slender in *Sosius foliaceus* females (3.75 length, 4.00 width) than in *S. australis* (3.25 length, 4.12 width). However, the thorax is similar in males. The two diverging carinae on the posterior thoracic lobe of males of *S. australis* are less prominent and the corrugations of the lobe more pronounced than in those of *S. foliaceus*. White abdominal sterna occur in Mexican males, whereas abdominal sterna are uniformly dark in both sexes of austral forms. The eighth tergum of the females is different, as in Figs. 5 and 17; the depression on each is shallower and less defined than in the drawings.

KEY TO SEPARATE THE SPECIES IN *SOSIUS*

1. Males 2
– Females 3
2. Abdominal sterna with white areas; discal divergent carinae of posterior lobe of pronotum poorly defined, corrugations between these relatively thick and conspicuous ...... *S. foliaceus*
– Abdominal sterna uniformly dark; discal divergent carinae of posterior lobe of pronotum well defined, corrugations fine and inconspicuous between these .... *S. australis*
3. Eighth tergum twice as wide as long, subapical depression with lateral margins quite parallel (Fig. 5); thorax slightly wider than long (3.75: 4.00) .... *S. australis*
– Eighth tergum 1.8 times as wide as long, subapical depression with lateral margins converging posteriorly (Fig. 17); thorax clearly wider than long (3.25:4.12) .... *S. foliaceus*

ACKNOWLEDGMENTS

Our thanks are due to Miss Janet Margerison Knight, from the British Natural History Museum, for the loan of Champion's syntype; to Dr. R. C. Froeschner, from the National Museum of Natural History at Washington, D.C., for the Brasilian and Dr. Harry Brailovsky, Universidad Autónoma de Mexico, for the Mexican specimen. Dr. T. J. Henry, from the National Museum at Washington, D.C., greatly improved the quality of the text with his sharp comments.

LITERATURE CITED

Carpintero, D. J. 1981. Sobre Reduviidae predatores de Triatominae. Com. Mus. Argentino Ci. Nat. Bernardino Rivadavia. Entomologia 1(6): 83–92.

Champion, G. C. 1898–1899. Insecta Rhynchota. Hemiptera–Heteroptera, Vol. II. *In* Godwin and Salvin, eds., Biologia Centrali Americana. Rhynchota. London, XVI + 416 pp. 22 plates.

Maldonado Capriles, J. 1987. *Orbella*, a new harpactorine genus (Hemiptera: Reduviidae). Journal of Agriculture, University of Puerto Rico 71: 199–202.

———. 1990. Systematic Catalogue of the Reduviidae of the World. Special Edition, Caribbean Journal of Science, College of Arts and Sciences, University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico 00681. x + 694 pp.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 228–240

NEW GENUS AND FIVE NEW SPECIES OF MILEEWINE LEAFHOPPERS FROM NEW GUINEA (HOMOPTERA: CICADELLIDAE)

DAVID A. YOUNG[1]

Abstract.—A new genus, ***Archeguina*** (type species: ***Archeguina disparata***, n. sp.), and five new species are described with a key to species and illustrations. The species, all from New Guinea, include ***A. alternata***, ***A. spatulata***, ***A. melanota***, ***A. interstincta***, and ***A. disparata***. *Archeguina* is placed in the tribe Mileewini [subfamily Cicadellinae].[2]

Key Words: Homoptera, Cicadellidae, leafhoppers, new species, New Guinea

INTRODUCTION[3]

Young's (1986) treatment of the Old World Cicadellini includes notes on morphology, techniques, illustrations, and locality data that are relevant to the present paper. *Mileewa* Distant, 1908, and related genera, including the new genus described below, were omitted from the 1986 work because they were considered to constitute a separate category based on the presence of only two distinct anteapical cells in the forewings (crossvein r and vein M_{1+2} are absent; see Evans' 1947 description and figures of Mileewanini [sic!]). The spelling of Mileewanini Evans, 1947 (type genus: *Mileewa*), is here corrected to Mileewini Evans, 1947 (Article 32(c)(iii) and (d) of the International Code of Zoological Nomenclature, 3rd edition).

The following workers were helpful in making specimens available or verifying label information. The symbols are those used later in this work to refer to their institutions.

BMNH	W. J. Knight and R. J. Izzard, Department of Entomology, The Natural History Museum, formerly British Museum (Natural History), London SW7 5BD, England, United Kingdom.
BPBM	J. L. Gressitt and K. Arakaki, Department of Entomology, Bernice P. Bishop Museum, P.O. Box 19000-A, Honolulu, HI 96819.
MCZ	S. P. Cover and P. J. Darlington, Museum of Comparative Zoology, Harvard University, Cambridge, MA 02138.
RMS	L. Brundin and P. Lindskog, Naturhistoriska Riksmuseet, Entomologiska avdelningen, S104 05, Stockholm 50, Sweden.
SAM	G. F. Gross and E. Matthews, South Australian Museum, North Terrace, Adelaide, South Australia 5000.
ZSM	M. Baehr and H. Freude, Zoologische Sammlung des Bayer-

---

[1] Published posthumously in memory of Dr. D. A. Young who was unable to see the manuscript through publication (see Acknowledgments). Address correspondence to: Lewis L. Deitz, Department of Entomology, Box 7613, North Carolina State University, Raleigh, NC 27695-7613.

[2] On the manuscript Dr. Young noted, "I think this should be placed in the Mileewani [sic!] or very near—not in Cicadellini. There are only 2 anteapical cells." Although the tribe Mileewini (as Mileewanini, the incorrect original spelling) is currently placed in the subfamily Cicadellinae, Young (1986, p. 1) alluded to the possibility that *Mileewa* Distant and related genera may belong to another, but unnamed, category of rank equal to Cicadellinae.

[3] Authorship of the Introduction and the Acknowledgments: L. L. Deitz *in* D. A. Young. The remainder of the text is as written by Young with only minor editorial changes.

ischen Staates, Münchhausenstrasse 21, D-8000, München 60, Germany.

Archeguina Young, New Genus

Figs. 1–5

Type species.—*Archeguina disparata,* n. sp.

Length of male 9.7–13.4 mm; of female 10.7–14.3 mm.

Head not strongly produced, median length of crown varying from approximately 0.4 to 0.6× interocular width and from approximately 0.25 to 0.4× transocular width, anterior margin broadly rounded in dorsal view, without a carina at transition from crown to face, ocelli located behind a line between anterior eye angles, each almost always closer to median line than to adjacent anterior eye angle, crown concave medially, the concavity forming part of a longitudinal fovea in some specimens and of a transverse concavity (seen in profile) in others (variable intraspecifically), surface without sculpturing or setae; lateral clypeal sutures extending onto crown and usually attaining ocelli (variable intraspecifically); antennal ledges not protuberant, in lateral view with anterior margins oblique and slightly convex, ledges not carinate dorsally; clypeus flattened medially, muscle impressions distinct; face strongly pubescent beneath; transclypeal suture obscure medially; clypellus not produced, its profile at a slight angle to contour of clypeus which is almost vertical.

Thorax with pronotal width much greater than transocular width of head, lateral margins convergent anteriorly, dorsopleural carinae absent, posterior margin almost always convex, disc usually without punctures or rugosity, not pubescent; scutellum not striate behind transverse sulcus. Forewing without a membrane, veins not distinct, with more than four apical cells, with an anteapical plexus of veins, texture coriaceous and without sculpturing; forewings of female in rest position exceeding apex of ovipositor. Hind leg with femoral setal formula 2:0:0, tibia with setae of row I close-set throughout, variable in size, setae of row II close-set in basal half, more widely spaced in apical half and with intercalary much smaller setae; length of first tarsomere equal to or greater than combined length of two more distal tarsomeres and with two parallel rows of small setae on plantar surface.

Male genitalia: Pygofer moderately produced, with a conspicuous apicoventral process directed posteroventrally, with numerous minute microsetae occurring on most of surface of disc. Plates elongate, fused in basal two-thirds, the free apical portions laterally compressed, extending posteriorly farther than pygofer apex, without macrosetae but with localized microsetae. Style extending posteriorly to a variable extent in comparison with connective, shank tapered and acute. Connective trilobate basally, stem short. Aedeagus symmetrical, without dorsal apodemes, shaft slender, curved gradually posterodorsally, with one or two pairs of anteapical processes near apex; gonopore anteapical and ventral. Paraphyses absent.

Female abdominal sternum VII moderately to strongly produced, its form variable interspecifically. Dorsal membrane of genital chamber without sclerites. Ovipositor with second valvulae slender, curving gradually posterodorsally, without teeth. Tergum IX without macrosetae.

Species of *Archeguina* are usually black and orange to yellow, with the markings occurring as transverse bands (exception: *A. alternata,* n. sp.). The range of the genus is northeast and southeast New Guinea. Although the species of *Archeguina* are large and showy and their occurrence widespread, I have been unable to associate either the genus or any of the species with names employed previously.

The relationship of *Archeguina* to other genera is unknown. It is so peculiar in many respects—the form of the second valvulae of the ovipositor, the posterior femoral setal formula, the unusual setal arrangement of row II of the posterior tibiae, and the irregular venation of the forewings—that it stands well apart from all other genera of Cicadellinae, and perhaps should be removed from the subfamily.

A few specimens of *Archeguina* bear host plant labels indicating they were collected on tea or quinine.

KEY TO SPECIES OF *ARCHEGUINA*

1\. Forewing black with at least one yellow band, or yellow with at least one black band in addition to black apex; aedeagus with only one pair of anteapical processes 2

– Forewing gray or orange, without a complete black band except at or near apex; aedeagus with two pairs of anteapical processes (Fig. 1b, c) .... *alternata*, n. sp.

2\. Male with aedeagus conspicuously and usually abruptly narrowed anteapically in lateral view (Figs. 4d, e, g, 5e, g); female abdominal sternum VII neither produced and spatulate nor strongly bilobed; pronotum usually mostly yellow 4

– Male with aedeagus not, or much less, conspicuously narrowed anteapically (Figs. 2e, 3b); female abdominal sternum VII either produced and spatulate (Fig. 2h), or strongly bilobed (Fig. 3d); pronotum black 3

3\. Male with aedaegus expanded anteapically in caudoventral view (Fig. 2d, f); female with abdominal sternum VII produced and spatulate (Fig. 2h, i) .... *spatulata*, n. sp.

– Male with aedeagus gradually tapered throughout length of shaft in caudoventral view (Fig. 3c); female with abdominal sternum VII excised medioapically and bilobed (Fig. 3d) ... . *melanota*, n. sp.

4\. Male with aedeagal shaft abruptly narrowed anteapically in caudoventral view (Fig. 4c, f); female abdominal sternum VII weakly produced with posterior margin oblique on each side of median apical notch (Fig. 4j) .... *interstincta*, n. sp.

– Male with aedeagal shaft not abruptly narrowed anteapically in caudoventral view (Fig. 5f, h); female abdominal sternum VII strongly produced, its posterior margin transverse and undulate, with or without a median apical notch (Fig. 5i, j) .... *disparata*, n. sp.

Archeguina alternata **Young,**
NEW SPECIES
Fig. 1

Length of male 9.7–10.9 mm; of female 10.7–11.4 mm. Head with median length of crown varying from slightly more than 0.4 (usually from 0.5) to 0.7× interocular width, and from 0.25 to 0.4× transocular width. Male with aedeagus not strongly narrowed anteapically in lateral view, in ventral view with a pair of longer processes extending basally then curved slightly laterally and a pair of short acute processes arising more distally and directed apically and laterally. Female abdominal sternum VII not strongly produced, posterior margin almost rectilinear, with a narrow median notch. Color of typical variety: crown black except apex and in some specimens (including the holotype) a narrow transverse line slightly more posteriorly, which are yellow; pronotum black except a broad border parallel to posterior margin extending anteriorly on each side along lateral margins, pale yellow (holotype) to gray; scutellum black except portion behind transverse sulcus, which is gray; forewings gray, with a transverse incomplete stripe opposite apical half of scutellum, a transverse complete anteapical stripe which is arcuate and parallel to, but not touching, apical margin on each wing and a number of spots variable in size and location between the transverse stripes, black; face and propleura yellow to orange, face with a Y-shaped marking and median line between arms of "Y," black; remaining thoracic pleura black, marked with yellow; legs black. Color, atypical variety: crown black except a narrow transverse stripe before ocelli, often with a short median angular posterior projection, orange; pronotum black with posterior margin broadly bordered with orange which does not extend forward to border completely the lateral margins; scutellum as in typical variety but the apical pale marking less extensive; forewings orange with transverse stripes as in typical variety except that posterior stripe is often broader and extends to posterior wing margin and with its anterior margin irregularly rectilinear instead of concave (the transverse stripe then not appearing arcuate on each wing), with black spots between the two transverse stripes irregular in number,

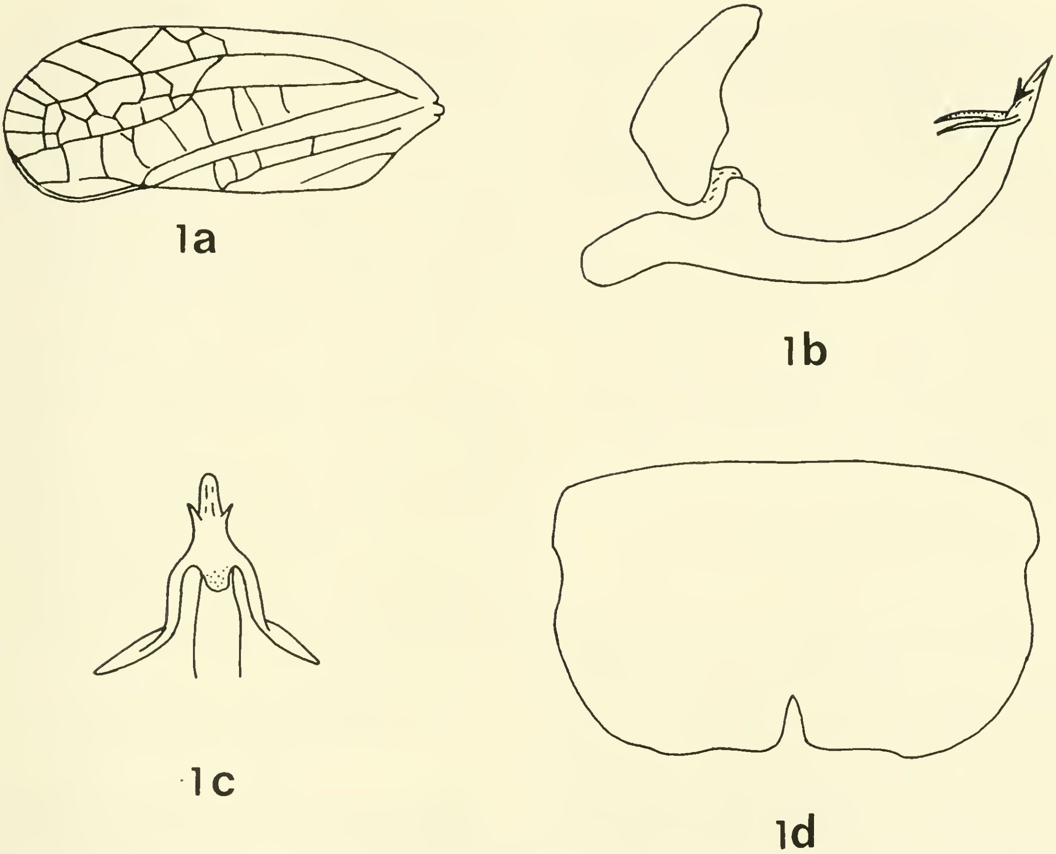


Fig. 1. *Archeguina alternata*, n. sp. (all from Mt. Wilhelm, New Guinea): **a**, forewing; **b**, aedeagus and sclerite at base of anal tube, lateral view (holotype); **c**, apex of aedeagus, caudal view (holotype); **d**, female sternum VII, ventral view.

shape, and arrangement, but with many occurring in the cells of the anteapical plexus and angular as a result; face with clypeus and clypellus shining black (one specimen with a pair of circular yellow spots on clypeus at transition to crown), genae varying from completely black to mostly yellow; thoracic pleura varying from yellow to black, marked with yellow; legs black.

Holotype male, Mt. Wilhelm, NE New Guinea, 3000 m, 4-VII-1955 (J. L. Gressitt) (BPBM). Additional specimens of typical variety, all from NE New Guinea: 21 specimens, same data as holotype; 15 specimens, same data as holotype but with additional label "above Keglsugl"; 4 specimens, same data as holotype except date which is 30-VI-1955; 9 specimens, above Kerowagi, 2300 m, 6-VII-1955 (J. L. Gressitt); 1 specimen, Upper Chimbu-Kerowagi divide, 2800 m, 6-VII-1955 (J. L. Gressitt) (all BPBM); 1 specimen, Mt. Wilhelm, Bismarck Range, forest, 2134–3048 m (as 7–10,000 ft.), X-1944 (Darlington) (MCZ). Additional specimens of atypical variety, all from NE New Guinea: 1 specimen, Daulo Pass, 2500 m, Asaro-Chimbu divide, 12-VI-1955 (J. L. Gressitt); 5 specimens, same data except 3000 m and 13-VI-1955; 3 specimens, same data except 2400 m and 15-VI-1955; a series of specimens (in capsule), Daulo Pass, 2500 m, 2-V-1959 (C. D. Michener); 2 specimens, Mt. Otto, 2200 m, 24-VI-1955 (J. L. Gressitt);

2 specimens, Daulo Pass, 2800 m, Asaro-Chimbu divide, 14-VI-1955 (J. L. Gressitt); and 2 specimens Miramar-Gobavabe, Asaro Valley, 2000 m, 29-VI-1955 (J. L. Gressitt) (all BPBM). The maximum distance between the localities is 20 minutes of latitude and 35 minutes of longitude.

Archeguina alternata, n. sp., can be separated from most other species in the genus by its smaller size and its different, although variable, color pattern. The form of the female abdominal sternum VII (Fig. 1d) and of the apex of the aedeagus, with its four processes instead of the usual two, are also diagnostic.

Archeguina spatulata Young, New Species

Fig. 2

Length of male 13.0–13.9 mm; of female 13.5–14.3 mm. Head with median length of crown from slightly less than 0.4 (usually from more than 0.4) to almost 0.6× interocular width, and from slightly less than 0.25 to slightly less than 0.3× transocular width. Male with aedeagus not appreciably narrowed anteapically in lateral view, in ventral view with a single pair of anteapical processes arising almost at apex and extending basally and laterally. Female abdominal sternum VII abruptly narrowed near midlength, then produced posteriorly in a broad truncate spatulate lobe (asymmetrical and slightly bilobed in one specimen) (Fig. 2h, i). Color black except two large orange markings on each forewing: the more anterior marking quadrate, beginning slightly behind scutellar apex, occupying entire breadth of wing except a very narrow black border on costal and commissural margins, extending posteriorly to apical one-fourth of clavus; the more posterior marking much shorter, oval to quadrate, confined to corium, beginning near apex of clavus, more widely bordered with black on costal and commissural margins, the more apical black area more than half length of orange marking.

Holotype female, Wau, Morobe District, NE New Guinea, 1700 m, 7-II-1963 (J. Sedlacek) and 3 additional specimens, same data; 1 specimen, same data except 1200 m, 16-VI-1961; 3 specimens, same locality, 1200–1250 m, 24-XII-1961 (J. and J. H. Sedlacek); 1 specimen, 6 km W of Wau, Nami Creek, 1700 m, 10-VI-1962 (J. Sedlacek) (all BPBM); 1 specimen, Morobe District, Mt. Mission (Stevens) (MCZ).

Archeguina spatulata, n. sp., may be separated readily from all other species in the genus by the distinctive form of the female abdominal sternum VII. In the males, the aedeagus bears only two apical processes and is not abruptly narrowed anteapically in lateral view, a combination of characters which will separate *spatulata* from other species of the genus except *A. melanota,* n. sp., in which the aedeagus is more uniformly tapered in caudoventral view (cf. Figs. 2f, 3c).

Archeguina melanota Young, New Species

Fig. 3

Length of male 10.9–11.2 mm; of female 11.3–12.2 mm. Head with median length of crown from less than 0.5 to more than 0.6× interocular width and from slightly less than 0.3 to almost 0.4× transocular width. Male with aedeagus slightly narrowed anteapically in lateral view, with or without one or two dorsal processes near base of shaft, in ventral view with pair of anteapical processes extending basally and laterally, without additional processes near apex, shaft regularly tapered from base to apex. Female abdominal sternum VII with median posterior deep excision extending almost half distance to base of sternum and dividing its posterior portion into two distinct lobes which are convex apically. Color of crown, pronotum and scutellum black, some specimens (not the holotype) with arcuate, narrow band, which may be interrupted, on disc of crown before ocelli, some specimens (including the holotype) with posterior margin narrowly bordered with orange or yellow

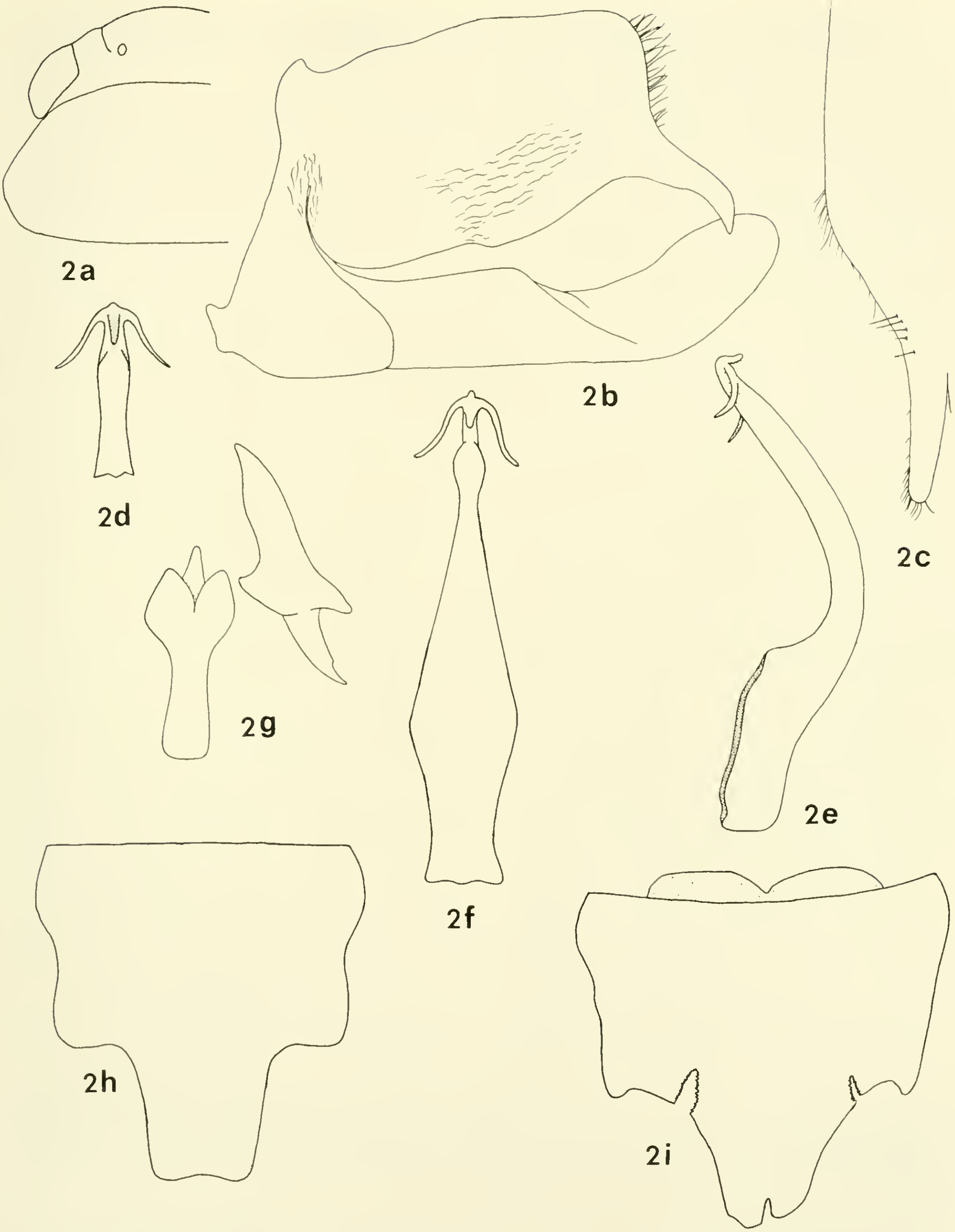


Fig. 2. *Archeguina spatulata,* n. sp.: **a,** head and pronotum, dorsal view; **b,** male pygofer, valve and plate, lateral view; **c,** right plate, ventral view; **d,** apex of aedeagus, ventral view; **e–f,** aedeagus; e, lateral view, f, ventral view; **g,** connective and right style, dorsal view; **h–i,** female sternum VII, ventral view (h, Wau, Morobe District, New Guinea; i, Nami Creek, 6 km W of Wau, New Guinea).

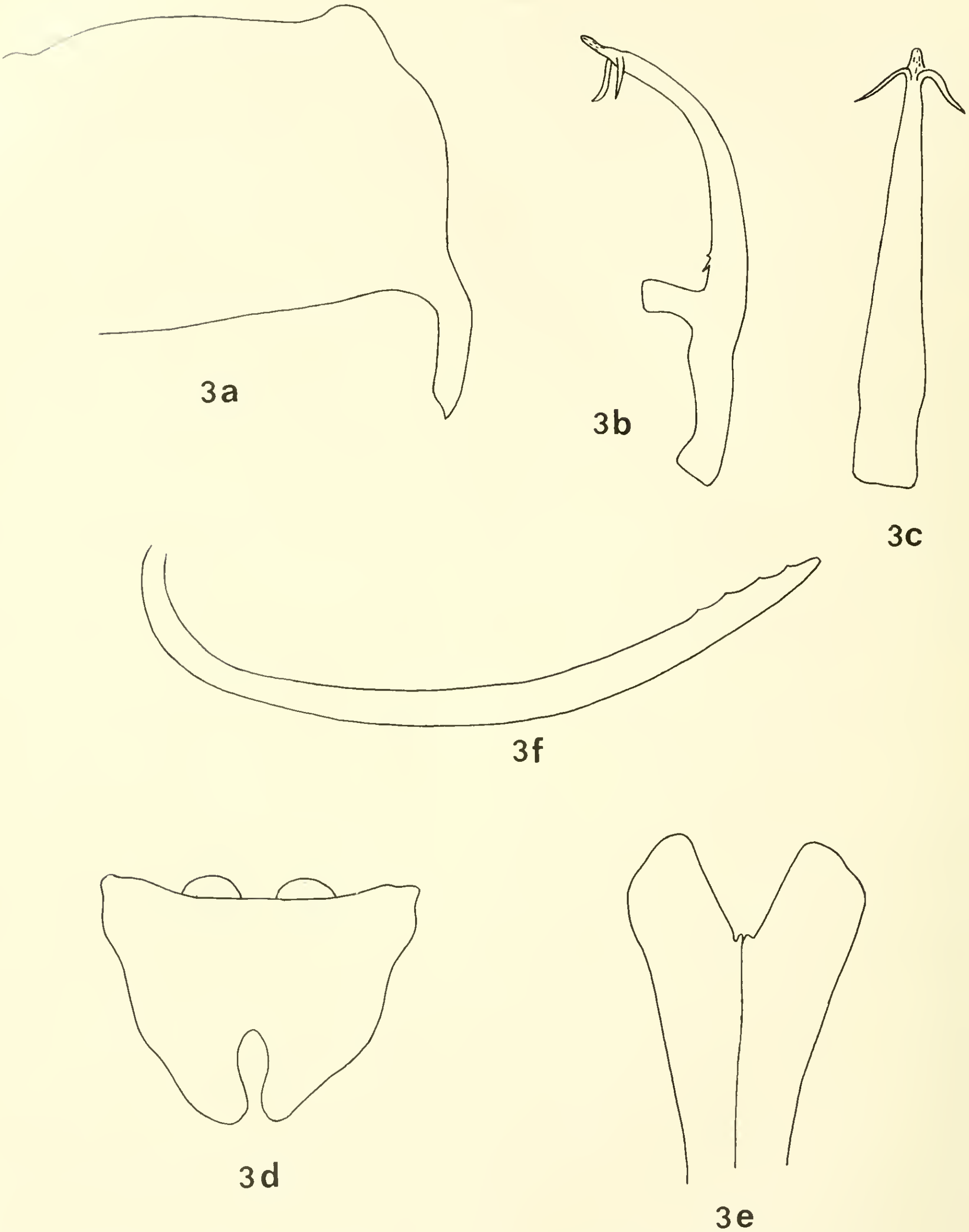


Fig. 3. *Archeguina melanota,* n. sp. (all from Bome, Gailala, Owen Stanley Range, Papua, New Guinea): **a,** male pygofer, lateral view; **b-c,** aedeagus: b. lateral view, c, ventral view; **d,** female sternum VII, ventral view; e, bases of first valvulae, ventral view; **f,** second valvulae, lateral view.

(holotype) line which is interrupted (holotype) or not; forewing black with inconspicuous narrow yellow marking extending across claval suture near base, large conspicuous yellow quadrate spot extending across wing at midclavus except for narrow black costal and commissural margins, and smaller oval yellow transverse spot on corium opposite claval apex which is more broadly bordered with black on costal margin; face, legs and thoracic pleura black, the last with one or more small yellow markings.

Holotype male, and 11 additional specimens, Owen Stanley Range, Papua, New Guinea, Goilala: Bome, 1950 m, 24-II to 7-III-1958 (W. W. Brandt); 3 specimens, same data except 8 to 15-III-1958; 4 specimens, same data except 16 to 31-III-1958; 1 specimen, same data except 1 to 15-IV-1958; 1 specimen, same data except 16 to 30-IV-1958; 5 specimens, same data except Goilala: Tororo, 1560 m, 21 to 24-II-1958; 1 specimen, same data except 15 to 20-II-1958; 14 specimens, Edie Creek, 11.2 km W of Wau, NE New Guinea, 1700 m, 16-VII-1961 (J. H. Sedlacek and J. and M. Sedlacek); 2 specimens, Edie Creek, 2000 m, 4 to 10-X-1961 (J. and J. H. Sedlacek); 1 specimen, same locality, 200 m [sic], 5 to 11-X-1961 (J. Sedlacek); 3 specimens, Wau, Morobe District, 1200 m, 11 to 15-X-1961 (J. Sedlacek); and 1 specimen, same data except 1400 m, 27-VIII-1961; 3 specimens, Mt. Kaindi, NE New Guinea, 2400 m, 27-I-1963 (J. Sedlacek); 1 specimen, same data except 16 km SW of Wau, 8 to 9-VI-1962, 2200 m; 3 specimens, same data except 2300 m; 1 specimen, same data except 6-X-1962; 1 specimen, 19–29 km S of Wau, NE New Guinea, Bulldog Rd., 2200–2500 m, 31-V-1962 (J. Sedlacek); and 1 specimen, Laiagam, NE New Guinea, 2180 m, 18 to 19-VI-1963 (J. Sedlacek) (all BPBM).

Archeguina melanota, n. sp., is very similar to *A. spatulata,* n. sp., in color and structure of the male genitalia. The aedeagus in *spatulata* is slightly broadened anteapically, regularly tapered in *melanota.* Females of *melanota* are readily separable from all other species in the genus by the strongly bilobate abdominal sternum VII.

Archeguina interstincta Young, New Species

Fig. 4

Length of male 13.0–13.4 mm; of female 12.4–13.7 mm. Head with median length of crown varying from 0.4 to 0.5× interocular width, and from 0.25 to almost 0.3× transocular width. Male with aedeagus strongly narrowed anteapically in lateral view (Fig. 4d, f, g), in ventral view with one pair of anteapical processes extending laterally and basally and with shaft slightly constricted near midlength or in apical half, gradually broadened more distally, then abruptly narrowed anteapically. Female abdominal sternum VII not strongly produced, its posterior margin slightly oblique on each side of slight median notch. Head black, in some specimens with narrow transverse line before ocelli, giving off a short median posterior branch in some specimens (including the holotype); pronotum with anterior one-third black in most specimens (including the holotype), but the black extending over more than basal one-half in a few specimens, forewing variable, from completely black with interrupted broad transverse orange stripe opposite midlength of clavus (holotype) and occasionally with a very small orange spot in inner apical cell, to black with two transverse orange bands, one as in typical variety, second band much smaller and anteapical; face, legs and thoracic pleura black except proepimeron over posterior portion of which orange pronotal band is usually (holotype) continued.

Holotype male, Sakalang, Salawaket Range, NE New Guinea, 10-IX-1956 (E. J. Ford, Jr.) and 6 additional specimens, same data (BPBM). Also from NE New Guinea: 8 specimens, Sepalakambang, Salawaket Range, 1920 m, 11 to 14-IX-1956 (E. J. Ford, Jr.); 10 specimens, Tuwep, Salawaket Range, 1350 m, 8-IX-1956 (E. J. Ford, Jr.); 6 specimens, same data as preceding except 9-IX-1956; 3 specimens, Finisterre Range, Saidor, Matoko Village, 6 to 24-IX-1958 (W. W. Brandt); 1 specimen, same data as preceding except 38-VIII to 5-IX-1958; 2 specimens, Finisterre Range, Saidor, Funyende, 1200 m, 24-IX-1958 (W. W. Brandt); 1 specimen, same data as preceding except 24 to 30-IX-1958; 4 specimens, Main Fin-

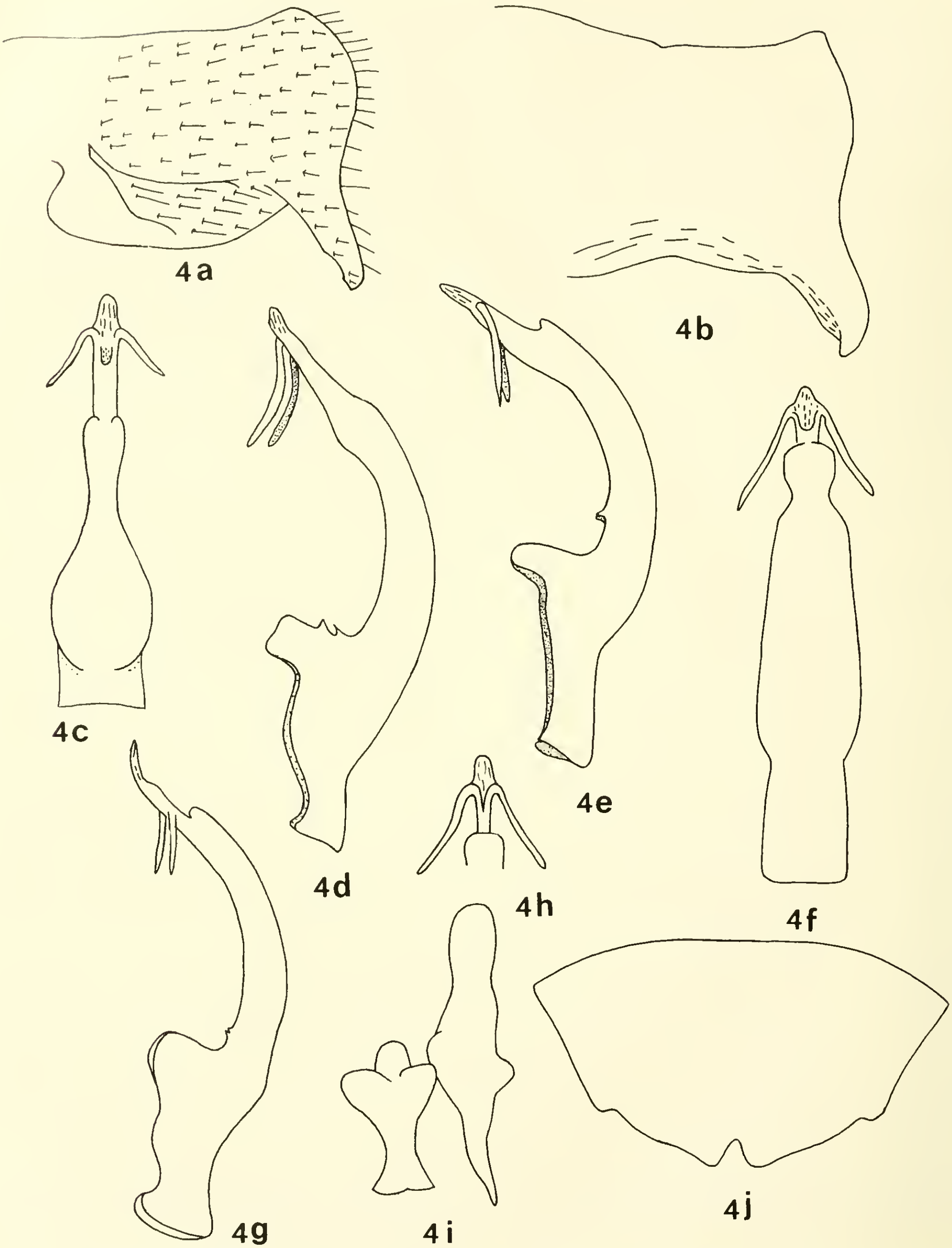


Fig. 4. *Archeguina interstincta*, n. sp.: **a-b,** male pygofer, lateral view; **c-g,** aedeagus: c, ventral view, d, lateral view (Finisterre Range, Saidor, New Guinea), e, lateral view, f, ventral view (Sakalong, Salawaket Range, New Guinea), g, lateral view (specimen erroneously labeled Caracas, Venezuela); **h,** apex of aedeagus, ventral view; **i,** connective and right style, dorsal view; **j,** female sternum VII, ventral view.

isterre Range near Freyberg Pass (N), 2550 m, 1 to 21-X-1958 (W. W. Brandt) (all BPBM). Also, 34 specimens, Komba, (Northeast?), New Guinea; 6 specimens, Finschafen, NE New Guinea; and 3 specimens, "Hudewa," New Guinea (all Rev. L. Wagner) (all SAM); 1 specimen, Ogelbeng [near Mt. Hagen, Central Highlands] (ZSM). There is also one specimen mislabeled "Caracas, Venezuela" in ZSM.

Archeguina interstincta, n. sp., is similar externally to *A. spatulata,* n. sp., and to some specimens of *A. disparata,* n. sp., in neither of which is the aedeagus abruptly narrowed anteapically in ventral view as it is in *interstincta* (Fig. 4g). The abdominal sternum VII of the female is not produced in *interstincta* nearly as much as in *spatulata* (Fig. 2h) or *disparata* (Fig. 5h).

Archeguina disparata Young, NEW SPECIES

Fig. 5

Length of male 12.6–13.1 mm; of female 12.6–14.1 mm. Head with median length of crown varying from slightly more than 0.3 to 0.5× interocular width and from 0.25 to 0.3× transocular width. Male with aedeagus strongly narrowed anteapically in lateral view, in ventral view with one pair of processes extending laterally and basally, with shaft not constricted, lateral margins almost parallel or very slightly convergent, anteapical processes in ventral view variable in length (Fig. 5e, f). Female abdominal sternum VII strongly produced, posterior margin concave on each side of a broad median convexity which is notched (Fig. 5h) or not (Fig. 5i) medially. Head black with narrow transverse ivory to orange stripe before ocelli; pronotum varying from completely black, or black with small pale spot on posterior margin on each side, to chiefly yellow with anterior transverse black band which may be (holotype) margined anteriorly by very narrow transverse band of ivory, yellow, or orange; scutellum black with pale (ivory to orange) anteapical spot; forewing black with large quadrate more anterior orange spot involving most of clavus except basally and apically, and a similarly colored smaller spot or corium behind claval apex, both spots narrowly bordered mesally and laterally by the narrow, black commissural and costal margins, respectively, in some specimens (including the holotype) also with small orange marking at base of both clavus and corium; face, thoracic pleura and legs black except small yellow to orange genal spot on each side bordering lateral clypeal suture between lorum and antennal base in some specimens (including the holotype), and orange posterior portion of proepimeron in some specimens (including the holotype).

Holotype male, Daulo Pass, Asaro-Chimbu divide, NE New Guinea, 3000 m, 13-VI-1955 (J. L. Gressitt) (BPBM); 3 additional specimens, same data; 2 specimens, same data except 2800 m, 14-VI-1955; 3 specimens, same data as holotype except 2400 m, 15-VI-1955; a series of specimens in capsule, Daulo Pass, 2500 m, 2-V-1959 (C. D. Michener) (all BPBM). Additional specimens from NE New Guinea; 1 specimen, Eliptamin Valley, 1200–1350 m, 16 to 30-VIII-1959 (W. W. Brandt); 1 specimen, Kepilam, 2420–2540 m, 21-VI-1963 (J. Sedlacek); 1 specimen, 6–12 km W of Wabag, 2020–2400 m, 13-VI-1963 (J. Sedlacek); 1 specimen, Yaibos, 2030–2180 m, 11-VI-1963 (J. Sedlacek); 2 specimens, Tomba, slopes of Mt. Hagen, 2450 m, 23-V-1963 (J. Sedlacek); 1 specimen, same data except 2500–2650 m, 24-V-1963; 4 specimens, Tomba, 38 km W of Mt. Hagen, 2450 m, 21 to 24-V-1963 (J. Sedlacek); 1 specimen, Western Highlands, Hagen, SE of Kornfarm, 15-X-1958 (J. L. Gressitt); 1 specimen, same data except 16-X-1958; 1 specimen, Mt. Hagen, 1600 m, 23-V-1961 (J. L. and M. Gressitt); 1 specimen, 11 km south of Mt. Hagen, 2000–2300 m, 20-V-1963 (J. Sedlacek); 2 specimens, Lake Sirunki, 2550 m, 17-VI-1963 (J. Sedlacek); 1 specimen, Tsenga, Upper Jimmi Valley,

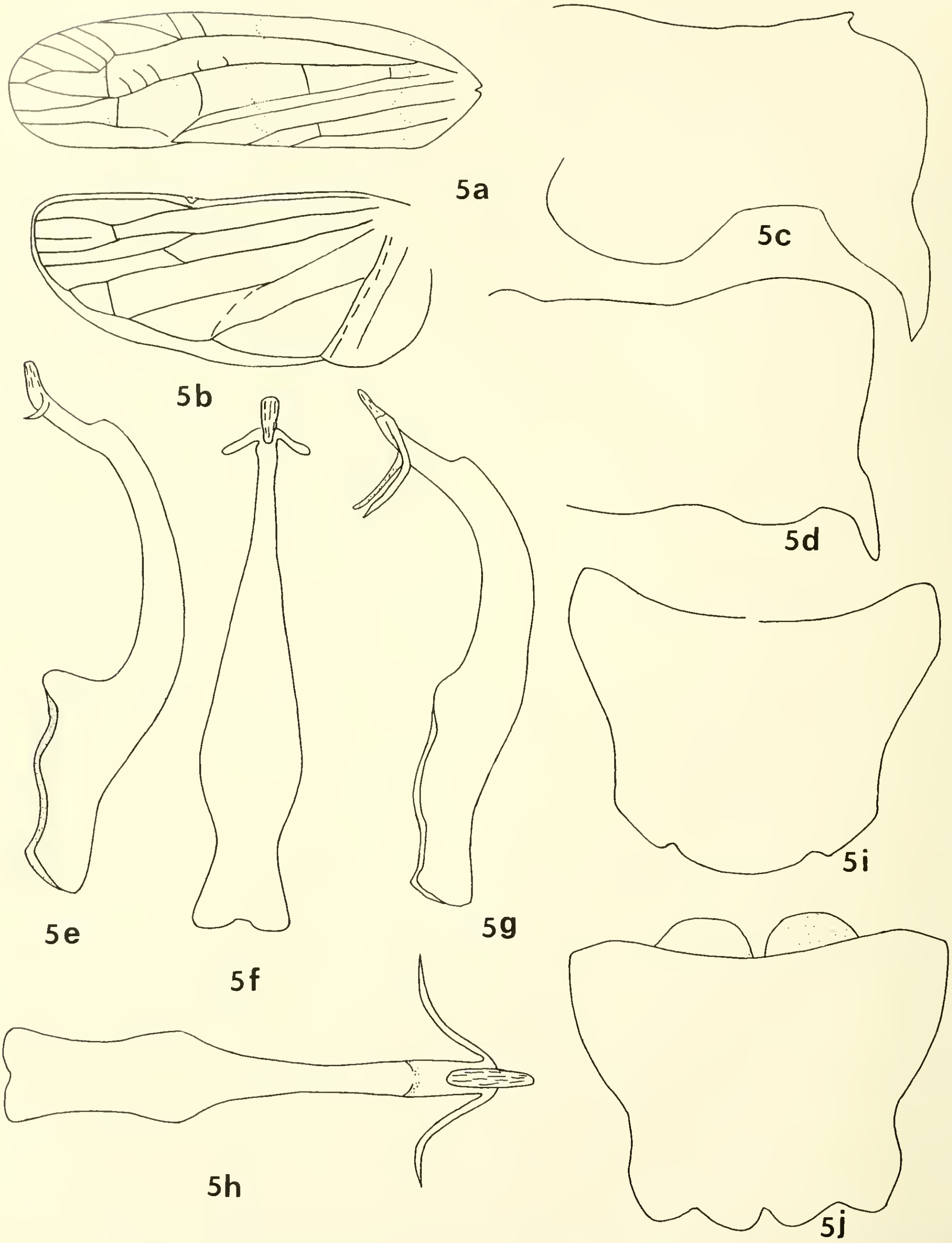


Fig. 5. *Archeguina disparata,* n. sp.: **a,** forewing; **b,** hind wing (a–b, Aiyura, New Guinea); **c–d,** male pygofer, lateral view (c, Kassam, 48 km E of Kainantu, New Guinea; d, Mt. Otto, New Guinea); **e–h,** aedeagus: e–g, lateral view, f–h, ventral view (e–f, Mt. Otto, New Guinea; g–h, Aiyura, New Guinea); **i–j,** female sternum VII, ventral view (i, Mt. Otto, New Guinea; j, Aiyura, New Guinea).

1200 m, 14-VII-1955 (J. L. Gressitt); 1 specimen, Wana, Upper Jimmi Valley, 1500 m, 11-VII-1955 (J. L. Gressitt); 2 specimens, Ahl Valley, Nondugl, 1750 m, 8-VII-1955 (J. L. Gressitt); more than 22 specimens, Nondugl, 2200–2700 m, 28-V-1959 (C. D. Michener) (all BPBM); 4 specimens, Nondugl, 1600 m, IX to XI-1951 (G. Gyldenstolpe) (RMS); 2 specimens, Chimbu Valley, Bismarck Range, 1524–2286 m (as 5000–7500 ft), X-1944 (Darlington) (MCZ); 1 specimen, Numbu, Upper Chimbu Valley, 2400 m, 5-VII-1955 (J. L. Gressitt); 1 specimen, Toromomburo, Mt. Wilhelm, 2200 m, 29-VI-1955 (J. L. Gressitt); 2 specimens, above Kabebe, Mt. Otto, 2200 m, 23-VI-1955 (J. L. Gressitt); 17 specimens, Mt. Otto, 2200 m, 22-VI-1955 (J. L. Gressitt); 2 specimens, same data, except 24-VI-1955; 6 specimens, above Kerowagi, 2300 m, 6-VII-1955 (J. L. Gressitt); 1 specimen, Kassam, 48 km E of Kainantu, 1350 m, 30-X-1959 (T. C. Maa); 1 specimen, same data except 7-XI-1959; 12 specimens, Miramar, Asaro Valley, 1800 m, 27-VI-1955 (J. L. Gressitt); 6 specimens, Nenguag, Asaro-Chimbu divide, 2500 m, 29-VI-1955 (J. L. Gressitt) (all BPBM); 11 specimens, Aiyura, VII-1954 (H. Womersley) (SAM); 5 specimens, Aiyura, XII-1939 (A. S. Cantor) on tea and quinine; 8 specimens, Aiyura, 25-IX-1957 (J. Smart); 2 specimens, Aiyura, III-1945 (B. O'Connor); 2 specimens, Moke, 3-X-1957 (J. Smart) (all BMNH); 1 specimen, Moife, 2100 m, 11 to 13-X-1959 (T. C. Maa); 21 specimens, same data except 7 to 14-X-1959; 1 specimen, Edie Creek, 11.2 km W of Wau, 1700 m, 16-VII-1961 (J. and M. Sedlacek); 1 specimen, Wau, Morobe District, 1650 m, 5-XII-1961 (J. Sedlacek); 1 specimen, same locality, 1200–1250 m, 24-XII-1961 (J. and J. H. Sedlacek); 1 specimen, same locality, 1200 m, 17-VI-1961 (J. L. Gressitt); 1 specimen, Tuwep, Salawaket Range, 1350 m, 8-IX-1956 (E. J. Ford, Jr.); 2 specimens, Sakalang, Salawaket, 10-IX-1956 (E. J. Ford, Jr.) (all BPBM). Additional specimens from SE New Guinea: 10 specimens, Kiunga, Fly River, 26 to 30-VII-1957 (W. W. Brandt); 9 specimens, Anga Gorge, E of Mendi, 14-X-1958 (J. L. Gressitt); 7 specimens, South Highlands, N of Mendi, 1800 m, 8-X-1958 (J. L. Gressitt); 1 specimen, South Highlands, Aiyurop, near Mendi, 1530 m, 7-X-1958 (J. L. Gressitt); 10 specimens, Mt. Giluwe, 2500 m, 25-V-1961 (J. L. and M. Gressitt); 10 specimens, same locality, 2500–2650 m, 28-V-1963 (J. Sedlacek); 3 specimens, same locality, 2550 m, 27-V-1963 (J. Sedlacek); 1 specimen, same locality, 2400–3000 m, 30-V-1961 (J. L. and M. Gressitt); 1 specimen, same locality, 2550 m, 27-V to 6-VI-1963 (J. Sedlacek); 1 specimen, Malgi, Mt. Giluwe, 2500 m, 25-V-1961 (J. L. and M. Gressitt); 5 specimens, South Highlands, SE of Mt. Giluwe, Dimifa, 2200 m, 9-X-1958 (J. L. Gressitt); 10 specimens, same data except 10-X-1958; 1 specimen, same data except 12-X-1958 (all BPBM). Also 4 specimens, Ogelbeng [near Mt. Hagen, Central Highlands] (H. Schein) (ZSM). In addition to the above, the following were examined from a locality that I was unable to locate on maps or otherwise: 13 specimens, Weiga, 2600 m, IX to XI-1951 (G. Gyldenstolpe) (RMS).

Archeguina disparata, n. sp., is somewhat similar in appearance to *A. spatulata* and *A. interstincta*, n. spp. The males of *disparata* can be separated from those of other species in the genus by the aedeagus which is narrowed anteapically in lateral view but not in caudal view. Females of *disparata* can be separated from other species in the genus by the strongly produced abdominal sternum VII which has a concavity on each side of the central lobe which is with or without a median concavity. Only *interstincta* approaches the latter condition, but in that species the sternum VII is much shorter.

ACKNOWLEDGMENTS

H. D. Blocker, L. L. Deitz, C. H. Dietrich, P. H. Freytag, W. J. Knight, H. H. Neunzig, and M. W. Nielson reviewed the manuscript and promoted it through the publication process. Merv Nielson was especially helpful in overseeing this initiative and in laying out the figures. The assistance of those who lent or checked specimens and of C. O. Smith, typist, is also gratefully acknowledged. This work was funded in part by the North Carolina Agricultural Research Service, Raleigh, North Carolina.

LITERATURE CITED

Evans, J. W. 1947. A natural classification of leafhoppers (Jassoidea, Homoptera). Part 3. Jassidae. Transactions of the Royal Entomological Society of London 98(6): 105–271.

Young, D. A. 1986. Taxonomy of the Cicadellinae (Homoptera: Cicadellidae). Part 3. Old World Cicadellini. North Carolina Agricultural Research Service Technical Bulletin 281. v + 639 pp.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 241–244

ON THE HOST RANGE OF THE DELPHACID PLANTHOPPER *STOBAERA PALLIDA* OSBORN (HOMOPTERA)

W. A. PALMER

(WAP) North American Field Station, Queensland Department of Lands, 2801 Arrowhead Circle, Temple, Texas 76502.

Abstract.—The host specificity of *Stobaera pallida* was investigated as part of a biological control program against *Baccharis halimifolia.* This planthopper was collected from *B. halimifolia* and *B. neglecta* in the United States and from *B. conferta* in Mexico. In laboratory studies it oviposited in *B. halimifolia* and *B. neglecta* but not on 31 other plant species. Early instar nymphs survived on *B. halimifolia* and *B. neglecta* but not on five other asteraceous species. The host range for this insect was considered to be confined to the genus *Baccharis* and most probably the section *Baccharis* within that genus.

Key Words: *Baccharis, Stobaera pallida,* biological control

This short paper describes observations and experiments that were undertaken to confirm the host range of the delphacid *Stobaera pallida* Osborn which was investigated as part of our studies to find suitable biological control agents for *Baccharis halimifolia* L. (Asteraceae: Astereae) which is a serious weed in Australia.

Kramer (1973) revised the Nearctic genus *Stobaera* Stål and indicated that all eleven described species fed only on asteraceous plants. Furthermore the host records presented by Kramer indicated that all the species possessed host ranges limited to two plant genera or less.

Stobaera pallida has been reported only from *B. halimifolia* and *B. neglecta* Britton (Kramer 1973). It could reasonably be expected to also utilize the very closely related *B. glomerufolia* Pers. and *B. angustifolia* Michx. that are sympatric with *B. halimifolia* in Florida. In 1989 we also collected *S. pallida* on *B. conferta* Kunth. growing in the state of Morelos, Mexico. All these species of *Baccharis* were placed in the section *Baccharis* by Nesom (1990).

Two experiments were conducted at the North American Field Station to confirm the host range of this insect. The first examined the oviposition preference and the second the ability of early instar nymphs to survive on various hosts.

METHODS

Thirty-three plant species were selected in the first experiment which was conducted in July and August, 1984. Most were representatives of Asteraceae, particularly Astereae. Two replications of each species were used. Twelve potted plants (of 12 species but including *B. halimifolia*) were randomly placed within each 53 × 69 × 84 cm gauzed cage. Wooden planks were placed above the pots so that the foliage and stems of the plants protruded through small holes in these planks. Six cages were so prepared so that each plant species was exposed twice except for *B. halimifolia* (6 exposures) and *B. neglecta* (4 exposures). The cages were housed in an outdoor shade house. Approximately fifty insects (including both adults and nymphs) which had been collected from *B.*

Table 1. The host specificity of *Stobaera pallida* as indicated by ovipositional preference of adults and survival of early instars.

Plant species	Mean Number of Eggs Oviposited in 25 cm of Stem	Mean Number of Early Instars Surviving 3 Days
Asteraceae: Astereae		
Aster noviae-anglae L.	0	0
Baccharis halimifolia L.	18	6
Baccharis neglecta Britton	13	4
Callistephus chinensis (L.) Nees	0	NT
Chrysothamnus nauseosis (Pall.) Britt.	0	0
Conyza canadensis L.	0	0
Dimorphotheca aurantiaca Hort.	0	NT
Gutierrezia microcephala (DC) Gray	NT	0
Gymnosperma glutinosum (Spreng.) Less	0	NT
Haplopappus sp.	0	NT
Isocoma wrightii (Gray) Rydb.	NT	0
Solidago altissima L.	0	0
Asteraceae: Heliantheae		
Dahlia pinnata Cav.	0	NT
Gaillardia pulchella Foug.	0	NT
Helianthus anuus L.	0	NT
Iva frutescens L.	0	NT
Parthenium hysterophorus L.	0	NT
Xanthium strumarium L. (*sensu lato*)	0	NT
Zinnia elegans Jacq.	0	NT
Asteraceae: Tageteae		
Tagetes lucida Cav.	0	NT
Asteraceae: Cynareae		
Carthamus tintoris L.	0	NT
Cynaria scolymus L.	0	NT
Asteraceae: Eupatorieae		
Ageratum houstonianum Mill.	0	NT
Asteraceae: Cichorieae		
Lactuca sativa L.	0	NT
Malvaceae		
Gossypium hirsutum L.	0	NT
Solanaceae		
Lycopersicon esculeatum Mill.	0	NT
Fabaceae		
Vicia faba L.	0	NT
Verbenaceae		
Lantana camara L.	0	NT
Verbena sp.	0	NT
Lamiaceae		
Salvia splendens Sellow	0	NT
Amaranthaceae		
Gomphrena globosa L.	0	NT

Table 1. Continued.

Plant species	Mean Number of Eggs Oviposited in 25 cm of Stem	Mean Number of Early Instars Surviving 3 Days
Apocynaceae		
Vinca minor L.	0	NT
Caryophyllaceae		
Dianthus sp.	0	NT
Poaceae		
Zea mays L.	0	NT

NT = not tested.

halimifolia at Conroe, Texas, were introduced into each cage by scattering them over the wooden planks. Nymphs were not excluded because it was assumed that they would soon eclose to the adult stage.

After 2 weeks, 25 cm of stem from each plant were selected, dissected and the number of eggs oviposited by *S. pallida* counted. In the smaller plants this meant dissecting the whole plant. The eggs were similar to those of *S. tricarinata* (Say) (Reimer and Goeden 1981, 1982) and *S. concinna* Stål (McClay 1983) being smooth, hyaline and fusiform–elliptical in shape and measuring on average 0.98 × 0.22 mm. They were usually laid singly in the pith of the stems with the tapered end of the egg pointing towards the epidermis. Often they could be detected by oviposition scars left on the outer epidermis.

In a second experiment, the ability of nymphs to feed on various hosts was tested. Ten early instars were placed on bouquets of foliage of each of seven species of Astereae. Each treatment was replicated twice. After three days surviving nymphs were counted.

RESULTS AND DISCUSSION

In the first experiment eggs were oviposited only in *B. halimifolia* and *B. neglecta* (Table 1) and between these two plants there did not appear to be a preference.

In the second experiment approximately half the nymphs survived on *B. halimifolia* and *B. neglecta* but none survived on any other plant (Table 1).

These experiments clearly supported field observations and indicated that the host range of *S. pallida* is limited to the genus *Baccharis.* As all the known hosts are in the section *Baccharis,* it is probable that the host range is actually limited to this section of the genus.

Permission was obtained to import *S. pallida* into quarantine facilities in Australia. However, attempts to rear the insect in quarantine facilities were unsuccessful and so it has not been released there.

ACKNOWLEDGMENTS

Dr. J. P. Kramer of the Systematic Entomology Laboratory, USDA, and Dr. M. R. Wilson of the Institute of Entomology, C. A. B., kindly provided expert identifications of this species.

LITERATURE CITED

Kramer, J. P. 1973. Revision of the American planthoppers of the genus *Stobaera* (Homoptera: Delphacidae) with new distributional data and host plant records. Proceedings of the Entomological Society of Washington 75: 379–402.

McClay, A. S. 1983. Biology and host-specificity of *Stobaera concinna* Stål (Homoptera: Delphacidae), a potential biocontrol agent for *Parthenium* *hysterophorus* L. (Compositae). Folia Entomologica Mexicana 56: 21–30.

Nesom, G. L. 1990. Infrageneric taxonomy of North and Central American *Baccharis* (Asteraceae: Astereae). Phytologia 68: 40–46.

Reimer, N. J. and R. D. Goeden. 1981. Descriptions of the immature stages of *Stobaera tricarinata* (Say) (Hemiptera–Homoptera: Delphacidae). Pan-Pacific Entomologist 57: 429–433.

———. 1982. Life history of the delphacid planthopper *Stobaera tricarinata* (Say) on western ragweed, *Ambrosia psilostachya* Décondolle, in southern California (Hemiptera–Homoptera: Delphacidae). Pan-Pacific Entomologist 58: 105–108.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 245–252

ANTENNAL SENSILLA OF THE CHINESE LANTERN FLY, *PYROPS CANDELARIA* L. (HOMOPTERA: FULGORIDAE)

GERALD T. BAKER AND ANGSUMARN CHANDRAPATYA

(GTB) Department of Entomology, Mississippi State University, P.O. Drawer EM, Mississippi State, Mississippi 39762, U.S.A.; (AC) Department of Entomology, Kasetsart University, Bangkok, 10900, Thailand.

Abstract.—The antennal pedicel of *Pyrops candelaria* has four types of sensory receptors: sensilla basiconica, sensilla campaniformia, sensilla chaetica and plaque organs. Porous and multi-innervated, sensilla basiconica are situated among the plaque organs on the female and male antennae. Sensilla campaniformia occur individually or in pairs on the pedicel. A single, large and fluted sensillum chaeticum is situated on the apex of the pedicel near the flagellum. Plaque organs cover the surface of the pedicel. They vary in size and consist of a central portion of pitted cuticular folds that may or may not be branched. This central area is surrounded by guard setae. The amphora-shaped flagellum has a long extension and an opening that leads to an atrium. Three sensilla basiconica are situated on the atrial walls. Sensillum chaeticum is the only type of sensillum to be situated on the scape and about 20 of these sensilla form an encircling band around the scape.

Key Words: Homoptera, Fulgoridae, *Pyrops,* antenna, sensilla

---

INTRODUCTION

Pyrops candelaria L., Chinese lantern fly, feeds on several horticulturally important plants such as longan, *Dimnocarpus longan* Lour., mango, *Mangifera indica* L., and litchi, *Litchi chinensis* Sonn., in China and southeast Asia. This very large homopteran (3–4 cm in length) at times can reach numbers at which it can do severe economic damage. Basically, the antenna consists of a scape, which is very flexible; a large, bulbous pedicel which is covered with plaque organs; and a flagellar annulus, which is amphora-shaped with a long slender extension.

The ultrastructure of the plaque organs was described by Lewis and Marshall (1970), Marshall and Lewis (1971), and Marshall (1973). Marshall and Lewis (1971) showed that the changes in plaque organ complexity are in accordance with the taxonomic classification of Fulgoroidea by Metcalf (1951). Since there is no current information about the other sensilla on the antennae of *P. candelaria,* this paper provides an account of the morphology, number, and distribution of sensilla that are found on the antennal annuli of *P. candelaria.*

MATERIALS AND METHODS

Specimens of *P. candelaria* were collected on longan trees at Su-won Farm Res. Station of Kasetsart University, Thailand. For transmission electron microscopy (TEM), antennae were fixed over-night in Karnovsky's fixative in cacodylate buffer, pH 7.2 at 4°C. After rinsing, the specimens were placed in 2% osmium tetroxide for 4 hours on ice. The specimens were then washed in distilled water, dehydrated in ethanol, and embedded in Spurr's low viscosity resin.

Thick sections (0.5 μm) were stained with toluidine blue for light microscopy and ultra-thin sections were stained with uranyl acetate and lead citrate for TEM. The sections were examined with a JEOL or Hitachi TEM scope at 60 kV.

For SEM, fixation and dehydration were the same, after which the antennae were critical-point dried. They were mounted on aluminum stubs with double-sided adhesive tape and coated with gold-palladium. The specimens were examined with a Cambridge S360 SEM at 20 kV. Some antennae were stained with crystal violet (Slifer 1960) or silver nitrate (Schafer and Sanchez 1976) to detect pores in cuticle of the sensilla. All measurements which are given in microns and counts of sensilla are given as a mean plus the range and are based upon 10 specimens.

RESULTS

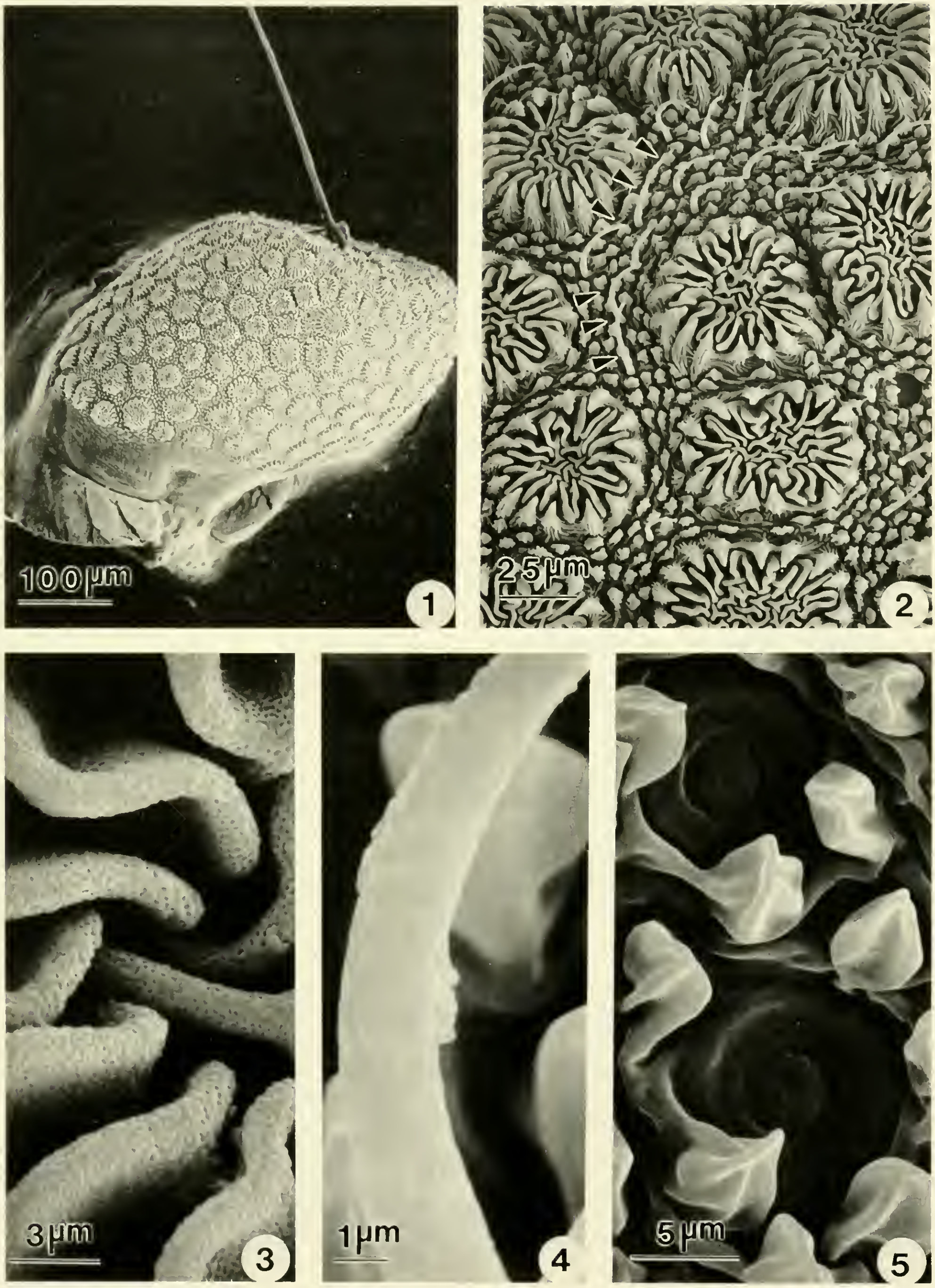
The pedicel, which is the largest, most obvious annulus and has the most sensilla, is a bulbous structure that measures 400 (385–410) wide at the base and 620 (605–635) wide at the apex in females and 390 (378–402) and 611 (601–619) in males (Fig. 1). Plaque organs cover the surface of the pedicel (Fig. 1). Between 168 and 190 plaque organs may be situated on the pedicel and no significant difference in total number of plaques exists between males 175 (168–183) and females 180 (174–190). Externally, each plaque consists of two distinct components, guard setae and the cuticular folds of the sensillum. (Fig. 2). The number of guard setae varies between 10 and 34 depending upon the diameter of the plaque. Guard setae are 16.5 (13–22) long and 10.5 (9–12) wide at the base and are longitudinally folded. They are situated on the periphery of the plaque and project inwards between the cuticular folds (Fig. 2). The guard setae appear to be a longer type of projection than the highly folded and shorter cuticular projections that cover the surface of the pedicel (Fig. 2).

The external portion of the plaque organ consists of deeply pitted cuticular folds that may or may not be branched (Fig. 3). These folds are 1.3 (0.8–2) wide, 13 (10–17) long and 5.2 (4–6) high. Most of the folds on the periphery of the plaques are unbranched and longer as compared to those in the central region which are branched and shorter. Plaque organs are 55 (24–81) in diameter. The distribution of the various size classes of plaques is random, i.e. small or large plaques are found on all areas of the pedicel. These sensilla stain intensely with crystal violet and silver nitrate, which indicates their porosity. The number of neurons associated with each plaque organ ranged from 128 to 152; based upon counts made from 0.5 μm serial sections of 16 plaques.

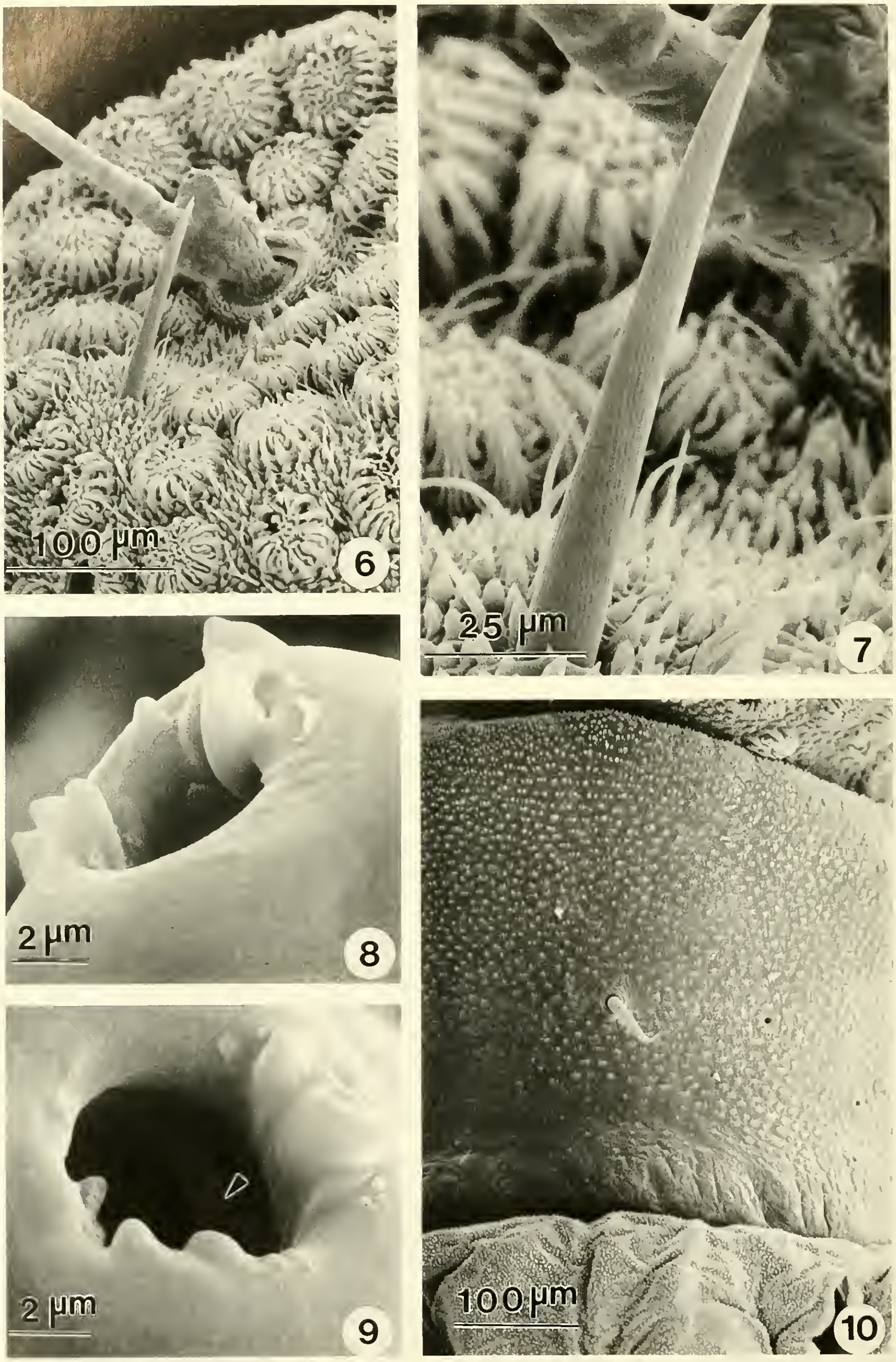
Sensilla basiconica are dispersed among the plaque organs and may be found as a single sensillum or in groups that range from 2 to 25 sensilla (Fig. 2). This sensillum is 27 (23–31) long and 3.6 (3.1–4.2) wide at the base. The shaft portion of the sensillum has a rough, pitted surface and is tapered and curved at the apex (Figs. 2, 4). It is hollow and porous, as indicated by the crystal violet and silver nitrate staining. Dendrites from the sensory neurons extend into the peg portion of the basiconic sensillum. There are 152 (140–164) of these sensilla on the pedicel.

The third type of sensillum that is situated on the pedicel is the sensillum campaniformium. This sensillum consists of a disc-like portion with a central pit and an area of raised cuticle that surrounds the disc-like portion (Fig. 5). The diameter is 9.7 (9.4–10.2) and they are located on various areas of the pedicel. Sensilla campaniformia occur as singles or doubles (Fig. 5) and do not stain with the crystal violet or silver nitrate.

A single, large sensillum chaeticum is the fourth type of sensillum on the pedicel, and it is situated on the apex of the pedicel near the flagellar annulus (Fig. 6). The sensillum is 110 (105–114) long and 14.6 (13.7–15.8)



Figs. 1–5. Sensilla on the pedicel of *P. candelaria.* 1. Plaque organs on the pedicel. 2. Sensilla basiconica (arrows) among the plaque organs. 3. Pitted cuticular folds of a plaque organ. 4. Surface of a sensillum basiconicum. 5. Two disc-like sensilla campaniformia.



Figs. 6–10. Antennal sensilla. 6. Sensillum chaeticum and flagellum on the apex of the pedicel. 7. Sensillum chaeticum with forked apex and fluted surface. 8 & 9. Cuticular extensions around the flagellar opening and basiconic sensillum (arrow) in the atrium. 10. Sensillum chaeticum on the scape.

wide at the base. The apex of the sensillum is forked, and the surface is fluted (Fig. 7). There was no staining of the sensillum by the crystal violet or silver nitrate.

The flagellum is composed of a single annulus that has two distinct portions, an amphora-like base and a long, slender, apical extension (Fig. 6). There is no evidence of any sensilla on the outer surface of the flagellum. An opening is situated on the apex of the amphora-like base (Fig. 8). This opening is 6.1 (5.2–7.3) in diameter and is surrounded partially by triangular, cuticular extensions (Fig. 9). The number, size, and shape of the extensions vary among the specimens (Figs. 8, 9). An atrium, which is irregularly shaped, is located beneath the opening and at its greatest width is approximately 9.5 μm. There are three sensilla basiconica and two cuticular projections situated on the atrial wall (Fig. 11). These sensilla are 2.8 μm (2.6–3.1 μm) long and 1.3 μm (1.1–1.5 μm) wide at the base. The sensilla are hollow and fluted externally; dendrites from several sensory neurons occur in the hollow peg (Fig. 11).

Although the scape is the first antennal annulus, it is hidden by the bulbous pedicel. It is 405 μm (390–415 μm) long and 250 μm (238–259 μm) wide. Sensilla chaetica (22–27) are arranged in a band that encircles the scape. The sensillum is 48 (45–54) long and 9 (8–12) wide at the base (Fig. 10). The apical end is extended into a long, fine tip that is slightly curved, and the base is inserted into a socket of flexible cuticle. The outer surface of the sensillum is smooth. In cross section, this sensillum has a solid cuticular wall; no pores were indicated by the crystal violet and silver nitrate staining.

Discussion

Lewis and Marshall (1970) presented a thorough and detailed description of the plaque organs on the antenna of *P. candelaria.* But there are some differences between their results and the information presented in this paper. First, the plaque differs in the range of diameters, 26 to 80 versus 30 to 60 (Marshall and Lewis 1971) and in the number of guard setae surrounding, 10 to 34 versus 12–28 (Marshall and Lewis 1971). Second, the number of neurons in a plaque organ did not exceed 152 neurons and the average for the sixteen plaques was 137; this is less than the 200 to 300 given by Lewis and Marshall (1970). Third, Lewis and Marshall (1970) do not state anything about similarities or differences in the total number of plaques on female and male antennae. The male antennae have fewer plaque organs and this is probably due to the male pedicels being slightly smaller than the female pedicels.

The plaque organ on *P. candelaria* probably evolved from the coalescence of a group of sensilla basiconica (Lewis and Marshall 1970, Marshall and Lewis 1971). This plaque organ is not similar to the type found on the antennae of many different Hymenoptera (Esslen and Kaissling 1976, Borden et al. 1978a, b) and on the antennae of Sternorrhyncha (Homoptera) (Bromley et al. 1979, Slifer et al. 1964). Bourgoin (1985) is the only publication that provides a detailed description of the morphology, number, and distribution of the various types of sensilla that occur on fulgoroid antennae; he described those on several species from the family Tettigometridae (Homoptera: Fulgoroidea). Sensilla chaetica encircle the scape of *Tettigometra sulphurea* (Mulsant & Rey) just as in *P. candelaria,* but no sensilla basiconica are situated on the scape of *P. candelaria* as with *T. sulphurea* and other tettigometrids (Bourgoin 1985).

The number (35 plaques), distribution (few plaques on the ventral surface of the pedicel) and morphology (dome shaped plaques) of plaque organs on *T. sulphurea* pedicel differ greatly from the 168 to 190 plaques that cover all surfaces of the pedicel and are ridged and surrounded by guard setae on *P. candelaria.* Marshall and Lewis (1971) presented a gradation in complexity of plaque morphology and its correlation

Fig. 11. Longitudinal section of the flagellum showing the internal atrium (A), three sensilla basiconica (asterisks), nuclei of perikarya (N) and thick cuticle (EC—exocuticle; EnC—endocuticle) of the flagellum.

with the taxonomic classification for the Fulgoroidea (Metcalf 1951). In their gradation diagram there is a blank slot for the subcohort Tettigometraia. Bourgoin's (1985) description of *T. sulphurea* plaques clearly places these structures into the vacant slot in the gradation scheme of plaque complexity in accordance with Metcalf's taxonomic classification. Sensilla ampulaca are present on the pedicel of *T. sulphurea* (Bourgoin 1985) but none occur on the pedicel of *P. candelaria.* Also, only one sensillum chaeticum is situated on the pedicel of *P. candelaria* whereas *T. sulphurea* has 32 (Bourgoin 1985). *Tettigometra sulphurea* has only 8 sensilla basiconica as compared to more than 140 on the pedicel of *P. candelaria.*

The flagellum on *P. candelaria* and *T. sulphurea* are basically the same shape and have the same components, an amphora-like base with an apical opening and a long, slender extension. Over 100 denticles surround the opening on the flagellum of *T. sulphurea* (Bourgoin 1985), whereas in *P. candelaria,* only 4 to 6 denticles are associated with the flagellar opening. At first, it appeared that the denticles on *P. candelaria* were a type of solidified excretion but the structures remained even after using solvents such as water, acetone, ethanol, methanol, chloroform and sodium hydroxide. There are two cuticular projections (non-innervated) and three sensilla that project from the atrial wall in *P. candelaria,* whereas *T. sulphurea* has two non-innervated cuticular projections and two cuticular sensory receptors (Bourgoin 1985).

No electrophysiological data for the various types of sensilla are available at the present time. The sensilla chaetica on the scape are probably involved in monitoring the position of the other antennal annuli in relation to the scape and the antennae to the head, whereas the large chaeticum on the pedicel may be monitoring the movement of the flagellum. Sensilla basiconica and plaque organs have the ultrastructural characteristics of a chemoreceptor, and the sensilla campaniformia are involved in detecting cuticular stress in the bulbous pedicel (McIver 1975, Zacharuk 1980). Behavioral and electrophysiological data are needed to determine the functions of the sensilla on the pedicel and those inside the flagellar atrium.

ACKNOWLEDGMENTS

We would like to thank the staff at the Su-won Farm Research Station, Thailand, for their help in collecting specimens and use of facilities. Also, we extend our appreciation to W. Monroe for technical assistance with some of the specimens and J. Tisdale for typing the manuscript. Partial support was provided by NSF grant #DIR9001493. This paper is No. J-8078 of the Mississippi Agricultural and Forestry Experiment Station.

LITERATURE CITED

Borden, J. H., L. Chong, and A. Rose. 1978a. Morphology of the elongate placoid sensillum on the antennae of *Itoplectis conquisitor.* Annals of the Entomological Society of America 71: 223–227.

Borden, J. H., A. Rose, and R. J. Chorey. 1978b. Morphology of the elongate sensillum placodeum on the antennae of *Aphidius smithi* (Hymenoptera: Aphidiidae). Canadian Journal of Zoology 56: 519–525.

Bourgoin, T. 1985. Morphologie antennaire des Tettigometridae (Hemiptera: Fulgoromorpha). Nouvelle Revue Entomologie (N.S.) 2: 11–20.

Bromley, A. K., J. A. Dunn, and M. Anderson. 1979. Ultrastructure of the antennal sensilla of aphids. I. Coeloconic and placoid sensilla. Cell Tissue Research 203: 427–442.

Esslen, J. and K. E. Kaissling. 1976. Zahl and Verteilung antennaler Sensillen bei der Honigbiene (*Apis mellifera* L.). Zoomorphologie 85: 227–251.

Lewis, C. T. and A. T. Marshall. 1970. The ultrastructure of the sensory plaque organs of the antennae of the Chinese lantern fly, *Pyrops candelaria* L., (Homoptera: Fulgoridae). Tissue and Cell 2: 375–385.

Marshall, A. T. 1973. Vesicular structures in the dendrites of an insect olfactory receptor. Tissue and Cell 2: 375–385.

Marshall, A. T. and C. T. Lewis. 1971. Structural variation in the antennal sense organs of fulgoroid

Homoptera (Insecta). Zoological Journal of the Linnean Society 50: 181–184.

McIver, S. G. 1975. Structure of cuticular mechanoreceptors of arthropods. Annual Review of Entomology 20: 381–397.

Metcalf, Z. P. 1951. Phylogeny of the Homoptera: Auchenorhyncha. Comment. Biology 12: 1–14.

Schafer, R. and T. V. Sanchez. 1976. The nature and development of sex attractant specificity in cockroaches of the genus *Periplaneta*. I. Sexual dimorphism in the distribution of antennal sense organs in five species. Journal of Morphology 149: 139–158.

Slifer, E. H. 1960. A rapid and sensitive method for identifying permeable areas in the body wall of insects. Entomological News 71: 179–182.

Slifer, E. H., S. S. Sekhon, and A. D. Lees. 1964. The sense organs on the antennal flagellum of aphids (Homoptera), with special reference to the plate organs. Quarterly Journal of Microscopic Science 105: 21–29.

Zacharuk, R. Y. 1980. Ultrastructure and function of insect chemosensilla. Annual Review of Entomology 25: 27–47.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 253–257

FIRST RECORD OF *KRATOYSMA* (HYMENOPTERA: EULOPHIDAE) FROM THE NEW WORLD, INCLUDING THE DESCRIPTION OF TWO NEW SPECIES

Christer Hansson and Ronald D. Cave

(CH) Department of Systematic Zoology, Lund University, Helgonavägen 3, S-223 62 Lund, Sweden; (RDC) Depto. de Proteccion Vegetal, P.O. Box 93, Tegucigalpa, Honduras.

Abstract.—The genus *Kratoysma* Boucek is reported from the New World for the first time and two new species are described. ***Kratoysma gliricidiae* Hansson & Cave,** n. sp. is described from material reared from an undescribed species of Gracillariidae on *Gliricidia sepium* (Fabaceae) in Honduras. ***Kratoysma ecuadorensis* Hansson,** n. sp. is described from a single swept specimen from Ecuador.

Key Words: Eulophidae, *Kratoysma*, taxonomy, biology, Honduras, Ecuador

The genus *Kratoysma* was described by Boucek (1965), including a single European species (*Derostenus usticrus* Erdös). Later, Hansson (1985) described and included two new species from Nepal (*K. longifacies* and *K. nepalensis*). Boucek (1988) described a new species of this genus from Papua New Guinea (*K. citri*), and stated that he had seen undescribed species belonging to the genus from Australia, New Guinea, India and South China. Hitherto no material of *Kratoysma* has been reported from the New World. Below two new species from the Neotropical region are described.

Hosts are known only for two of the four species. The European species, *K. usticrus*, has been reared from *Phyllocnistis suffusella* Zeller (Lep., Gracillariidae) (Boucek 1965), and the species from New Guinea has been reared from *P. citrella* Stainton (Boucek 1988). One of the new species described below was reared from an undescribed species of Gracillariidae (Lepidoptera) on *Gliricidia sepium* (Jacq.) Steud. in Honduras.

The views expressed under "Phylogeny" are the sole responsibility of the senior author.

Phylogeny

The genus *Kratoysma* is regarded as most closely related to *Chrysocharis* and *Derostenus,* according to Schauff (1991). Boucek (1965) regards the genus as intermediate between *Chrysocharis* (= *Kratochviliana*) and *Achrysocharoides* (= *Enaysma*), on the one hand, and *Pediobius* on the other hand.

In spite of the recent publication on the phylogeny of the Holarctic genera of Entedontinae (Schauff 1991), the placement of *Kratoysma* remains somewhat unclear, but I agree with Schauff that there is no close relationship between *Kratoysma* and *Pediobius.* Boucek (1965) found two characters that linked *Kratoysma* with *Pediobius*: the wing venation and the possession of plicae on the propodeum. However, in my opinion neither character is much different from some species of *Chrysocharis.* I am more inclined to agree with Schauff that *Kratoysma* is related to *Chrysocharis.* Nevertheless, the similarities with *Achrysocharoides,* i.e. the hairy eyes, the shape of the male head and the pale subbasal spot of male gaster (which occurs in several different genera), as pointed out by Boucek (1965), should be stressed. The sole synapomorphy for *Kratoysma* is the straight and raised ridge-like frontal groove (Schauff 1991).

The two American species differ from the other species of *Kratoysma* in the mainly smooth and shiny scutellum, with reticulation delimited to two sublateral rows. *Kratoysma gliricidiae* differs from other known species, including the new species from Ecuador, in lacking median carina(e) on the propodeum. Nevertheless, both American species without doubt belong in *Kratoysma,* sharing the apomorphy consisting of the frontal groove present as a raised ridge.

Abbreviations used in the text are: HE = height of eye; MO = width of mouth opening; MS = malar space; WH = width of head; WT = width of thorax across shoulders; PM = length of postmarginal vein; ST = length of stigmal vein; TP = length of thorax and propodeum (mesosoma of some authors); G = length of gaster. Abbreviations of museums and private collections are as follows: CH = collection of Christer Hansson; EAPZ = Escuela Agricola Panamericana, EL Zamorano, Honduras; LUZM = Lund University Zoological Museum, Lund, Sweden; USNM = United States National Museum of Natural History, Washington, D.C., U.S.A.

Genus *Kratoysma* Boucek

Kratoysma Boucek, 1965: 5–6. Type species: *Derostenus usticrus* Erdös 1954: 346–347, by original designation and monotypy.

Diagnosis.—Frontal groove present as a straight and raised ridge; occipital margin with a strong and sharp carina along entire vertex; pronotal collar with a raised carina; propodeum with plicae; petiole at least as long as wide and with parallel sides.

Kratoysma gliricidiae
Hansson and Cave, New Species
Figs. 1–4

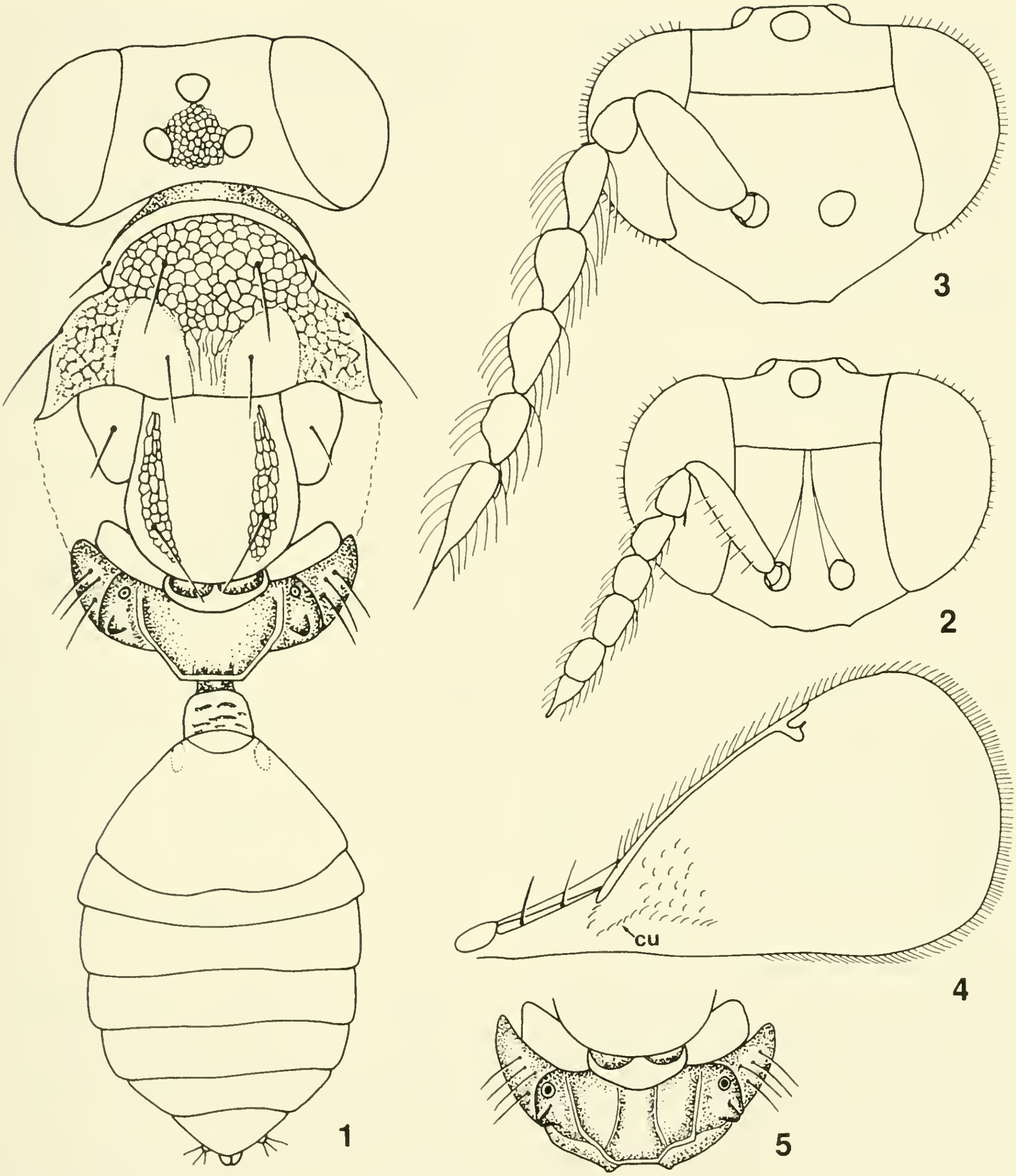
Diagnosis.—Scutellum mainly smooth and shiny, with reticulation delimited to two sublateral rows; fore coxa pale; cubital hairline distinctly curved upwards; median part of propodeum smooth, without median carinae.

Description.—Female. Scape pale, remaining antenna dark and metallic. Face golden-green. Frons below frontal groove golden, above frontal groove metallic purple. Vertex golden-green, tinged with blue at the sides. Mesoscutum golden-green, tinged with blue at the sides. Scutellum golden-green, metallic purple in the meshes of reticulation, (two small females with entire scutellum metallic purple). Propodeum golden-green. Fore coxa pale, mid and hind coxae dark and metallic; remaining parts of legs pale, except fuscous claws. Wings hyaline. Gaster golden-green, first tergite tinged with blue.

Length of body: 1.0–1.5 mm.

Head: Antenna as in Fig. 2. Face, frons above frontal groove and vertex smooth and shiny—vertex inside ocellar triangle with smoothened reticulation; frons below frontal groove with quite strong and small-meshed reticulation. Scrobal grooves never join. Frontal groove present as a straight and raised ridge. Occipital margin with a strong and sharp carina along entire vertex. Eyes densely pubescent. Ratios HE/MS/MO: 3.1/1.0/1.1. Quotient WH/WT = 1.2.

Thorax: Pronotal collar with a transverse carina. Midlobe of mesoscutum with quite strong reticulation, sidelobes with weaker reticulation; notaular depressions smooth and shiny. Scutellum smooth and shiny except strong sublateral rows of reticulation. Axillae smooth and shiny. Dorsellum smooth and shiny with two deep pits anteriorly. Propodeum smooth and shiny, with plicae—sometimes short and in some specimens completely missing; without median carina; propodeal callus with three setae.



Figs. 1–5. *Kratoysma* spp. 1–4, *Kratoysma gliricidiae* n. sp. 1, Body excl. wings (dorsal). 2, Head, female (frontal). 3, Head, male (frontal). 4, Forewing, female (cu = cubital hair-line). 5, *Kratoysma ecuadorensis* n. sp., propodeum and dorsellum, female (dorsal).

Forewing with speculum closed, cubital hairline curved upwards; postmarginal vein slightly longer than stigmal vein, quotient PM/ST = 1.3.

Gaster: Raised surface of petiole about as long as wide with subparallel sides, surface smooth and shiny, with some transverse ridges. Ovate; mean ratio TP/G = 1.1 ± 0.07, n = 10.

Male. Color same as female except: Head

uniformly brilliant metallic golden-green except for golden interocellar area; pedicel metallic green. Gaster with a large pale subbasal spot.

Length of body: 1.4–1.6 mm.

Head: As in female except: Frons below frontal groove with quite strong reticulation and with distinctly transverse meshes. Scrobal grooves absent. Hairs on eyes longer than in female. Ratios HE/MS/MO: 3.0/1.6/1.0. Quotient WH/WT = 1.2.

Thorax: As in female.

Gaster: Narrower than in female; mean ratio TP/G = 1.2 ± 0.07, n = 10.

Type material.—Holotype a female labelled "HONDURAS: Fco. Morazan, San Antonio de Oriente, El Zamorano, 15 Ago 1991.03, rcol R. Cave/Gliricidia sepium/ex: larva de Gracillariidae," deposited in USNM. Paratypes: following with same locality and host data as holotype but with different collection dates: 6♀♀ 5♂♂ 880716, 3♀♀ 3♂♂ 880805 (1♂ in coll. CH), 1♂ 880815, 4♀♀ 2♂♂ 890627 (leg. R. Caballero), 3♀♀ 910523, 18♀♀ 11♂♂ 910815 (4♀♀ 2♂♂ in coll. CH), 7♀♀ 5♂♂ 910914 (3♀♀ 3♂♂ in coll. CH), 880721 1♀ (CH) (unless otherwise stated types are in EAPZ); 2♀♀ "HONDURAS: Fco. Morazan, Guimaca, Guaimaca, 1 Jun 1991.01, rcol R. Cave/Gliricidia sepium/ex: larva de Gracillariidae" (EAPZ), 2♀♀ from same locality as previous but collected 910921 (CH); 18♀♀ 18♂♂ "HONDURAS: Atlantida, La Ceiba, La Ceiba, 6 Jun 1991.03, rcol R. Cave/Gliricidia sepium/ex: larva de Gracillariidae" (4♀♀ 9♂♂ in coll. CH, remaining in EAPZ); 2♂♂ "HONDURAS: Fco. Morazan, Tegucigalpa, Tegucigalpa, 16 Jun 1991.01, rcol R. Cave/Gliricidia sepium/ex: larva de Gracillariidae" (EAPZ); 2♀♀ 2♂♂ "HONDURAS: Cortes, San Antonio de Cortes, Amapa, 20 Jun 1991.34, rcol. R. Cave/Gliricidia sepium/ex: larva de Gracillariidae" (EAPZ), following from same locality but collected 911003: 7♀♀ 1♂ (3♀♀ in coll. CH, remaining in EAPZ); 2♀♀ "HONDURAS: Ocotepeque, Concepcion. Playa del Rio, 5 Ago 1991.12, rcol R. Cave/Gliricidia sepijm/ex: larva de Gracillariidae" (EAPZ); 1♀ "HONDURAS: Sta. Barbara, La Flecha, La Flecha, 8 Ago 1991.01, rcol R. Cave/Gliricidia sepium/ex: larva de Gracillariidae" (EAPZ). Paratypes (1♀ 1♂) will be distributed to the Canadian National Collections (CNC), Ottawa, Canada; California Academy of Sciences, San Francisco, California, USA; Florida State Arthropod Collection, Gainesville, Florida, USA; Lund University Zoological Museum (LUZM), Lund, Sweden; the Natural History Museum, London, England; United States National Museum of Natural History (USNM), Washington, D.C., USA.

Host and biology.—*Kratoysma gliricidiae* is an endoparasitoid of the larva of a new species of Gracillariidae (Lep.) on *Gliricidia sepium.* It is the most abundant parasitoid among a complex of about six species which attack the gracillariid leafminer (RDC, unpublished data). The host larva dies after spinning a silken pupal chamber but before pupating. The number of *K. gliricidiae* individuals developing per host ranges from one to three. Pupation occurs beneath the host's mine cover.

Distribution.—Honduras.

***Kratoysma ecuadorensis,* Hansson, NEW SPECIES**

Fig. 5

Diagnosis.—Scutellum mainly smooth and shiny, with reticulation delimited to two sublateral rows; all coxae dark; cubital hairline almost straight; propodeum with two submedian carinae.

Description.—Female. Very similar to the female of *Kratoysma gliricidiae,* except: Entire scape infuscate. Anterior part of mesoscutum purplish, mesoscutum otherwise golden-green. Scutellum metallic purple. Propodeum metallic greenish-blue. All coxae dark and metallic; femora predominantly infuscate; fore tarsus and 4th tarsal segment on mid and hind legs infuscate; remaining parts of legs pale. Gaster brown with golden tinges.

Length of body: 1.3 mm.

Head: Ratios HE/MS/MO: 2.8/1.0/1.5. Quotient WH/WT = 1.2.

Thorax: Transverse carina along pronotal collar weak. Anterior part of axillae smooth and shiny, posterior part with quite strong reticulation. Propodeum with two submedian carinae; propodeal callus with four setae. Forewing with cubital hair-line almost straight.

Gaster: Ovate; ratio TP/G = 0.9, n = 1.

Male. Unknown.

Type material.—Holotype female labelled: "Ecuador: Napo, Sacha, 9.iii.1983, leg. L. Huggert," in LUZM.

Hosts.—Unknown.

Distribution.—Ecuador.

LITERATURE CITED

Boucek, Z. 1965. Studies on European Eulophidae, IV: *Pediobius* Walk. and two allied genera (Hymenoptera). Acta entomologica Musei Nationalis Pragae 36: 5–90.

———. 1988. Australasian Chalcidoidea (Hymenoptera). A biosystematic revision of genera of fourteen families, with a reclassification of species. C A B International, Wallingford, 832 pp.

Erdös, J. 1954. Eulophidae hungaricae indescriptae. Annales Historico-Naturales Musei Nationalis Hungarici (N.S.) 5: 323–365.

Hansson, C. 1985. The entedontine genera *Achrysocharoides* Girault, *Chrysocharis* Förster and *Kratoysma* Boucek (Hymenoptera: Eulophidae) in the Oriental region. Entomologica Scandinavica 16: 217–226.

Schauff, M. E. 1991. The Holarctic genera of Entedoninae (Hymenoptera: Eulophidae). Contributions of the American Entomological Institute 26(4): 1–109.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 258–263

TWO NEW *MICROSTIGMUS* SPECIES (HYMENOPTERA, SPHECIDAE), WITH THE DESCRIPTION OF THEIR PARASITE, *GONIOZUS MICROSTIGMI* sp. n. (HYMENOPTERA, BETHYLIDAE)

Gabriel Augusto R. de Melo and Howard E. Evans

(GARM) Departamento de Biologia Geral, Universidade Federal de Viçosa, 36570 Viçosa MG, Brazil; (HEE) Department of Entomology, Colorado State University, Fort Collins, Colorado, 80523, U.S.A.

Abstract.—Two new *Microstigmus* species are described from Brazil, ***M. xylicola*** Melo, sp. n. and ***M. similis*** Melo, sp. n., that nidify within abandoned beetle burrows in wood beams. This biology is atypical because most species of *Microstigmus* construct pendulous nests of particulate material aggregated with silk. These new species prey on nymphs of thrips and are parasitized by a bethylid, ***Goniozus microstigmi*** Evans, sp. n.

Key Words: *Microstigmus,* Sphecidae, *Goniozus,* Bethylidae, new species

---

The genus *Microstigmus* is restricted to the Neotropical region and contains 17 described species (Richards 1972). However, the number of undescribed species considerably exceeds that number (West-Eberhard 1977, Melo, in prep.). All species whose nests are known construct pendulous nests built with particulate material aggregated with silk produced by females (Matthews 1968, Richards 1972, West-Eberhard 1977).

The present paper describes two new *Microstigmus* species with very unusual nesting habits for the genus. It also describes their bethylid parasite. In the *Microstigmus* descriptions, microsculptural terms follow Harris (1979).

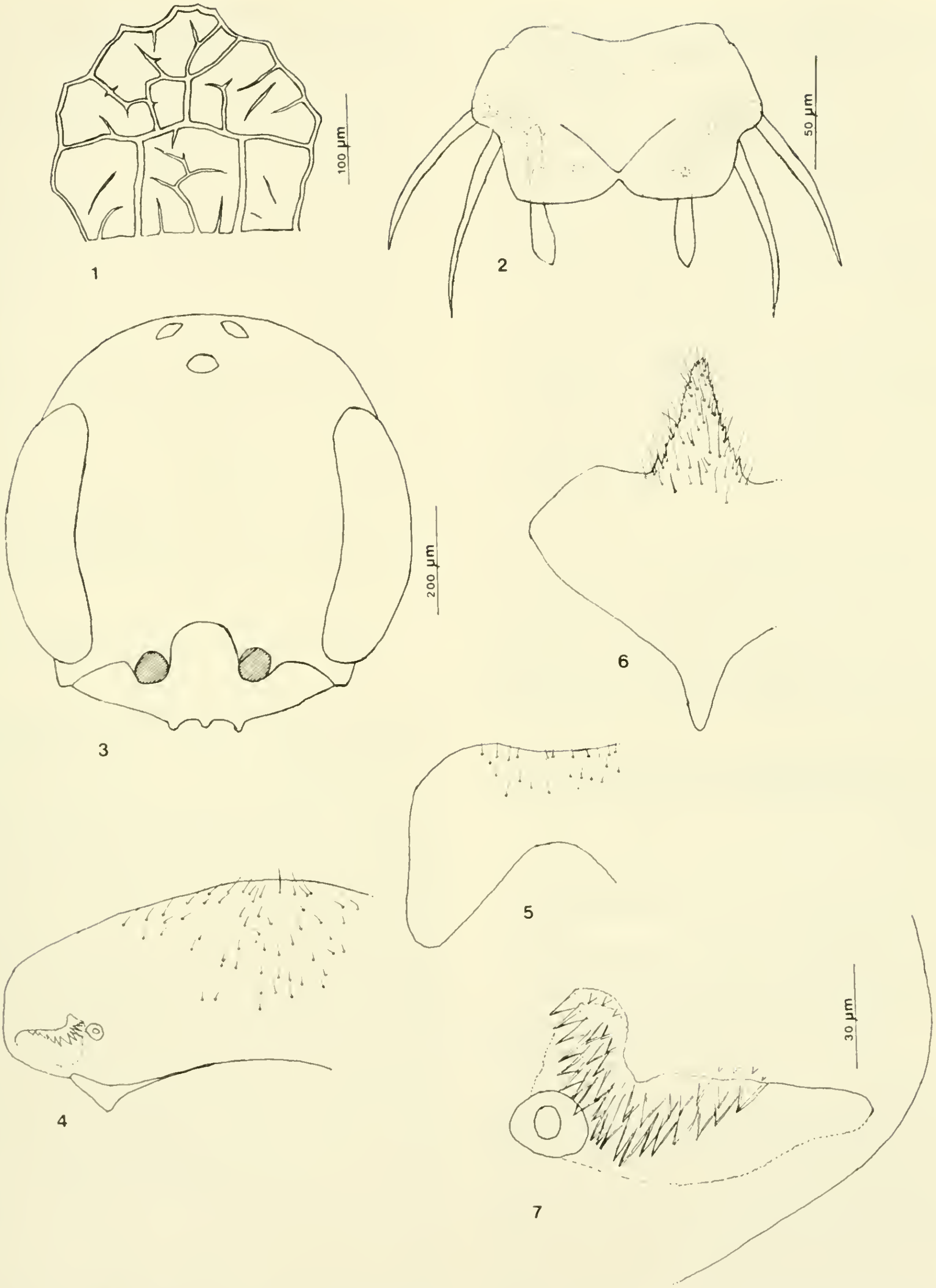
Microstigmus xylicola Melo, New Species
(Figs. 1–7)

Female.—*Dimensions* (in mm): Body length, 2.7; fore wing length, 2.0; width of mesoscutum (between tegulae), 0.5; maximum width of metasoma, 0.5.

Colour: Black. Mandibles rusty brown, with reddish teeth. Antennae testaceous. Legs, pronotal lobes and tegulae, pale yellow; tarsomeres V, claws and most of posterior coxae and tibiae, brown. Anterior margin of pronotum, sternum I and lateral parts of tergum I, dark brown. Wing membranes hyaline; pterostigma black; veins light brown.

Vestiture: Head and thorax with short pale setae, denser on frons, vertex, mesoscutum and mesepisternum. Wings covered with brown setae, darker to the wing apices. Terga I and II with a few sparse very short setae. Terga III–VI covered with short pale setae, sparser on the central portion of tergum III, and longer and yellowish on tergum VI.

Structure: Setigerous punctures not conspicuous, more evident on clypeus, vertex near ocelli and scutellum. Disk of clypeus smooth, shining, except for large punctures; at sides, beneath antennal alveoli, with very weak transverse carinae. Scapal basin, just above clypeus, with parallel, fine oblique carinae (finely costulate), and with short longitudinal carina arising from the antennal alveolus (shorter than alveolus diameter). Frons irregularly colliculate, vertex



Figs. 1–7. *M. xylicola*, sp. n., ♀: 1, Pattern of carinae on the dorsal surface of propodeum; 2, Labrum; 3, Head. ♂: 4, Tergum VII; 5, Sternum VII; 6, Sternum VIII; 7, Detail of tegumental denticulation on tergum VII (Figs. 4–6 same scale as Fig. 1).

smoother; gena strigulate. Median carina of frons extended over base of clypeus. Transverse carina of pronotum weak; pronotal collar, just behind transverse carina, with a shallow sulcus. Mesoscutal surface imbricate, posterior two-thirds of disk with weak longitudinal carinae (stronger near scutellum). Scutellum flat, without carinae. Transverse carinae of metanotum stronger at sides and absent at middle. Episternal sulcus narrow, shallow, crossed by numerous parallel longitudinal carinae which extend over whole mesopleuron (costulate pattern). Mesepisternum with oblique carinae converging to median depression posteriorly. Lateral surface of propodeum costulate, interspaces with cross carinae posteriorly. Pattern of carinae on the dorsal surface of propodeum as in Fig. 1. Ventral tooth of mandible about one and a half times as long as dorsal one. Labrum as in Fig. 2. Clypeus roundly convex between the antennae, apex emarginate over central third and with median and two lateral projections (Fig. 3).

Proportions (80 units correspond to 0.98 mm; in parenthesis male allotype proportions):

01. Length and width of marginal cell, 41:18 (40:18)
02. Length and width of pterostigma, 27:13 (25:13)
03. Length (from vertex to clypeal apex) and maximum width of head, 60:57 (57:57)
04. Length and maximum width of compound eye and gena width (lateral view), 42:21:15 (37:23:12)
05. Superior, middle and inferior interorbital distances, 34:36:30 (33:36:33)
06. Length and width of clypeus and clypeo-ocellar distance, 15:35:35 (15:33:35)
07. Malar space and pedicel length, 3:7 (3:7)
08. Interalveolar, alveolo-orbital, and alveolo-ocellar distances and alveolus diameter, 11:6:41:4 (10:9:41:4)
09. Anterior interocellar, posterior interocellar, and ocello-orbital distances and transversal diameter of anterior ocellus, 5:5:16:4 (5:5:15:4)
10. Length and maximum diameter of scape, 21:5 (21:5)
11. Length of flagellomeres I–III and diameter of third flagellomere, 3:4:4:4 (3:4:4:4)
12. Horizontal segment of transversal carina of pronotum and length of pronotal collar, 28:4 (27:4)
13. Length of mesoscutum and of scutellum, 27:14 (30:15)
14. Width of episternal sulcus (just below pronotal lobe) and distance from episternal sulcus to mesopleural suture (at scrobe), 2:20 (2:20)
15. Length of tibia, basitarsus and distitarsus (tarsomeres II–V) of midleg, 30:20:25 (33:20:25)
16. Length and maximum width of tibia and length of basitarsus and distitarsus of hindleg, 40:8:23:30 (44:9:27:30)

Male.—Dimensions as in female. Similar to female in colour and structure. Tergum VII and sterna VII and VIII as in Figs. 4, 5 and 6, respectively.

Type material.—Holotype ♀, Viçosa-MG, BRASIL 24/11/1990, G. A. R. MELO [Ninho 1: 3 ♀ (1 pre-p.; 1 p. de parasita). Telhado de cisterna]; allotype ♂, Viçosa-MG, BRASIL 24/11/1990, G. A. R. MELO [Ninho 2: 1 ♀ e 1 ♂ (1 p. ♀). Telhado de cisterna], paratypes, 4 ♀♀ and 2 ♂♂, Viçosa-MG, BRASIL 24/11/1990, G. A. R. MELO, Museu de Zoologia da Universidade de São Paulo. Additional paratypes: Viçosa-MG, BRASIL, G. A. R. MELO, 2 ♀♀ and 1 ♂, 26/10/1990, Museu de Entomologia da Universidade Federal de Viçosa; 2 ♀♀, 27/10/1990, Museu Nacional, Rio de Janeiro; 2 ♀♀ and 1 ♂, 27/10/1990, Museu Pe. J. S. Moure, Universidade Federal do Paraná, Curitiba; ♀, 15/11/1990, Museu Paraense Emílio

Goeldi, Belém; ♀, 21/10/1990 and ♀, 24/10/1990, U.S. National Museum of Natural History, Washington.

Discussion.—*M. xylicola,* sp. n. and *M. similis,* sp. n. constitute a distinct group within *Microstigmus* and can be distinguished from other known species by their elongated head, the strong lateral projections of the clypeus apex, the strong microsculpture of frons and gena, the black prothorax, and by their nesting habits. An analysis of the phylogenetic relationships among *Microstigmus* species will appear in another paper (Melo, in prep.). *M. xylicola* sp. n. has the median carina of frons strong and extented over the base of the clypeus, the frons irregularly colliculate (reticulation more elongated and rectangular, notably near the vertex), and the whole gena strigulate.

Microstigmus similis **Melo,**
New Species

Female.—Dimensions as in *M. xylicola,* sp. n. Very close to *M. xylicola,* sp. n., but differs as follows: wing veins brown; short setae on central portion of tergum III more sparse; frons (including scapal basin) and vertex uniformly colliculate; gena, above oral cavity, weakly colliculate, shining; median carina of frons not extended over base of clypeus; episternal sulcus crossed by short carinae; mesopleuron weakly colliculate (not costullate), with longitudinal carinae only at hypersternaulus; carinae on lateral surface of propodeum stronger, interspaces without cross carinae; median projection on clypeal apex less pronounced.

Proportions (80 units correspond to 0.98 mm):

01. Length and width of marginal cell, 45:18
02. Length and width of pterostigma, 28:14
03. Length (from vertex to clypeal apex) and maximum width of head, 63:58
04. Length and maximum width of compound eye and gena width (lateral view), 43:19:16
05. Superior, middle and inferior interorbital distances, 34:38:33
06. Length and width of clypeus and clypeo-ocellar distance, 15:38:38
07. Malar space and pedicel length, 4:6
08. Interalveolar, alveolo-orbital, and alveolo-ocellar distances and alveolus diameter, 12:8:40:5
09. Anterior interocellar, posterior interocellar, and ocello-orbital distances and transversal diameter of anterior ocellus, 5:5:14:5
10. Length and maximum diameter of scape, 20:5
11. Length of flagellomeres I–III and diameter of third flagellomere, 4:4:4:4
12. Horizontal segment of transversal carina of pronotum and length of pronotal collar, 27:4
13. Length of mesoscutum and of scutellum, 30:15
14. Width of episternal sulcus (just below pronotal lobe) and distance from episternal sulcus to mesopleural suture (at scrobe), 3:21
15. Length of tibia, basitarsus and distitarsus (tarsomeres II–V) of midleg, 31:20:26
16. Length and maximum width of tibia and length of basitarsus and distitarsus of hindleg, 43:9:25:32

Male unknown.

Type material.—Holotype ♀, Viçosa-MG, BRASIL 29/11/1991, G. MELO & M. COSTA [Ninho em orifício em esteio. Mata do Paraíso (Casa do Sr. R. Stanciola)]; paratypes, 2 ♀♀ (data as in holotype), Museu de Zoologia da Universidade de São Paulo, São Paulo.

Discussion.—*M. similis,* sp. n. can be easily distinguished from *M. xylicola,* sp. n. by having the frons regularly colliculate (rounded reticulation), and by having the gena (above oral cavity) and mesopleuron weakly colliculate. Also, the median carina of the frons does not extend over the base of the clypeus, as it does in *xylicola*.

The nests of these species are constructed in abandoned beetle galleries within beams of exposed roofs. The wasps excavate the beetle frass and cover the nest walls with silk. These species do not build a turret at the nest entrance as do some *Spilomena* species. Generally, the brood cells are constructed in linear series (2 to 3 cells) placed at the end of the burrows. Most open nests were ramified internally. The cells are mass provisioned with Thysanoptera nymphs. Contrary to most other *Microstigmus* species (Melo, in prep.), in these species, the larvae have spinnerets and spin a cocoon. After cocoon spinning, the pre-defecating larvae orient with their heads directed to the nest entrance and defecate at the opposite end. Some nests contained more than one female. Males were also present in some nests and, as in other *Microstigmus*, they appear to reside in the nests.

Goniozus microstigmi **Evans, New Species**

Type.—♀, BRASIL: Viçosa, Minas Gerais, 30 Nov. 1990, G. A. R. de Melo [Entrando em ninhos de *Microstigmus* (orifício em caibro). Cisterna (UFV).]. Museu de Zoologia da Universidade de São Paulo, São Paulo.

Description of the female type.—Length 2.3 mm; fore wing 1.8 mm. Black, except mandibles dull rufous apically, antennae light brown, darkened on upper surface and apically; legs dark brown except tibiae and tarsi light yellow-brown; wings hyaline, costa, prostigma, and stigma dark brown, other veins light brown. Mandibles nearly straight, terminating in four small teeth apically; clypeus angulate apically, surface convex, with a polished median carina which continues up the frons to just above level of antennal scrobes, this carina arched in profile; scrobes well defined but not carinate. Width of head 0.88 times length of head; width of frons 0.91 times height of eye; sides of head roundly convergent behind eyes to a straight, sharp vertex crest. Front angle of ocellar triangle about a right angle; ocello-ocular distance subequal to width of ocellar triangle; posterior ocelli separated from vertex crest by about a quarter of their own diameters. Antennae short, barely able to reach crest of vertex; first four segments in a ratio of about 6:3:2:2, segment three and those following slightly wider than long. Frons alutaceous, moderately shining, with small, setigerous punctures separated by 3 to 8 times their own diameters.

Thoracic dorsum alutaceous, moderately shining and with sparse, small punctures much like frons. Propodeum polished along a broad median band, alutaceous dorsolaterally. Front femur robust, twice as long as its maximum width. Gaster slightly depressed, strongly shining. Fore wing with a closed areolet.

Paratypes.—6 ♀♀, data as in type, except 24.xi.1990 [Nascido de pupa coletada em ninho de *Microstigmus*], 15.iii.1991 [*Microstigmus* de madeira. Cisterna (UFV)], 26.xi.1991 [Caminhando sobre esteio da cabana. Mata do Paraíso], 29.xi.1991 [Caminhando sobre esteio. Mata do Paraíso (Casa do Sr. R. Stanciola)]. 4 ♀♀, Museu de Zoologia da Universidade de São Paulo, São Paulo; 2 ♀♀, U.S. National Museum of Natural History, Washington.

Variation.—The paratypes vary in fore wing length from 1.3 to 1.8 mm. In three paratypes the tibiae are nearly as dark as the femora, and in these specimens the antennae are somewhat darker than in the type. Width of head varies from 0.86 to 0.91 times the length of head. The front femur varies from 1.9 to 2.0 times as long as its maximum width. Otherwise these specimens resemble the type closely.

Remarks.—This species is a member of the *punctaticeps* species-group, as defined by Evans (1978, p. 236). It differs from the seven known species of that group in having the clypeus merely convex medially, rather than in the form of a sharp median keel; also the frons is narrower as compared to the eye height than in any of those species. The short antennae suggest *emigratus* (Rohwer), but that species has more robust front femora and a broader frons.

Most species of *Goniozus* attack Microlepidoptera larvae occurring in concealed situations, including plant stems (Evans 1978, p. 274). However, there are isolated records of attacks on beetle larvae. There are no records of attacks on larvae of Hymenoptera, but an association with *Microstigmus* larvae occurring in wood seems not unreasonable. Adults of *G. microstigmi*, sp. n. were collected entering a nest or walking near nests of *M. xylicola*, sp. n. and *M. similis*, sp. n. One white pupa of the parasitoid was found within a brood cell of *M. xylicola*, sp. n.

LITERATURE CITED

Evans, H. E. 1978. The Bethylidae of America north of Mexico.Memoirs of the American Entomological Institute, no. 27. 332 pp.

Harris, R. A. 1979. A glossary of surface sculpturing. Occasional Papers in Entomology 28: 1–31.

Matthews, R. W. 1968. Nesting biology of the social wasp *Microstigmus comes*. Psyche 75: 23–45.

Richards, O. W. 1972. The species of the South American wasps of the genus *Microstigmus* Ducke (Hymenoptera: Sphecoidea, Pemphredoninae). Transactions of the Royal Entomological Society of London 124: 123–148.

West-Eberhard, M. J. 1977. Morphology and behavior in the taxonomy of *Microstigmus* wasps. Proceedings of the 8th Congress of the International Union for the Study of Social Insects, The Netherlands, pp. 123–125.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 264–270

ZDENEKIUS, A NEW GENUS OF NEARCTIC TORYMIDAE (HYMENOPTERA: CHALCIDOIDEA)

E. E. Grissell

Systematic Entomology Laboratory, USDA, ARS, PSI, % U.S. National Museum NHB 168, Washington, D.C. 20560.

Abstract.—***Zdenekius smithi***, new genus, new species is described. This nearctic genus of Torymidae is transcontinental across the northern United States extending into southeastern Canada. *Zdenekius* is reared in association with twig-nesting Sphecidae and Vespidae, but the exact host relations are not known. It may be a primary and/or a secondary parasite on dipterous and hymenopterous parasites of these wasps.

Key Words: Insecta, Torymidae, *Zdenekius smithi*, new genus, new species, Nearctic, parasite, Sphecidae, Vespidae

---

The following description is presented to validate a generic name to be used in a forthcoming publication entitled *Keys to the Genera of Nearctic Chalcidoidea*. This multi-authored manual will summarize our knowledge of nearctic genera of the superfamily but will not include descriptions of new taxa. I take this opportunity, therefore, to describe the only new nearctic genus of Torymidae discovered during my research toward a world generic reclassification. This research is nearing completion but will not be published before the nearctic key.

During many years of study, I have found numerous undescribed nearctic species of Torymidae that were difficult to place to genus. These taxa, as well as the known world genera, have been studied over a period of years using phylogenetic methods (Grissell, in prep.). Of nearctic taxa, only the one described below could not be integrated into a generic hierarchy without creating paraphyly. The superfamily Chalcidoidea is rife with monotypic genera, and I am reluctant to describe yet another myself. I have attempted to reflect phylogenetic patterns as objectively as possible while at the same time creating the least number of nomenclatural changes. That only a single new nearctic genus is being described, despite discovery of nearly two dozen new species, indicates I believe, that the generic limits of Torymidae, at least in the Nearctic, are becoming well-known relative to other families of Chalcidoidea such as Pteromalidae.

Zdenekius Grissell, New Genus
(Fig. 1)

Type species.—*Zdenekius smithi* Grissell, new species, present designation.

Diagnosis.—Occipital carina located nearer to occipital foramen than to dorsum of head and somewhat flattened along dorsal margin, ventrally reaching upper rim of hypostomal carina (Fig. 2); frenal sulcus weakly expressed as a depression in the otherwise evenly sculptured scutellum; hindfemur submedially enlarged with a single tooth (Fig. 9); hindtibia straight with apical, unmodified spurs; metasternum with broad square to transverse median area between hindcoxae (Fig. 13); metasoma of female (Fig. 5) dorsoventrally flattened, with broadly sclerotized sterna not overlapped

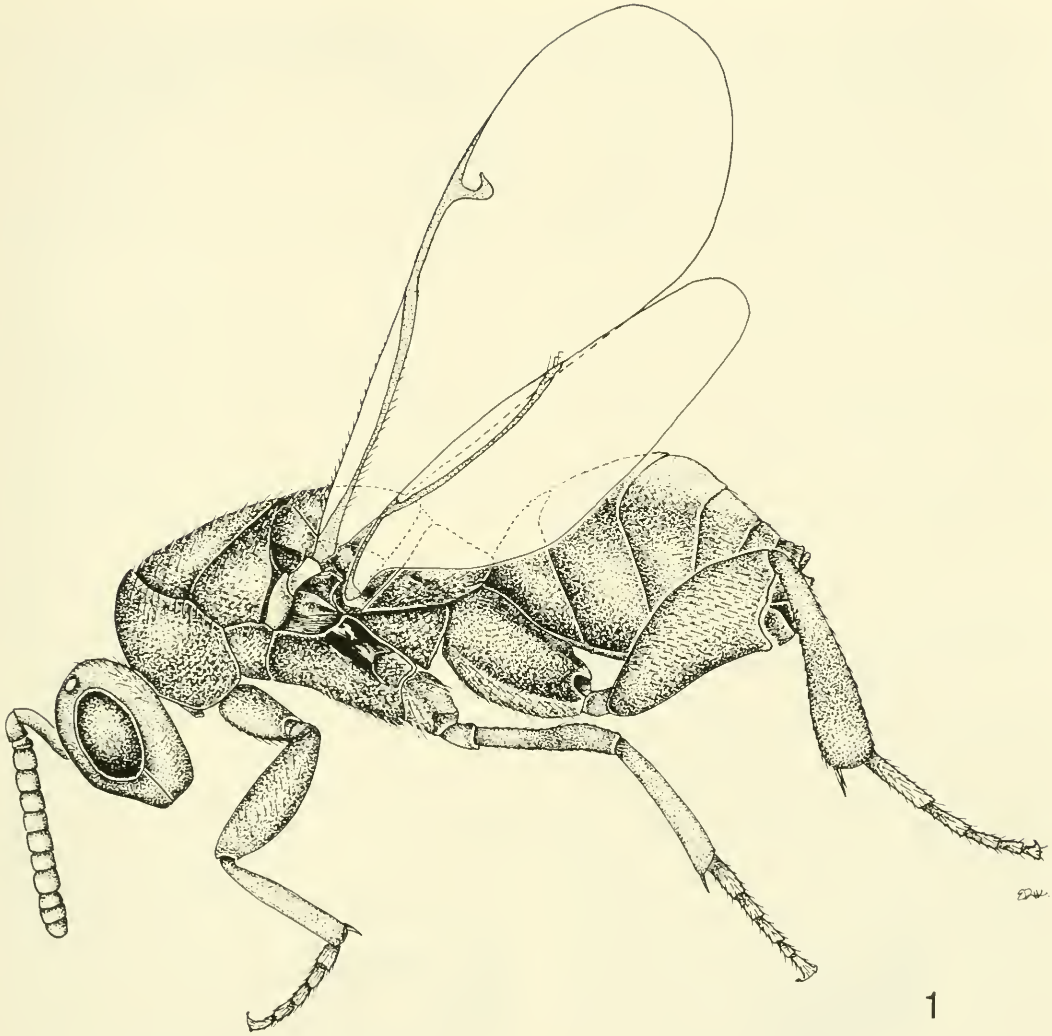
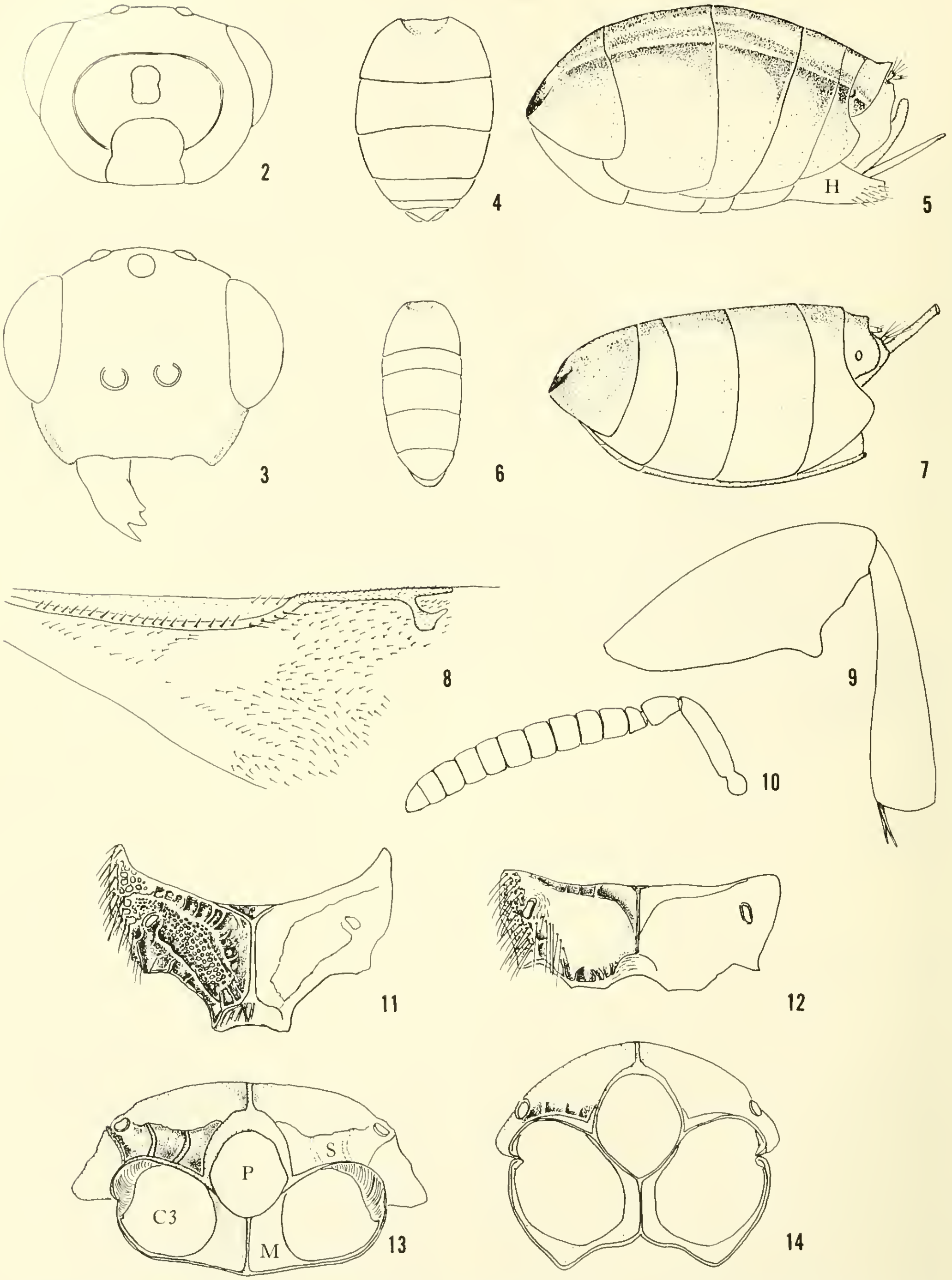


Fig. 1. *Zdenekius smithi*, female, habitus.

by terga (i.e. sterna are easily seen as flattened plates in ventral view), hypopygium broadly plow-shaped, and ovipositor sheaths curved upward and not exserted.

Description.—Occipital carina nearer to occipital foramen than dorsum of head and flattened along dorsal margin, ventrally reaching upper rim of hypostomal foramen (Fig. 2); antenna (Fig. 10) with 1 anellus, club 3 segmented (filiform); head in dorsal view transverse; clypeal apex straight (Fig. 3); malar keel absent; submarginal vein (Fig. 8) with normal, weakly developed bristles that are shorter than tegula; marginal vein greater than 3 × length of stigmal vein; stigmal and postmarginal veins subequal in length; hindfemur submedially enlarged with single tooth (Fig. 9); hindtibia straight, with 2 apical unmodified spurs of nearly equal length (Fig. 9); frenal sulcus weakly indicated as broad depression; notauli distinct, not meeting scutoscutellar suture, intersecting it laterally outside anterior edge of scutoscutellar suture; propodeum (Fig. 11)



Figs. 2–14. Figs. 2–5, 8–11, 13, *Zdenekius smithi* (female); Figs. 6, 7, 12, 14, *Monodontomerus obsoletus* (female). 2, 3, head (posterior, anterior, respectively); 4–7 metasoma (4, 6 dorsal view, 5, 7 lateral view; 6, ovipositor omitted; 7, only basal part of ovipositor shown; H = hypopygium). 8, Forewing. 9, Metafemur and tibia. 10, Antenna. 11, 12, Propodea. 13, 14, Metasterna (C3 = metacoxal foramen, M = metasternal plate, P = propodeal foramen, S = spiracular sulcus).

with median depression triangular and extending to nucha, with median carina appearing as extension of nucha, and with spiracular sulcus deeply pitted and extending from posterior of spiracle to nucha (Figs. 11, 13); metasternum (Fig. 13) with propodeal foramen and hindcoxal foramina abutting only tangentially, metasternal area between hindcoxal foramina a square or transverse plate subequal in width to diameter of a hindcoxal foramen, heavily sclerotized and with strong median carina; mesopleuron and metapleuron ventrally of equal length in lateral view, metasternal shelf absent; metasoma (Fig. 5) dorsoventrally flattened with broad sterna which are not ventrally completely overlapped by the terga (i.e. the sterna are easily seen as flattened plates in ventral view), metasomal terga nonemarginate, MT 6 with posterior margin obtusely concave in profile, ovipositor sheaths curved upward and appressed to MT 8, not exserted, hypopygium prominent, broadly plow-shaped.

Etymology.—This genus is named in honor of Zdenek Bouček, who discovered the first specimens and referred them to me for study. More than any other worker, Bouček has contributed to the understanding of the Chalcidoidea as we know them.

Relationships.—Having studied all genera of monodontomerines in preparation for a world reclassification of the complex of genera associated with Monodontomerinae/Toryminae, I hypothesize that *Zdenekius* is a member of the Monodontomerini based upon the following synapomorphies: occipital carina located nearer to occipital foramen than dorsum of head (Fig. 2), dorsally nearly straight (rather than arched), and reaching or nearly reaching upper rim of hypostomal foramen (Fig. 2); propodeum (Figs. 11, 12) with sublateral foveae on either side of a median carina, spiracular sulcus evident and reaching (or curved towards) nucha, and callus convex and setose; no metasternal shelf; 1 anellus (rarely 2); and hindfemur with a single, abruptly produced tooth (Fig. 9; or enlarged and with 1 or 2 rows of teeth in extralimital genera).

Zdenekius, based upon its metasternum, is hypothesized to be the sister taxon of a clade that includes *Monodontomerus.* In my unpublished phylogenetic work, the state of widespaced hindcoxal foramina (i.e. with a wide plate between them) is considered primitive with respect to narrowly spaced foramina with a narrow plate between them. In *Zdenekius* the metasternal plate (Fig. 13, M) is square or transverse and subequal in width to the diameter of a hindcoxal foramen. In *Monodontomerus* (Fig. 14) the metasternal plate is narrowly longitudinal and much narrower than the diameter of a hindcoxal foramen. The narrowness in *Monodontomerus* is apparently caused by an increase in coxal size and a correlated increase in foramen size (cf. Figs. 13 and 14, C3).

Females of *Zdenekius* have an autapomorphically structured metasoma. The metasomal terga (Fig. 5) are dorsally flattened, making the abdomen broad when viewed from above (Fig. 4), and the sterna are visible as broad, flat, heavily sclerotized plates that are not covered by the terga. Most notable is the hypopygium, a broad, plow-shaped sternum that arises at the apex of the metasoma. In other Monodontomerini (and most other torymines as well) the metasoma is not dorsally flattened (Fig. 7) and is thus narrowly oval (or parallel-sided) when viewed from above (Fig. 6), and the metasomal terga meet ventrally and conceal the sterna almost entirely. Rarely are the sterna exposed, in which case they are grouped at the base of the metasoma and are weakly sclerotized. If the hypopygium is seen at all in these taxa, it appears as an apically pointed structure (Fig. 7), but this is due more to the lack of lateral sclerotization than to its actual shape. Usually the hypopygium extends halfway or more to the base of the metasoma and is the only readily apparent sternum. The metasoma of males of *Zdenekius* are not so modified but appear instead as typical male *Monodontomerus.*

The host association with aculeate Hymenoptera is certainly similar to that of *Monodontomerus,* many of which are parasites of solitary bees and wasps. Hyperparasitism is commonly found in *Monodontomerus* as well, and this mode of parasitism also fits the possible behavior of *Zdenekius* (see hosts, below).

Zdenekius smithi Grissell, New Species

(Figs. 1–5, 8–11, 13)

Holotype female.—Body length 3.4 mm. Metallic blackish green, except scape and tibiae yellow. Face subquadrate in outline (Fig. 3), ratio width : height as 7:5; clypeus recessed (i.e. lying within imaginary line drawn between lateral corners of oral fossa); intermalar distance 2.0× malar distance; malar sulcus faintly indicated as shallow depression; torulus about own diameter above ventral level of eye; eye essentially without setae; scape almost reaching midocellus, 2.6× length of pedicel (Fig. 10), anellus slightly wider than long (5:7), F2 quadrate, remainder wider than long; mesepimeron heavily reticulately sculptured ventrally, dorsally more lightly sculptured except for slight smooth area just above epimeral depression; frenum 0.3× length of scutellum, as heavily sculptured as anterior of scutellum, frenal sulcus weakly expressed, anteriorly with broad depression, posterior rim of even width and evenly punctate; dorsellum reticulately sculptured, with obscure median carina; propodeum with median depression triangular and extending to nucha, median carina strong (Fig. 11), submedially as heavily reticulately sculptured as hindcoxa, posterior margin with deeply pitted spiracular sulcus extending from nucha to posterior of spiracle (Figs. 11, 13); forewing (Fig. 8) costal cell on anterior margin with 2 or 3 setae dorsally at distal apex, ventrally almost completely setose except for bare area in basal ⅓, cubital and basal veins setose, basal cell with partial setal row (in left wing, right wing with 3 setae), dorsal admarginal setae reaching to marginal vein and parastigma, stigma squarish, uncus subequal to width of stigma, stigmal area hyaline; hindcoxa with dorsal setae; hindfemur 2.7× as long as wide; hindfemoral tooth as in Fig. 9; longest hindtibial spur ca. 0.5× shortest length of basitarsis; metasoma dorsally flattened (Fig. 5); metasomal tergum 2 with reticulate sculpture in depression posteriad of petiole and laterally on sides, otherwise faintly alutaceously sculptured; ovipositor free from sheaths and extended at acute angle (but see variation, below).

Allotype male.—Length 2.5 mm. Differs from female as follows: intermalar distance 2.3× malar distance; scape 2.3× length of pedicel, 3.2× longer than wide, essentially cylindrical but slightly ventrally flattened, ventrally polished, no pores visible at 100×, asetose; funicular 2 wider than long.

Variation.—Females range in length from 2.1 to 3.4 mm, males from 2.3 to 3.2 mm. Body color is constant for the species in spite of its wide-ranging distribution. Sculpturing on metasomal tergum 2 varies within populations from polished to faintly alutaceous. In one female (of 3 from Louisa County, Virginia) tergum 2 is entirely heavily sculptured (i.e. tergum 2 and 3 equally reticulate). The other two specimens from the same series have tergum 1 faintly alutaceous. A single female from Prince Georges County, Maryland, is heavily sculptured as well. Because only 2 specimens of 46 show this condition, and it does not appear to be consistent within a population, I presume that this character is variable for the species. Another variable character is the posterior margin of the propodeum. In larger specimens a carina runs laterally from the nucha nearly to the posterior margin of the spiracle. This carina is prominent when viewed from above (Fig. 11) and delimits a channel-like groove (spiracular sulcus) that is best viewed from the side or below (Fig. 13).

This channel has a few perpendicular carinae. In smaller specimens the corresponding carinae become less prominent and the channel less obvious. In the holotype and most other specimens the ovipositor is free from the sheaths and projects at an acute angle as a short barb, but this is not true of all specimens. When the ovipositor is not projecting, this species appears to have no ovipositor.

Holotype.—Female, near Annandale, Fairfax County, Virginia, USA, 23 June 1986, D. R. Smith, Malaise trap, in USNM collection.

Paratypes.—32 females, 16 males as follows (all United States National Museum unless otherwise stated; CNC = Canadian National Collection, Ottawa; NHM = The Natural History Museum, London). USA.—Virginia: 10 females, same data as holotype except collected from 25 May to 24 August 1986–1987; 3 females, 4 mi. S. Cuckoo, Louisa County, 13 May to 5 July 1986–1987, K. Kloke, D. R. Smith, Malaise trap (USNM, CNC, NHM); 1 male, Black Pond, Fairfax County, "reared" 8 February 1921, dead willow (see hosts, below). Michigan: 1 male, Ann Arbor, June 1976, I. Gauld (NHM); 1 female, Midland County, 21 July 1952, R. R. Dreisbach. Oregon: 2 males, Prineville, "6-3-35," R. L. Furniss, W. J. Buckhorn, ex *Alnus rubra* (see hosts, below). New Hampshire: 1 male (11 September 1956) and 1 female (1 November 1982), Durham, 11 September 1956, W. J. Morse. Washington, D.C.: 1 male (no other data). Illinois: 1 male, Algonquin, "5-21-96." Maryland: 1 female, Patuxent Research Station, Prince Georges County, 15–21 June 1986, D. Wahl; 2 specimens (sex unknown), Woodstock, E. G. Reinhard, "Par. in nest *Symmorphus debilis*" (see hosts, below). CANADA.—Ontario: 11 females, Hamilton, 4 June to 14 August 1980–1982, M. Sanborne, Malaise trap (CNC); 5 females, 1 male Ottawa, 20 July to 10 August 1986, H. Goulet, Malaise trap (USNM, CNC). Quebec: 1 male, Mont Royal, Montreal, August 1956, J. Obenberger (NHM). New Brunswick: 1 female, Kouchibouguac National Park, 25 August 1977, S. J. Miller.

Etymology.—This species is named in honor of David R. Smith of the Systematic Entomology Laboratory, USDA, who collected the majority of specimens as well as tens of thousands of Chalcidoidea over many years of trapping for Hymenoptera.

Distribution.—*Zdenekius smithi* ranges from Oregon across the northern U.S. to Virginia and northward into eastern Canada.

Hosts.—Host records are vague but indicate two potential categories of host: primary parasites of solitary, twig-nesting wasps (sphecids and vespids) and/or facultative hyperparasites of dipterous or possibly hymenopterous parasites of these wasps. Two specimens (collected under U.S. Forest Service Hopkins Numbers) were reared in Oregon from nodes of *Alnus rubra*, which also produced *Anthrax irroratus* Say (Diptera: Bombyliidae). This fly is a known parasite of aculeate wasps. Another specimen (also under Hopkins Number) was reared in Virginia from a "dead soft and rather dry willow limb" which "contained a number of yellow larvae." These larvae, which were in cells with aphids, were thought to be crabronine sphecids. Also present were some white larvae thought to be ichneumonids. One specimen of *Zdenekius smithi* and 2 specimens of an unidentified ichneumonid were reared from this material. Two additional specimens were reared in Maryland from a nest of *Odynerus canadensis* (Vespidae, original rearing given as *Symmorphus debilis*). This is a twig-nesting aculeate with numerous recorded parasites (see Krombein [1967] for biology of the wasp, and Krombein [1979] for summary of nest associates) so that no definite host can be pinpointed.

ACKNOWLEDGMENTS

I thank Zdenek Bouček for the original specimens upon which this study was begun and David Smith who collected additional specimens; Gary Gibson, Agriculture Canada, for the loan of specimens from the Canadian National Collection (CNC in text); and Erik Denno for preparing the habitus illustration (Fig. 1). I also thank Steven Heydon (University of California, Davis), Gary Gibson, and David Nickle and Norm Woodley (Systematic Entomology Laboratory) for reading the manuscript and suggesting necessary corrections.

LITERATURE CITED

Krombein, K. V. 1967. Trap-nesting Wasps and Bees: Life Histories, Nests, and Associates. Smithsonian Press, Washington, D.C. 570 pp.

———. 1979. Superfamily Vespoidea, pp. 1469–1522. *In* Krombein, K. V., P. D. Hurd, D. R. Smith, B. D. Burks, eds., Catalog of Hymenoptera in America North of Mexico. Vol. 2. Apocrita (Aculeata). Smithsonian Institution Press, Washington, D.C. 1010 pp.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 271–277

RELATIVE EGG SUCCESS AND IMPLICATIONS FOR DISTRIBUTION OF THREE SYMPATRIC MANTIDS (MANTODEA: MANTIDAE)

R. M. Eisenberg and L. E. Hurd

Ecology Program, School of Life Sciences, University of Delaware, Newark, Delaware 19716.

Abstract.—We compared hatching success and mortality of eggs among three sympatric mantid species (*Tenodera aridifolia sinensis* Saussure, *T. angustipennis* Saussure, *Mantis religiosa* Linnaeus) in two field sites in northern Delaware. Oothecae were heavier in CHRY than AG (two old-field study sites) for all three species, indicating a difference in feeding opportunity for adults in the parental generation. However, hatching success did not differ between sites, so that adult feeding condition did not affect the probability of successful emergence of the next generation. None of the egg mortality for any species was caused by natural enemies in these populations. Hatching success was dramatically lower for *M. religiosa* than for the two *Tenodera* species, reflecting a difference in tolerance to abiotic environmental factors.

Key Words: Egg ecology, Mantodea, Mantidae, *Mantis, Tenodera,* oothecae, predators

---

Nymphal production by a number of mantid species has been reported in the literature (Girault 1907, Rau and Rau 1913, Laurent 1913, Weiss 1914, Bromley 1932, Roberts 1937, Fox 1939a, b, Eisenberg and Hurd 1977, Matsura 1979, Matsura and Morooka 1983). However, only Fox (1939a) and Eisenberg et al. (1992) compared egg hatching success between species or sites. Such comparisons are of value, because they may indicate differences in suitability of the environment within and between geographical regions as well as among species. The failure of an egg to produce a viable offspring might be a function of a number of factors including genetic defects, disease and natural enemies (e.g. egg parasites and egg predators). Eggs may also succumb to rigors of the abiotic environment, such as desiccation or temperature extremes. A thorough knowledge of the success of eggs could aid us in explaining the distribution and abundance of mantid species.

Tenodera aridifolia sinensis Saussure was introduced from Asia to the area of Philadelphia, Pennsylvania, in 1896 (Laurent 1898). It is extremely common in our area and extends north to southern New York State (Fox 1939a) and south to the Carolinas and Georgia (personal observation). This is the species most commonly available to organic gardeners (Ross 1984) as oothecae distributed by mail, which well may explain the breadth of its distribution. *Tenodera angustipennis* Saussure, another Asian species, was first found in Maryland in 1926 (Gurney 1950) and was established in Delaware by 1930 (Jones 1933). While common in our area, this species does not attain the large population sizes which we find for *T. a. sinensis,* and does not appear to have a very broad distribution. The third species, *Mantis religiosa* Linnaeus, was introduced from Europe to the area of Rochester, New York, in 1899 (Gurney 1950). While common in most of the northeastern states and extending into Canada, the southern limit to its range appears to be in our area, where we find it in a limited number of sites. We have not found this species in southern Delaware or states to the south. All three species also are sympatric in China (Yan et al. 1981). In the present study we examine the egg ecology of these three introduced species of praying mantids from two separate field sites, where they co-occur in northern Delaware.

Materials and Methods

The oothecae of the three species of praying mantids were collected in late April 1985 from the two old-field study sites. These sites, designated AG and CHRY (see site description in Hurd and Eisenberg 1989a) are separated by approximately 3 km. Each ootheca was weighed and placed in an individual container and kept in the laboratory at room temperatures (ca. 20–22° C) until nymphal emergence was complete. Nymphs were then counted and each ootheca was cut into ca. 1-mm sections with a razor blade and examined for the presence of unhatched eggs. The majority showed no signs of development and were classified as dead eggs, which either were not fertilized or died before development could take place. Others clearly had undergone development and often appeared to be fully developed nymphs; these were classified as dead nymphs. No evidence of egg parasitism was found.

For each species from each population, linear regressions were calculated for the number of nymphs emerging from each ootheca and the total number of eggs in each ootheca, on ootheca weights. The regression lines within species were compared with ANOVA (Snedecor and Cochran 1980). Ootheca weights, number of nymphs emerging, the two categories of unhatched eggs, total unhatched eggs, the total number of eggs per ootheca, and the percentages of eggs which emerged were compared using *t*-tests between populations of the same species. The percentage data were arcsine-transformed prior to testing.

Results

A detailed analysis of the oothecae of the three mantid species is presented in Table 1. While *T. a. sinensis,* the largest of the three species, produced the heaviest oothecae (column C) and the greatest number of emerging nymphs (Column D), the egg totals in oothecae (D + G) were remarkably similar for all three species (H). The major differences among the species were found in percent emergence and the apportionment of egg mortality (E, F, and I). Over 80% of *T. a. sinensis* eggs emerged as nymphs, while this value for *T. angustipennis* was about 70%, and 30% for *M. religiosa.* About 75% of the mortality in *T. a. sinensis* oothecae was accounted for as dead eggs. In *T. angustipennis,* egg mortality was about evenly divided between dead eggs and dead nymphs, while in *M. religiosa,* almost 95% of the mortality was dead eggs.

Differences between the two populations of each of the three species for ootheca weight, number of merging nymphs, and total eggs in an ootheca varied consistently between the two habitats. For each species, for each of the above parameters, the values from the CHRY populations were always greater than those for the AG populations, and these differences were statistically significant (*t*-tests, $P < 0.05$) in five of the nine possible comparisons (Table 1). Differences in the unhatched egg categories between populations did not show the same trend. No differences in percent emergence were found between sites for any species.

The regression analyses on ootheca weight for number of nymphs emerging and total eggs are given in Table 2. In all cases no significant differences were found between either the slopes or intercepts of the lines for comparisons between populations of the same species from the two different sites. In

Table 1. Analysis of the oothecae of three mantid species from sites CHRY and AG. Columns C through H are means with their standard errors (SE). N = sample size. *T*-tests were done to test differences in mean values between sites for each species. TS = *Tenodera a. sinensis,* TA = *T. angustipennis,* MR = *Mantis religiosa.*

A. Species-site	B. N	C. Wt. (g)	D. Emerging Nymphs	E. Dead Eggs	F. Dead Nymphs	G. Dead Totals	H. Total D + G	I. % Emergence
TS-AG	28	1.58	193.3	29.8	13.1	42.9	236.2	81.8
SE		.08	14.9	9.5	5.3	10.1	10.4	
TS-CHRY	15	2.05	264.3	36.3	9.1	45.3	309.7	85.4
SE		.13	23.6	14.5	2.6	14.2	15.3	
t		3.19	2.66	0.39	0.53	0.14	4.05	0.44
P		.003	.011	.70	.60	.89	.0002	.67
TA-AG	20	0.97	148.1	32.8	26.8	59.6	207.7	71.3
SE		.08	22.6	10.3	5.5	11.9	17.5	
TA-CHRY	21	1.14	186.4	33.0	28.4	61.4	247.9	75.2
SE		.05	19.7	13.6	5.8	13.7	9.6	
t		1.86	1.28	0.01	0.20	0.10	2.04	0.90
P		.07	.21	.99	.85	.92	.048	.38
MR-AG	15	0.81	65.5	172.9	3.9	176.8	242.3	27.0
SE		.09	21.4	21.2	1.9	20.8	14.3	
MR-CHRY	39	1.11	115.1	160.0	14.6	174.9	289.9	39.7
SE		.06	17.9	20.1	2.5	19.0	13.9	
t		2.57	1.56	0.37	2.56	0.06	1.97	1.14
P		.013	.12	.71	.013	.95	.054	.26

every case, using egg totals rather than just the number of emerging nymphs improved the fit of the regression lines (elevated r^2 values, Table 2).

DISCUSSION

Our results show some clear differences among the three species and between populations of each species. The consistent nature of the variation between the two populations for mean oothecae weights, mean number of nymphs emerging and mean total eggs per ootheca, indicates a qualitative difference between the two habitats (Eisenberg et al. 1992). Since food limitation has been well documented for field populations of mantids (Eisenberg et al. 1981, Matsura and Nagai 1983, Hurd and Eisenberg 1984, 1990, Hurd 1989, Fagan and Hurd 1991), we feel that the simplest explanation for the observed differences is that the AG populations of each species were more severely food limited than the CHRY populations. It seems unlikely that all three species have distinct genetic ecotypes in two nearby habitats. The notion that food limitation rather than some edaphic or genetic factor was responsible for the observed differences between sites is supported by two other lines of evidence: 1) the similarities of the regression lines between sites for numbers of nymphs emerging, on ootheca weight, and 2) the similarity in the proportions of egg mortality in each category for each species. Also, in an earlier work (Eisenberg and Hurd 1977) we reported on the emergence characteristics of a mixed collection of *T. a. sinensis* oothecae from various sites. Combining the data from the two *T. a. sinensis* populations in our present study and comparing the resultant regression line with that of Eisenberg and Hurd (1977) for number of nymphs emerging on ootheca weight shows no significant difference in either slope ($F_{1,69} = 1.50$, $P > 0.05$) or intercept ($F_{1,70} = 0.02$, $P > 0.05$). In fact, the 1977 regression predicted 5148 nymphs of the 5413 which actually emerged in the present study. The

Table 2. Regression analyses for the number of nymphs emerging and total eggs on ootheca weight for three species from sites CHRY and AG. Symbols as in Table 1.

Species	Location	Regression Values Intercept	Slope	r^2 (%)
TS	CHRY	−24.62	140.68	60.16 (nymphs)
		87.59	108.12	84.13 (total eggs)
TS	AG	−1.89	123.86	49.58 (nymphs)
		72.14	104.10	71.66 (total eggs)
TA	CHRY	−78.20	230.49	39.07 (nymphs)
		74.14	151.31	70.97 (total eggs)
TA	AG	−86.44	242.29	77.49 (nymphs)
		6.77	207.57	94.60 (total eggs)
MR	CHRY	−58.04	152.30	39.15 (nymphs)
		121.57	151.34	48.89 (total eggs)
MR	AG	−76.98	172.63	38.52 (nymphs)
		142.34	123.25	57.45 (total eggs)

constancy of this relationship over time and space argues against intrinsic differences among populations and also indicates that, at least for *T. a. sinensis,* emergence behavior in our area is rather consistent from year to year and that oothecae weights are good predictors of numbers of emerging nymphs.

One way to examine hatching success is to compare the distance between regression lines for numbers of eggs and numbers of hatched nymphs across ootheca weights. For example, the relative constancy of hatching success between the two habitats held even for *M. religiosa,* which had the poorest success of the three species. The difference between numbers of emerging nymphs and numbers of eggs was relatively large, but varied neither between sites or among ootheca weights (Fig. 1). Therefore, the nutritional success, or lack thereof, of a parent female does not affect the probability that her eggs will hatch. This guarantees the decoupling of individuals across generations, such that a newly hatched nymph is neither advantaged or disadvantaged by its parents' environment.

What remains unexplained is the reason for the relatively low percent emergence observed for *M. religiosa* in this study, less than half the values reported for 1986 by Eisenberg et al. (1992). Since hatching success was approximately equally low for both sites, this would seem to indicate that the poor emergence of *M. religiosa* was due to regional abiotic factors (temperature, humidity, etc.) which can vary among years. The eggs of *M. religiosa* require exposure to cold in order to terminate diapause (Salt and James 1947). This may limit their southern distribution to those regions in which the winters are long and cold enough to allow completion of diapause. Thus, the difference between the regression lines for emerging nymphs and total eggs (Fig. 1) may well be a reflection of insufficiently low temperatures during winter in northern Delaware. If so, we predict that this difference and the variation therein between years would decline closer to the center of this species' geographic distribution (e.g. New York State).

Fall-collected oothecae of both *Tenodera* species routinely are hatched in our laboratory without being subjected to cold, which makes it easy to run laboratory studies the year round. In fact, this can be a problem in the southern portion of their distribution; we have seen eggs of *T. a. sinensis* hatch in October in North Carolina, which assures that the nymphs will be killed by frost long before they can mature. Therefore, in Del-

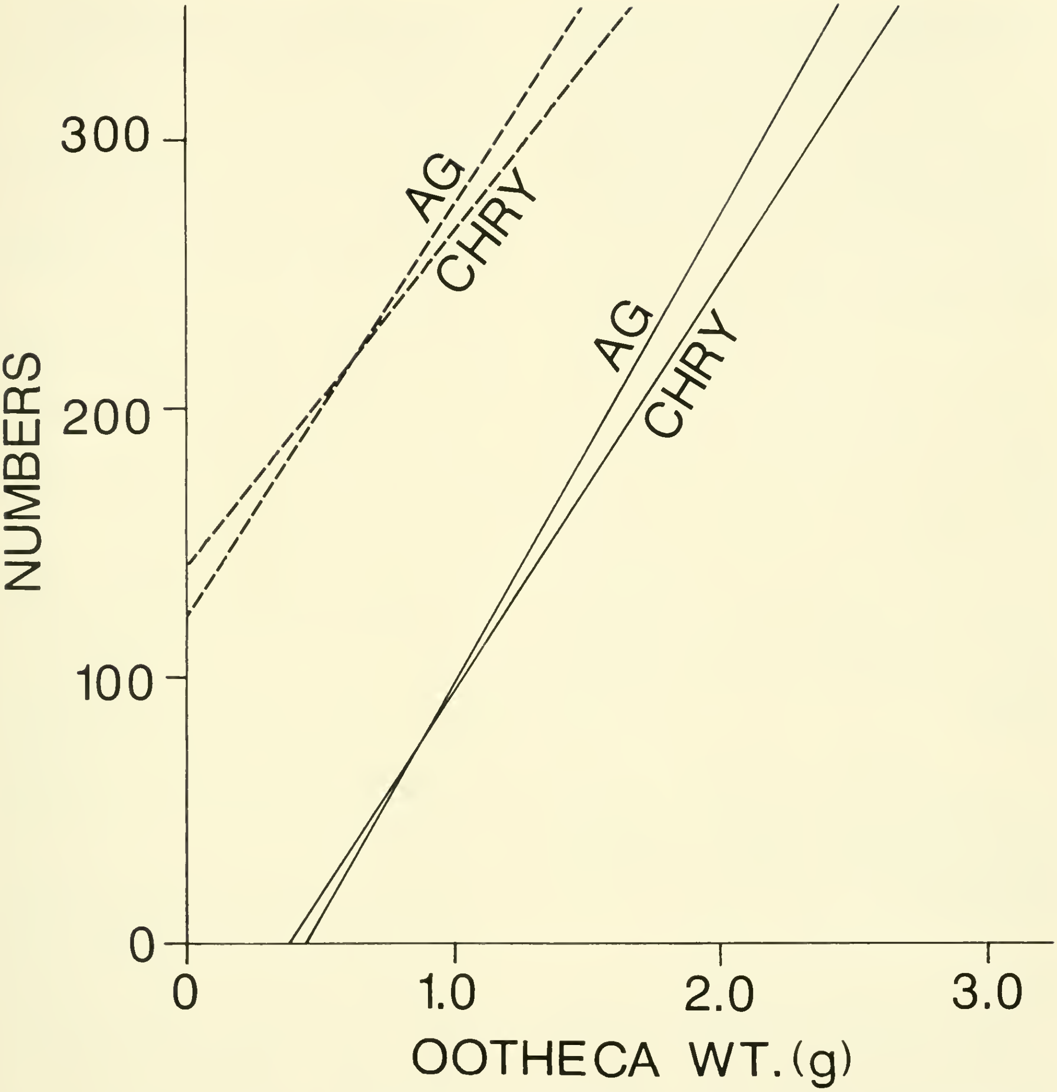


Fig. 1. Regression lines for numbers of nymphs emerging (solid lines) and total numbers of eggs (dashed lines), on oothecae weights for *Mantis religiosa* (see Table 2 for regression summary statistics). CHRY and AG are the two different field sites (see text).

aware the earlier oviposition takes place in the fall the earlier eggs are likely to hatch the following spring, so that asynchronous oviposition may at least partially explain the asynchrony in emergence times for these two species (Hurd and Eisenberg 1989b). Asynchronous emergence can translate into differences in life history stage within a population which may persist throughout the season (Hurd and Eisenberg 1989a), and induce cannibalism among co-occurring nymphs of different stadia (Hurd 1988).

Both fecundity and egg mortality are important components of population growth. Although fecundity in mantids has been linked to food supply (Matsura and Morooka 1983, Eisenberg et al. 1981, Hurd 1989), egg mortality apparently is not. Our results implicate abiotic mortality factors; however, natural enemies may be important in some cases. In the present study and in an earlier one (Eisenberg et al. 1992) we found no evidence for any egg mortality caused by natural enemies. Fox (1939b) found the egg parasite *Podagrion mantis* in about 4% of the oothecae of both *T. angustipennis* and *T. a. sinensis* in collections from Cape May County, New Jersey, and we have seen this parasite in *T. angustipennis* oothecae from southern Delaware. A high incidence of egg parasitism by *P. mantis* in our native mantid, *Stagmomantis carolina,* was reported by Girault (1907) and Rau and Rau (1913), and Fox (1939b) speculated that low incidence of *P. mantis* in *T. angustipennis* was due to its recent introduction and the lack of overlap of its range with *S. carolina.* It is interesting to note that more than 50 years after Fox's work, mantids in northern Delaware still are free of this egg parasite.

Acknowledgments

We thank Cindy Kendall for skilled dissection of oothecae. This is contribution #176 from the Ecology Program, University of Delaware.

Literature Cited

Bromley, S. W. 1932. Observations on the Chinese mantid, *Paratenodera sinensis* Saussure. Bulletin Brooklyn Entomological Society 27: 196–201.

Eisenberg, R. M. and L. E. Hurd. 1977. An ecological study of the emergence characteristics for egg cases of the Chinese mantis (*Tenodera aridifolia sinensis* Saussure.) American Midland Naturalist 106: 209–218.

Eisenberg, R. M., L. E. Hurd, and J. M. Bartley. 1981. Ecological consequences of food limitation for adult mantids (*Tenodera aridifolia sinensis* Saussure). American Midland Naturalist 106: 209–218.

Eisenberg, R. M., E. Pilchik, L. L. Bedwell, S. Winram, M. Rodgers, S. McFalls, C. T. Kessler, M. Gross, A. Walter, E. Wadman, K. M. Dougherty, W. Smith, C. L. Berman, and L. E. Hurd. 1992. Comparative egg ecology of two sympatric mantids (Mantodea: Mantidae). Proceedings Entomological Society Washington 94: 366–370.

Fagan, W. F. and L. E. Hurd. 1991. Late season food level, cannibalism, and oviposition in adult mantids: Sources of variability in a field experiment. Proceedings Entomological Society Washington 93: 956–961.

Fox, H. 1939a. The egg content and nymphal production and emergence in oothecae of two introduced species of asiatic mantids. Annals Entomological Society America 32: 549–560.

———. 1939b. Infestation of oothecae of introduced asiatic mantids by *Podagrion mantis* Ashmead. Annals Entomological Society America 32: 561–563.

Girault, A. A. 1907. Standards of numbers of eggs laid by insects. V. Entomological News 18: 89.

Gurney, A. B. 1950. Praying mantids of the United States, native and introduced. Smithsonian Institution Annual Report, 339–362.

Hurd, L. E. 1988. Consequences of divergent egg phenology to predation and coexistence in two sympatric, congeneric mantids (Orthoptera: Mantidae). Oecologia 76: 547–550.

———. 1989. The importance of late season flowers to the fitness of an insect predator, *Tenodera sinensis* Saussure (Orthoptera: Mantidae) in an old field community. Entomologist (London) 108: 223–228.

Hurd, L. E. and R. M. Eisenberg. 1984. Experimental density manipulations of the predator *Tenodera sinensis* (Orthoptera: Mantidae) in an old-field community. I. Mortality, development and dispersal of juvenile mantids. Journal Animal Ecology 53: 269–281.

———. 1989a. A mid-summer comparison of sizes and growth rates among nymphs of three sympatric mantids (Mantodea: Mantidae) in two old-field habitats. Proceedings Entomological Society Washington 91: 51–54.

———. 1989b. Temporal distribution of hatching times in three sympatric mantids (Mantodea: Mantidae) with implications for niche separation and coexistence. Proceedings Entomological Society Washington 91: 55–58.

———. 1990. Arthropod community responses to manipulation of a bitrophic predator guild. Ecology 71: 2107–2114.

Jones, F. M. 1933. Another oriental mantis well established in the U. S. (*Tenodera angustipennis* Saussure). Entomological News 44: 1–3.

Laurent, P. 1898. A species of Orthoptera. Entomological News 9: 144–145.

———. 1913. Nymphal emergence in *Paratenodera sinensis.* Entomological News 24: 431.

Matsura, T. 1979. Mortality rate and factors during the egg stage of a mantid, *Paratenodera angustipennis* de Saussure. Bulletin Kyoto Kyoiku University Series B 55: 49–58.

Matsura, T. and K. Morooka. 1983. Influence of prey density on fecundity in a mantis, *Paratenodera angustipennis* (S.). Oecologia 56: 306–312.

Matsura, T. and S. Nagai. 1983. Estimation of prey consumption of a mantid, *Paratenodera angustipennis* (S.) in a natural habitat. Researches Population Ecology 25: 298–308.

Rau, P. and N. Rau. 1913. The biology of *Stagmomantis carolina.* Transactions Academy Sciences St. Louis 22: 1–58.

Roberts, R. A. 1937. Biology of the bordered mantis, *Stagmomantis limbata* Hahn. Annals Entomological Society America 30: 96–108.

Ross, E. S. 1984. The praying predators. National Geographic 165: 268–280.

Salt, R. W. and H. G. James. 1947. Low temperature as a factor in the morality of eggs of *Mantis religiosa.* Canadian Entomologist 79: 33–36.

Snedecor, G. W. and W. G. Cochran. 1980. Statistical Methods. Second Edition. Iowa State Univ. Press, Ames, Iowa.

Weiss, H. B. 1914. Some facts about the egg-nest of *Paratenodera sinensis.* Entomological News 25: 279–282.

Yan, J., C. Xu, D. Yao, and Y. Li. 1981. Studies on the bionomics of six mantids from China. Collected Research Papers Chinese Academy Forestry 2: 67–74.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 278–285

AN ANNOTATED CATALOGUE OF THE SIPHONAPTERAN PRIMARY TYPES IN THE CANADIAN NATIONAL COLLECTION OF INSECTS (INSECTA: SIPHONAPTERA)[1]

Robert E. Lewis, Edward C. Becker, and Robert E. Skidmore

(REL) Department of Entomology, Iowa State University, Ames; (ECB & RES) Centre for Land and Biological Resources Research, Agriculture Canada. Ottawa, Ontario K1A 0C6, Canada.

Abstract.—Locality and host data are presented for the 41 primary types of species of fleas housed in the collection of the Centre for Land and Biological Resources Research, Agriculture Canada. Most have been described by the late G. P. Holland, but included are taxa described by M. A. Stewart (jointly with Holland), P. T. Johnson, H. E. Stark and J. Wagner. Most species are from Canada, but the United States, México, Brazil and New Guinea are also represented. Junior synonyms are included and their status indicated.

Key Words: Insecta, Siphonaptera, flea, ectoparasite, primary types, synonymy, birds, mammals, computerization

Throughout most of his productive life the late George P. Holland pursued the study of the siphonapteran ectoparasites of Canadian birds and mammals. As a result of these and related studies, he was able to develop the flea collection of the Canadian National Collection of Insects to the extent that today it ranks as one of the major collections in the world. Although he described new species from Mexico and New Guinea, and exchanged material with colleagues around the world, the strength of the collection lies in its representation of the Canadian fauna.

Shortly after Dr. Holland's tragic death in November of 1985, the collection was inventoried and a list of primary types was compiled. This list of specimens and their accompanying data have never been published in conformation with Recommendation 72G(4) of the third edition of the International Code of Zoological Nomenclature (see Ride and Sabrosky 1985: 147).

Following is an annotated list of the 41 primary type specimens currently housed in the Canadian National Collection. Although allotypes are not primary types and are not usually included, most taxa listed here are also represented by them in the collection. Junior synonyms are listed as well as valid names. The five-digit computerization number for the species is included in brackets. All data given on the slide labels are presented. Supplemental information not included on the slide labels is also given in brackets. Names of hosts are updated following Sibley and Monroe (1990) for birds and Honacki et al. (1982) for mammals.

SPECIES ACCOUNTS

adversus Wagner, 1936a. *Megabothris* [93635]. Z. Parasitenk. 8: 656, fig. 4.

Canada, B.[ritish] C.[olumbia], Vancouver [49°13′N, 123°06′W], fr.[om] *Peromuscus* [= *Peromyscus*] *maniculatus austerus,*

---

[1] Journal Paper No. J-14407 of the Iowa Agriculture and Economics Experiment Station, Ames, Iowa. Project No. 2581.

26.V.[19]35, G. J. Spencer [leg.], vial 353.5. Holotype ♀ (by monotypy), CNC No. 4550.

Remarks.—This is a junior synonym of *Megabothris* (*Amegabothris*) *abantis* (Rothschild, 1905) according to Holland (1942: 158).

aiyurensis Holland, 1969. [*Acanthopsylla*] [96907]. Mem. Ent. Soc. Canada 61: 18, figs. 11, 17, 19, 28.

New Guinea, Aiyura [06°20′S, 145°54′E], 6000′ [= 1829 m], [from] *Eudromicia* [= *Cercartetus caudatus*], 28.IX.[19]57, G. P. Holland [leg.], No.: 58-7. Holotype ♂, CNC No. 9739.

Remarks.—This is a junior synonym of *Acanthopsylla enderleini* (Wagner, 1933) according to Mardon (1981: 117). The original description gives the date as 20.IX.57, which is evidently wrong since the slides are both marked 28.IX.57. Generic name not included on either slide.

arcuegans Holland, 1952. *Ceratophyllus* [95222]. Can. Ent. 84: 300, figs. 8–15.

Canada, Y.[ukon] T.[erritory], Rampart House [67°25′N, 140°59′W], [from] nest of *Petrochelidon* [= *Hirundo pyrrhonota*], IX.[19]51, J. E. H. Martin [leg.], No.: 51-295. Holotype ♂, CNC No. 6000.

Remarks.—Now treated as *Ceratophyllus* (*Ceratophyllus*) *arcuegens* Holland.

athabascae Holland, 1952. *Malaraeus penicilliger* [95223]. Can. Ent. 84: 303, figs. 16–19.

Canada, N.W.T. [= Northwest Territories], Ft. Smith [60°01′N, 111°55′W], ex *Clethrionomys g.*[*apperi*] *athabascae*, 29.IV.[19]48, W. F. [= W. A. Fuller leg.], file No. 3246. Holotype ♂, CNC No. 6001.

Remarks.—The slide also has "*Amalaraeus dissimilis atha.*" written on the holotype label. Holland (1963: 58) elevated this to a full species. Smit (1965: 483) decided that *M. penicilliger dissimilis* Jordan, 1938 was distinct from *M. penicilliger* and elevated it to full species rank with *athabascae* as a subspecies. Holland (1985: 391) still treated it as a full species, although Traub et al. (1983: 45) retained it as a subspecies of *A. dissimilis*.

barretti Holland, 1969. [*Papuapsylla*] [96925]. Mem. Ent. Soc. Canada 61: 44, figs. 114, 116–117, 119, 124, 130, 136, 213.

New Guinea, Mt Wilhelm [05°46′S, 144°59′E], 11400′ [= 3475 m], [from] *Melomys* sp., 13.X.[19]57, G. P. Holland [leg.], No.: 58-27. Holotype ♂, CNC No. 9754.

Remarks.—The generic name is not included on the labels of either the holotype or the allotype.

calderwoodi Holland, 1979. *Ceratophyllus* [97924]. Can. Ent. 111: 717, figs. 9–12.

Canada, N.[ew] B.[runswick], Kouchibouguac Nat'l. Pk. [= National Park, ca. 46°55′N, 64°58′W], from *Petrochelidon* [= *Hirundo*] *pyrrhonota* nest, 7.IX.1977, G. Calderwood [leg.], 577-72. Holotype ♂, CNC No. 15896.

Remarks.—Now treated as *Ceratophyllus* (*Ceratophyllus*) *calderwoodi* Holland.

campestris Holland, 1949. *Callistopsyllus* [94936]. Canada Dept. Agric. Tech. Bull. 70: 98, figs. 120–121, map 14.

Canada, Alberta, Medicine Hat [50°03′N, 110°41′W], from *Peromyscus m.*[*aniculatus*] *osgoodi*, 6.VI.[19]40, G. P. Holland [leg.], File No.: 1827. Holotype ♂, CNC No. 5718.

Remarks.—Originally described as a full species. Redescribed and reduced to a subspecies, *Callistopsyllus terinus campestris* Holland, by Tipton et al. (1979: 359).

durangoensis Holland, 1965. *Anomiopsyllus* [96521]. Can. Ent. 97: 1056, figs. 7–8, 15, 18.

Mex[ico], D[uran]go [State], 3 mi. [5 km] W [ca. 24°01′N, 104°45′W], 6500′ [= 1981 m], from mouse nest in yucca, *Peromyscus*?, 24.VI.1964, J. E. H. Martin [leg.], No. J-64-100. Holotype ♂, CNC No. 8934.

eudromiciae Holland, 1969. [*Acanthopsyl-*

la] [96909]. Mem. Ent. Soc. Canada 61: 20, figs. 15, 18, 22, 26, 32.

New Guinea, Aiyura [06°20′S, 145°54′E], 6000′ [= 1829 m], [from] *Eudromicia* [= *Cercartetus caudatus*], 28.IX.[19]57, G. P. Holland [leg.], No.: 58-7. Holotype ♂, CNC No. 9741.

Remarks.—Generic name not included on either slide.

exsecatus Wagner, 1936b. *Megarthroglossus longispinus* [93639]. Can. Ent. 68: 196.

Canada, B.[ritish] C.[olumbia], Avola [51°74′N, 119°19′W], fr.[om] "squirrel" *Sciurus douglasii* [= *Tamiasciurus hudsonicus*], 2.IX.[19]32 [collector not given] (Vial 363). Holotype ♀, CNC No. 4112.

Remarks.—A junior synonym of *Megarthroglossus divisus* (Baker, 1898) according to Tipton et al. (1979: 384).

frustratus Johnson, 1957. *Polygenis* [95742]. Mem. Ent. Soc. Wash. 5: 161, pl. 86, figs. 1–3, 7, pl. 87, figs. 1, 3, 5.

Brazil, Brasilien, Nova Teutônia [Santa Catarina 27°03′S, 52°24′W, host unknown], VII.[19]42, F. Plaumann, No.: 55-6. Holotype ♂, CNC No. 21212.

fulleri Holland, 1951a. *Catallagia dacenkoi* [95113]. Can. Ent. 83: 157, figs. 1–7.

Canada, N.W.T. [= Northwest Territories], Ft. Smith [60°01′N, 111°55′W], from *Clethrionomys g.*[*apperi*] *athabascae*, 25.X.[19]47, W. A. Fuller [leg.], File No. 3209. Holotype ♂, CNC No. 5720.

Remarks.—Treated as a junior synonym of *Catallagia dacenkoi* Ioff, 1940 by Smit (1967: 83).

globata Holland, 1971. *Myodopsylla* [97101]. Can. Ent. 103: 95, figs. 1–4.

Mex[ico], Chis. [= Chiapas State], 7 mi. [ca. 11 km] E San Cristobal d. l. C. [de las Casas, ca. 16°45′N, 92°31′W, 7000′ (2134 m), from] bats [*Myotis velifer* or *Tadarida brasiliensis intermedia*], 16.V.1969, J. E. H. Martin [leg.], No.: S-69-85. Holotype ♀, CNC No. 11551.

grahami Holland, 1979. *Nearctopsylla* [97922]. Can. Ent. 111: 713, figs. 1–3, 5.

Canada, Ont.[ario], Thunder Bay Dist.[rict], Spruce Riv.[er] R[oa]d, Mi. 64 [ca. 49°28′N, 88°85′W], from *Martes a. americana*, 20.XII.[19]77, Bob Graham [leg.], No: S 78-11. Holotype ♂, CNC No. 15894.

gregsoni Holland, 1950. *Megabothris calcarifer* [95075]. Can. Ent. 82: 132, figs. 7–8.

United States, Alaska, Naknek [58°45′N, 157°00′W], ex *Microtus* sp., 28.VI.[19]48, J. D. Gregson [leg.], File No. 3276. Holotype ♂, CNC No. 5872.

Remarks.—Synonymized with the nominate form, *Megabothris calcarifer* (Wagner, 1913) by Holland (1985: 355).

jellisoni Holland, 1954. *Catallagia* [95435]. Can. Ent. 86: 383, figs. 1–7.

Canada, Alta.[= Alberta], Bow Pass [Rocky Mts, 105 km N Banff, Banff National Park, Peyto Lake Trail ca. 52°00′N, 116°10′W, 6500–7000′ (1981–2137 m), just below vantage point at Bow Summit], from *Clethrionomys* [*gapperi*], 10.X.[19]53, G. P. Holland [& O. Peck leg.], No.: 53.815. Holotype ♂, CNC No. 6131.

lari Holland, 1951b. *Ceratophyllus* [95123]. Can. Ent. 83: 282, figs. 5, 7, 9.

Canada, N.W.T. [= Northwest Territories, Whaleback Island], Great Slave Lake [ca. 62°00′N, 112°00′W], ex [nest of] *Larus* sp., 23.VI.1947, J. R. Vockeroth [leg.], 49-46. Holotype ♂, CNC No. 5952.

Remarks.—The original description gave the hosts as *Larus californicus* or *L. argentatus* nests. The species is now placed in the subgenus *Ceratophyllus*.

linsdalei Holland, 1957. *Hystrichopsylla* [95748]. Can. Ent. 89: 322, figs. 5, 18, 21, 26, 29.

United States, Calif.[ornia], Alameda Co.[unty], Berkeley Hills [37°53′N, 122°17′W], ex *Microtus* nest, 23.III.[19]54, [V. J.] Tipton, [E.] Méndez, [G.] Loshbaugh [leg.]. Holotype ♂, CNC No. 6548.

Remarks.—Now considered a subspecies of *Hystrichopsylla occidentalis* Holland, 1949.

luluai Holland, 1969. [*Papuapsylla*] [96924]. Mem. Ent. Soc. Canada 61: 42, figs. 90, 107–109, 115, 118, 123, 128–129, 212.

New Guinea, [Papua], Komia [= Komy, near Mendi 06°13′S, 143°39′E], 7200′ [= 2195 m, from] *Rattus* sp., 7.X.[19]57, G. P. Holland [leg.], No.: 58-25. Holotype ♂, CNC No. 9753.

Remarks.—Generic name not included on either slide.

markworthi Hubbard, 1949. *Peromyscopsylla hamifer* [94904]. Can. Ent. 81: 11, figs. [unnumbered].

Canada, Ont.[ario], Smoky Falls, near Kapuskasing [49°25′N, 82°26′W], from *Microtus pennsylvanicus*, 7.XI.[19]38, R. [V.] Whelan [leg.]. Holotype ♂, CNC No. 21246.

Remarks.—This is a junior synonym of *Peromyscopsylla hamifer hamifer* (Rothschild, 1906) according to Hopkins (1951: 542). The holotype was originally deposited in the Royal Ontario Museum of Zoology, Toronto.

martini Holland, 1965. *Anomiopsyllus* [96519]. Can. Ent. 97: 1054, figs. 1–3, 13–14, 17.

Mex[ico], Dur.[ango State], 10 mi. [17 km] W El Salto [ca. 23°45′N, 105°35′W, 9000′ (2743 m), from] nest of *S.*[*ciurus*] *aberti* in hollow tree, 21.VI.1964, J. E. H. Martin [leg.], S-64-96. Holotype ♂, CNC No. 8932.

martini Holland, 1971. *Kohlsia* [97102]. Can. Ent. 103: 97, figs. 5–8.

Mex[ico], [Chiapas State, Chiapas] N Oax.[aca] hwy. [= highway] 175, [km 145, ca. 18°00′N, 95°58′W, 4000′ (1219 m), from] *Oryzomys* sp., 22.V.1969, J. E. H. Martin [leg.], No.: S-69-78. Holotype ♂, CNC No. 11552.

Remarks.—In the original description, it is noted that this locality is in Chiapas State; in fact, the locality given is well within Oaxaca State.

mexicanus Holland, 1965. *Anomiopsyllus hiemalis* [96520]. Can. Ent. 97: 1056, figs. 4–5.

Mex[ico], Chi.[huahua State], Mesa del Huracan [29°40′N, 180°15′W, 7400′ (2256 m), from] *Neotoma* nest, 21–25.VII.1964, J. E. H. Martin [leg.], S-64-102. Holotype ♂, CNC No. 8933.

Remarks.—Now considered to be a subspecies of *Anomiopsyllus nudatus* (Baker, 1898) according to Barnes et al. (1977: 169).

neotomae Holland, 1957. *Hystrichopsylla dippiei* [95746]. Can. Ent. 89: 316, figs. 4, 11, 13, 25, 28.

United States, California [Alameda County], Berkeley, Strawberry Canyon [37°53′N, 122°17′W], ex *Neotoma* nest, 23.XII.1952, R. Lee & V. J. Tipton [leg.]. Holotype ♂, CNC No. 6546.

Remarks.—The original description lists the date as 26.II.1954, and the collectors as E. Méndez and G. Loshbaugh. These data match those on three female paratypes and there is a male with a similar label collected by Lee and Tipton on 17.IV.1954.

occidentalis Holland, 1949. *Hystrichopsylla* [94934]. Canada Dept. Agric. Tech. Bull. 70: 76, pl. X, figs. 47–49, map 6.

Canada, B.[ritish] C.[olumbia], Mt Seymour [near] Northlands [Burrard Inlet, 49°25′N, 122°57′W, 3400′ (1036 m)], ex *Clethrionomys gapperi* ssp., 14.VI.[19]47, G. P. Holland [leg.], File No. 3052. Holotype ♂, CNC No. 5716.

pacifica Holland, 1949. *Peromyscopsylla hesperomys* [94938]. Canada Dept. Agric. Tech. Bull. 70: 176, pl. XL, figs. 319–321, 324a–e, map 41.

Canada, B.[ritish] C.[olumbia], Vancouver, U.B.C. [= University of British Columbia] Campus [49°13′N, 123°06′W], ex *Pero-*

myscus m.[*aniculatus*] *austerus*, 3.X.[19]43 [H. D. Fisher leg.]. Holotype ♂, CNC No. 5719.

paraterinus Wagner, 1940. *Callistopsyllus* [94033]. Z. Parasitenk. 11: 465, figs. 5–6.

Canada, B.[ritish] C.[olumbia], N.[orth] F.[ork of] Eagle River [= Perry River, ca. 50°95′N, 119°69′W, from] *Peromyscus maniculatus* (prob.) *artemisiae* (Rhodes), 28.V.[19]34, E. R. B.[uckell leg.], Vial N 57. Holotype ♂ (by monotypy), CNC No. 21217.

Remarks.—The determination label on this slide reads: "*Callistopsyllus paraterinus* Wagn. (= ?*terinus* Roths.), Jul. Wagner det." This is now treated as a synonym of the nominate subspecies, *Callistopsyllus terinus terinus* (Rothschild, 1905) according to Holland (1949: 97). The original description gives the date as 24.V.34, but the holotype slide is clearly labeled 28.V.34.

petrochelidoni Wagner, 1936a. *Ceratophyllus* [93634]. Z. Parasitenk. 8: 655, fig. 2.

Canada, B.[ritish] C.[olumbia], Kamloops [50°39′N, 120°24′W], fr.[om] *Petrochelidon lunifrons lunifrons* [= *Hirundo pyrrhonota*], VII.[19]34, G. J. Spencer [leg.], Vial AOU 612.2. Holotype ♂, CNC No. 4551.

Remarks.—The data given in the original description for the holotype and allotype are reversed; the holotype is from Kamloops as noted above. Although we are not routinely recording allotypes, it should be noted that the allotype of this species was taken from the same host species, from Chilcotin, ca. 51°50′N, 123°00′W, British Columbia, 10.VIII.1930, by G. J. Spencer, and is also deposited in the collection. It is annotated "vial 512.1 (or 612.1)" in Wagner's handwriting.

pygmaeus Wagner, 1936b. *Megarthroglossus* [93642]. Can. Ent. 68: 196, pl. 11, fig. 4.

Canada, B.[ritish] C.[olumbia], Nicola [50°16′N, 120°69′W], fr.[om] *Neotoma cinerea occidentalis*, 25.VIII.[19]32 [E. Hearle? leg.] (vial 351). Holotype ♂, CNC No. 4113.

Remarks.—A junior synonym of *Megarthroglossus spenceri* Wagner, 1936 according to Hopkins and Rothschild (1962: 383).

rauschi Holland, 1960. *Ceratophyllus* [96036]. Can. Ent. 92: 792, figs. 6–8, 10.

Canada, Yukon [Territory], 30 mi. [48.3 km] N Stewart R.[iver] Crossing [on Klondike Highway, ca. 63°25′N, 136°45′W], ex nest of flicker [= *Colaptes auratus*], 16.VIII.1959, [G. P.] Holland & [J. E. H.] Martin [leg.], No.: 59-224. Holotype ♂, CNC No. 7154.

Remarks.—The original description gave the locality as the Stewart River crossing on the Alaska Highway. G. Haas (in litt.) indicated that "Alaska Highway" should read "Klondike Highway."

rauschi Holland, 1979. *Rhadinopsylla* (*Micropsylla*) [97923]. Can. Ent. 111: 716, figs. 6–7.

Canada, Sask.[atchewan], Cypress Lake, S. of Cypress Hills [49°28′N, 109°30′W, from] *Peromyscus maniculatus* [*osgoodi*], 24–26.X.[19]76, R. L. R.[ausch leg.], No.: S 77-39. Holotype ♂, CNC No. 15895.

scapani Wagner, 1936a. *Neopsylla* [93636]. Z. Parasitenk. 8: 657, fig. 5.

Canada, B.[ritish] C.[olumbia], Vancouver [49°13′N, 123°06′W], fr.[om] *Scapanus orarius orarius*, IV.1933, G. J. Spencer [leg.], vial 14.1. Holotype ♂, CNC No. 4552.

Remarks.—Now known as *Epitedia scapani* (Wagner, 1936).

scopulorum Holland, 1952. *Ceratophyllus* [95221]. Can. Ent. 84: 297, figs. 1–7.

Canada, Yukon Territory, Rampart House [67°25′N, 140°59′W, from] nest of *Petrochelidon* [= *Hirundo pyrrhonota*], 24–26.X.[19]76, R. L. R.[ausch leg.], No.: S 77-39. Holotype ♂, CNC No. 15895.

septentrionalis Stewart & Holland, 1940. *Aetheopsylla* [94017]. Can. Ent. 72: 41, figs. 1–2.

Canada, B.[ritish] C.[olumbia], Wigwam Mine [ca. 35 km south of Revelstoke, ca. 51°42′N, 118°12′W], ex *Marmota monax petrensis* Howell, 21.V.1939, E. R. Buckell [leg.], File No. 1505-a. Holotype ♀, CNC No. 4986.

Remarks.—Both the genus and the species were treated as junior synonyms of *Oropsylla* (*Oropsylla*) *arctomys* (Baker, 1904) by Jellison (1945: 90).

sinuatus Holland, 1965. *Anomiopsyllus* [96522]. Can. Ent. 97: 1058, figs. 9–10, 16, 19.

Mex[ico], Dur.[ango State], 30 mi. [= 48 km] W. Durango [ca. 24°02′N, 105°22′W], 8000′ [= 2438 m], from *Peromyscus* nest, 5.VI.1961, J. E. H. Martin [leg.], No. 61-111. Holotype ♂, CNC No. 8935.

Remarks.—The original description notes the altitude as 6500′ (1981 m).

spenceri Wagner, 1936a. *Thrassis* [93632]. Z. Parasitenk. 8: 655. [published 26.IX.1936].

Canada, B.[ritish] C.[olumbia], Birch Island [Granite Mtn, 51°36′N, 119°55′W], 7000′ [2134 m], from hoary marmot (Alpine) *Marmota* sp. [= *caligata*], 12.VIII.[19]31, Eric Hearle [leg.] (vial 67). Holotype ♂, CNC No. 4111.

Remarks.—This species was again described as new, under the same name, by Wagner in Can. Ent. 68: 197, pl. 11, figs. 5, 7a (published 3.X.1936) based on the same specimens. Therefore, the latter *spenceri* is a junior objective synonym of the former.

spenceri Wagner, 1936b. *Megarthroglossus* [93641]. Can. Ent. 68: 196, pl. 11, figs. 2, 3.

Canada, Br.[itish] C.[olumbia], Nicola [50°16′N, 120°69′W], fr.[om] *Ochotona princeps* (*fenisex* ?), 26.VIII.1932, E.[ric] H.[earle leg.], N. 352, vial N 49. Holotype ♀, CNC No. 21248.

Remarks.—In this same paper Wagner described *M. similis* from Beaverdell, British Columbia, from *Neotoma cinerea occidentalis*, 23.XI.1930, G. J. Spencer leg. The male specimen, labeled "Typus," was illustrated by Wagner in pl. II, fig. 1. It is in the Wagner Collection in the Zoologisches Museum (ZMH 1797) in Hamburg, Germany, and was designated Lectotype by Smit and Wright (1965: 40).

spinata Holland, 1949. *Hystrichopsylla* [94935]. Canada Dept. Agric. Tech. Bull. 70: 77, pl. X, figs. 50–52, map 6.

Canada, B.[ritish] C.[olumbia], Vancouver [University of British Columbia Campus, ca. 49°13′N, 123°06′W], ex *Spilogale g.*[*racilis*] *olympica*, 16.X.[19]36, G. P. H.[olland leg.] Holotype ♂, CNC No. 5717.

Remarks.—Now considered a subspecies of *Hystrichopsylla dippiei* Rothschild, 1902.

truncata Holland, 1957. *Hystrichopsylla dippiei* [95747]. Can. Ent. 89: 318, figs. 8, 14, 23.

Canada, B.[ritish] C.[olumbia], Okanagan Ldg. [= Landing, 50°12′N, 119°22′W], *Peromyscus m.*[*aniculatus*] *artemesiae*, 15.IX.[19]50, J. D. Gregson [leg.]. Holotype ♂, CNC No. 6547.

tundrensis Holland, 1945. *Ceratophyllus* [94501]. Can. Ent. 76: 242, figs. 1–3.

Canada, N.W.T. [= Northwest Territories], Baker Lake [64°10′N, 95°30′W, from] Arctic weasel, *Mustela arctica* [= *erminea*], 27.VIII.1937 [C. H. D. Clarke leg.]. Holotype ♂, CNC No. 5544.

vancouverensis Stark, 1957. *Thrassis spenceri* [95718]. J. Parasitol. 43: 334, pl. II, figs. 7–12.

Canada, B.[ritish] C.[olumbia], Vancouver Isl[an]d, Mt Washington [ca. 49°86′N, 125°67′W], ex Marmot [= *Marmota vancouverensis*], 30.VIII.[19]43, G. C. C.[arl], File No. 2371. Holotype ♂, CNC No. 21247.

Remarks.—Now considered a synonym of *Thrassis spenceri spenceri* Wagner, 1936 according to Stark, 1970: 39.

Literature Cited

Baker, C. F. 1898. Notes on Siphonaptera, with descriptions of four new species. Journal of the New York Entomological Society 6: 53–56.

———. 1904. A revision of American Siphonaptera, or fleas, together with a complete list and bibliography of the group. Proceedings of the United States National Museum 27: 365–469.

Barnes, A. M., V. J. Tipton, and J. A. Wildie. 1977. The subfamily Anomiopsyllinae (Hystrichopsyllidae: Siphonaptera). I. A revision of the genus *Anomiopsyllus* Baker. Great Basin Naturalist 32: 138–206.

Holland, G. P. 1942. Synonymy of some fleas from western North America (Siphonaptera). Canadian Entomologist 74: 157–158.

———. 1945 [1944]. Notes on some northern Canadian Siphonaptera, with the description of a new species. Canadian Entomologist 76: 242–246.

———. 1949. The Siphonaptera of Canada. Dominion of Canada—Department of Agriculture. Technical Bulletin 70. 306 pp.

———. 1950. Notes on *Megabothris asio* (Baker) and *M. calcarifer* (Wagner) with the description of a new subspecies (Siphonaptera: Ceratophyllidae). Canadian Entomologist 82: 126–133.

———. 1951a. A note on the occurrence of *Catallagia dacenkoi* Ioff in North America, with the description of a Nearctic subspecies (Siphonaptera: Neopsyllidae). Canadian Entomologist 83: 156–160.

———. 1951. Notes on some bird fleas, with the description of a new species of *Ceratophyllus*, and a key to the bird fleas known from Canada (Siphonaptera: Ceratophyllidae). Canadian Entomologist 83: 281–289.

———. 1952. Descriptions of fleas from northern Canada (Siphonaptera). Canadian Entomologist 84: 297–308.

———. 1954. A new species of *Catallagia* Rothschild from the Rocky Mountains of Alberta (Siphonaptera: Hystrichopsyllidae: Neopsyllinae). Canadian Entomologist 86: 381–384.

———. 1957. Notes on the genus *Hystrichopsylla* Rothschild in the New World, with descriptions of one new species and two new subspecies (Siphonaptera: Hystrichopsyllidae). Canadian Entomologist 89: 309–324.

———. 1960. Descriptions of two species of *Ceratophyllus* Curtis from Yukon Territory (Siphonaptera: Ceratophyllidae). Canadian Entomologist 92: 787–793.

———. 1963. Faunal affinities of the fleas (Siphonaptera) of Alaska: With an annotated list of species. Proceedings of the Tenth Pacific Science Congress: 45–63.

———. 1965. A new species and subspecies of *Anomiopsyllus* Baker from Mexico (Siphonaptera: Hystrichopsyllidae). Canadian Entomologist 97: 1051–1058.

———. 1969. Contribution towards a monograph of the fleas of New Guinea. Memoirs of the Entomological Society of Canada, No. 61. 77 pp.

———. 1971. New Siphonaptera from southern Mexico. Canadian Entomologist 103: 95–104.

———. 1979. Three new species of fleas from Canada (Siphonaptera). Canadian Entomologist 111: 713–719.

———. 1985. The fleas of Canada, Alaska and Greenland (Siphonaptera). Memoirs of the Entomological Society of Canada, No. 130. 631 pp.

Honacki, J. H., K. E. Kinman, and J. W. Koeppl. 1982. Mammal Species of the World. A Taxonomic and Geographic Reference. Allen Press and the association of Systematic Collections, Lawrence, Kansas. 694 pp.

Hopkins, G. H. E. 1951. Notes on fleas. Annals and Magazine of Natural History (12)4: 529–544.

Hopkins, G. H. E. and M. Rothschild. 1962. An Illustrated Catalogue of the Rothschild Collection of Fleas (Siphonaptera) in the British Museum (Nat. Hist.). Volume III. Hystrichopsyllidae (Acedestiinae, Anomiopsyllinae, Hystrichopsyllinae, Neopsyllinae, Rhadinopsyllinae and Stenoponiinae). British Museum (Nat. Hist.). University Press, Cambridge. 560 pp.

Hubbard, C. A. 1949. Fleas in the collection of the Royal Ontario Museum of Zoology. Canadian Entomologist 81: 11–12.

Ioff, I. G. 1940. Über einige neue und wenig bekannte Aphanipteren. Parazitologicheskii Sbornik 7: 210–229.

Jellison, W. L. 1945. Siphonaptera: The genus *Oropsylla* in North America. Journal of Parasitology 31: 83–97.

Johnson, P. T. 1957. A classification of the Siphonaptera of South America. Memoirs of the Entomological Society of Washington. No. 5. 299 pp.

Jordan, K. 1938. On some Nearctic Siphonaptera. Novitates Zoologicae 41: 119–124.

Mardon, D. K. 1981. An Illustrated Catalogue of the Rothschild Collection of Fleas (Siphonaptera) in the British Museum (Nat. Hist.). Volume VI. Pygiopsyllidae. British Museum (Nat. Hist.). Fletcher & Sons, Ltd., Norwich. 298 pp.

Ride, W. D. L. and C. W. Sabrosky (Eds.). 1985. International Code of Zoological Nomenclature. Third Edition. International Trust for Zoological Nomenclature. 338 pp.

Rothschild, N. C. 1902. Some new Nearctic fleas. Entomologist's Record and Journal of Variation 14: 62–63.

———. 1905. On North American *Ceratophyllus*, a genus of Siphonaptera. Novitates Zoologicae 12: 153–174.

———. 1906. Three new Canadian fleas. Canadian Entomologist 38: 321–325.

Sibley, C. G. and B. L. Monroe, Jr. 1990. Distribution and Taxonomy of Birds of the World. Yale University Press, New Haven & London. 1111 pp.

Smit, F. G. A. M. 1965. Siphonaptera collected by Dr. K. Zimmermann in northeast China (with a bibliography of Chinese Siphonaptera). Annals and Magazine of Natural History (13)7: 473–491.

———. 1967. Siphonaptera of Mongolia. Results of the Mongolian–German Biological Expeditions since 1962. No. 23. Mitteilungen aus dem Zoologischen Museum in Berlin 43: 77–115.

Smit, F. G. A. M. and A. M. Wright. 1965. Notes on the Wagner Collection of Siphonaptera in the Zoologisches Museum, Hamburg. Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut 62: 1–54.

Stark, H. E. 1957. Five new fleas of the genus *Thrassis* Jordan, 1929 (Ceratophyllidae: Siphonaptera), a genus of known importance in plague transmission. Journal of Parasitology 43: 332–346.

———. 1970. A revision of the flea genus *Thrassis* Jordan, 1933 (Siphonaptera: Ceratophyllidae), with observations on ecology and relationship to plague. University of California Publications in Entomology 53: 1–184.

Stewart, M. A. and G. P. Holland. 1940. A new genus of the family Dolichopsyllidae (Siphonaptera) from Canada. Canadian Entomologist 72: 41–42.

Tipton, V. J., H. E. Stark, and J. A. Wildie. 1979. Anomiopsyllinae (Siphonaptera: Hystrichopsyllidae). II. The genera *Callistopsyllus, Conorhinopsylla, Megarthroglossus* and *Stenistomera.* Great Basin Naturalist 39: 351–418.

Traub, R., M. Rothschild, and J. F. Haddow. 1983. The Rothschild Collection of Fleas, the Ceratophyllidae: Key to the Genera and Host Relationships, with Notes on Their Evolution, Zoogeography and Medical Importance. Cambridge University Press–Academic Press, Cambridge and London. 288 pp.

Wagner, J. 1913. *Ceratophyllus calcarifer* sp. n. Annuaire du Musée Zoologique de Académie Imperiale des Sciences. Saint Pétersburg 18: 263–267.

———. 1933. Aphanipteren-Material aus der Sammlung des Zoologischen Museums der Berliner Universität. Mitteilungen aus dem Zoologischen Museum in Berlin 18: 338–362.

———. 1936a. Neue nordamerikanische Floharten. Zeitschrift für Parasitenkunde 8: 654–658.

———. 1936b. The fleas of British Columbia. Canadian Entomologist 68: 193–207.

———. 1940. Beitrag zur Kenntnis der Flöhe von Brit.-Kolumbien. Zeitschrift für Parasitenkunde 11: 463–467.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 286–292

NEW SPECIES OF *NEOTRICHIA* FROM TEXAS AND PANAMA, WITH A PRELIMINARY REVIEW OF THE *N. CANIXA* GROUP (TRICHOPTERA: HYDROPTILIDAE)

S. C. HARRIS AND S. G. TIEMANN

(SCH) Department of Biology, Clarion University, Clarion, Pennsylvania 16214; (SGT) Biology Department, Southwest Texas State University, San Marcos, Texas 78666.

Abstract.—Two new species in the *Neotrichia canixa* group, ***N. juani*** from Texas and ***N. malickyi*** from Panama, are described and illustrated. An overview of the *N. canixa* group is presented with redescriptions and illustrations of *N. corniculans* Flint and *N. tauricornis* Malicky.

Key Words: Trichoptera, Hydroptilidae, *Neotrichia,* new species, Texas, Panama

The *Neotrichia canixa* group of Marshall (1979) is presently comprised of seven species, *N. canixa* (Mosely), *N. corniculans* Flint, *N. dubitans* (Mosely), *N. xicana* (Mosely), *N. maria* Bueno and Hamilton, *N. tauricornis* Malicky and *N. cuernuda* Harris. The group has several distinctive features in common, including a thin bifid process on the posterolateral margin of the ninth abdominal segment; inferior appendages divided in ventral aspect; a phallus with the apex usually divided into two short, curved processes; and the tergum of segment ten with horned processes. The species group was considered Neotropical, with *N. canixa, N. xicana* and *N. maria* from southern Mexico; *N. cuernuda* from Venezuela; *N. dubitans* from Brazil; *N. corniculans* from Dominica and Surinam; and *N. tauricornis* the most widespread, with records from Guadeloupe, Martinique and Trinidad in the Lesser Antilles, Panama and Colombia.

The distribution of the *N. canixa* group is expanded northward into the southwestern United States with the discovery of a new species from several streams and rivers in Texas. An additional new species is described from Panama. These species are compared to *N. tauricornis* and *N. corniculans* which are redescribed. Morphological terminology follows that of Marshall (1979). Length is measured from the top of the head to the tip of the forewings and is given as a range with more than one specimen. Holotypes are deposited in the National Museum of Natural History, Washington, D.C. (NMNH). Paratypes are deposited at the NMNH, Illinois Natural History Survey, Southwest Texas State University, University of North Texas and in the collection of the senior author.

Neotrichia juani Harris and Tiemann
NEW SPECIES
Fig. 1

Diagnosis.—In overall appearance of the genitalia, this species is similar to *N. maria.* It differs in the short, wide inferior appendages and presence of a lobate process from the inner posterolateral margin of segment IX.

Description.—Male. Length 1.9–2.4 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view

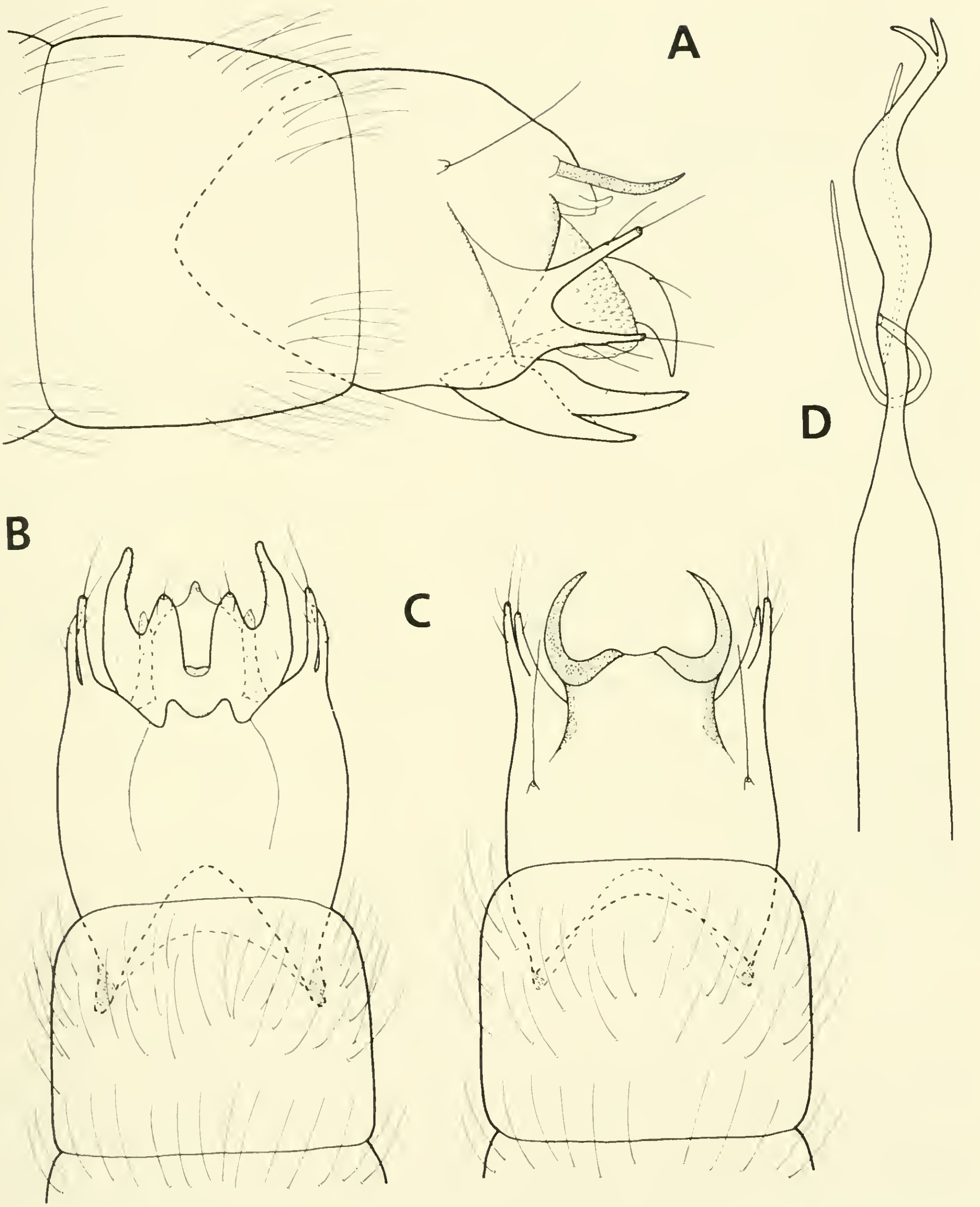


Fig. 1. *Neotrichia juani*, male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, lateral view.

with anterior margin tapered, bracteole from posteroventral margin developed into forked process, each arm thin and elongate, lobate process from inner posterior margin; in ventral view posterolateral processes narrow, anterior margin emarginate; dorsally with pair of small setiferous lobes. Segment X fused with IX, tergum developed as pair of curved horns, which are sclerotized and acute distally. Inferior appendages appearing bifid in lateral view, thin and narrowing distally; in ventral view, fused mesally, bifid laterally, inner process thick, rounded distally and bearing stout seta, outer process narrow, tapering distally. Subgenital plate a thin shelf in lateral view, curving ventrad to acute apex; in ventral view rounded, with short mesal projection. Phallus wide basally, sinuate apically, pair of short processes at apex, lower process bent inward; thin paramere encircling shaft at narrow midlength.

Type material.—Holotype; male. United States, Texas, Comal County, Honey Creek at Honey Creek Nature Preserve, 18 August 1990, S. G. Tiemann. Paratypes; Texas, Hays County, Blanco River at Post Road, 4 May 1991, S. G. Tiemann, 42 ♂, same but 4 June 1990, 2 ♂, same but 19 June 1991 98 ♂, San Marcos River at County Road 299, 8 April 1991, S. G. Tiemann, 1 ♂, same but 20 June 1991, 36 ♂, Johnson County, Ham Creek, FM 916, 4 km W Rio Vista, 13 June 1991, Dan Petr, 2 ♂, same but 2 October 1991, 8 ♂.

Etymology.—Named for John Tiemann.

Discussion.—*Neotrichia juani* occurs at the edge of the Edwards Plateau in central Texas. The species has been collected along permanent and intermittent rivers, as well as small spring-fed streams.

Neotrichia malickyi Harris

New Species

Fig. 2

Diagnosis.—Although similar to *N. tauricornis,* this new species is readily identified by the asymmetrical horns of the tenth tergum and the simple subgenital plate.

Description.—Male. Length 2.5–2.8 mm. Antennae broken, but more than 15 segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior margin rounded, bracteole from posteroventral margin developed into forked process, each arm thin and short; in ventral view posterolateral process short, anterior margin emarginate; dorsally with pair of small setiferous lobes. Segment X fused with IX, tergum developed as pair of asymmetrical, curved horns. Inferior appendages short, upturned distally in lateral view; in ventral view bifid, outer process sclerotized, wide basally, tapering distally to rounded apex, inner process thin and narrowing apically, bearing stout seta at apex. Subgenital plate a narrow shelf in lateral aspect, sclerotized and downturned at apex; in ventral view rounded with mesal projection apically, bearing elongate setae posterolaterally. Phallus wide basally, tubular distally, pair of bent processes at apex, small subapical process; thin paramere encircling shaft at midlength.

Type material.—Holotype; male. Panama, Barro Colorado Island, Lutz, February–March 1986, H. Malicky. Paratypes; same data as holotype, 6 ♂.

Etymology.—Named for Hans Malicky, who collected the type series, in recognition of his many contributions to the study of caddisflies.

Neotrichia tauricornis Malicky

Fig. 3

Neotrichia tauricornis Malicky, 1980: 220.

Diagnosis.—Similar in many respects to *N. malickyi* and *N. corniculans, N. tauricornis* is easily separated by the structure of the subgenital plate.

Redescription.—Male. Length 1.5–1.9 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior margin rounded, bracteole from posteroventral margin developed into forked process, upper arm about half length of elongate lower arm; in ventral view lateral processes elongate, anterior margin emarginate; dorsally with pair of small setiferous lobes. Segment X fused with IX, tergum developed as pair of short, curved, sclerotized horns. Inferior appendages nearly rectangular in lateral view with numerous short spines dorsoapically; in ventral view bifid, outer process sclerotized, nearly uni-

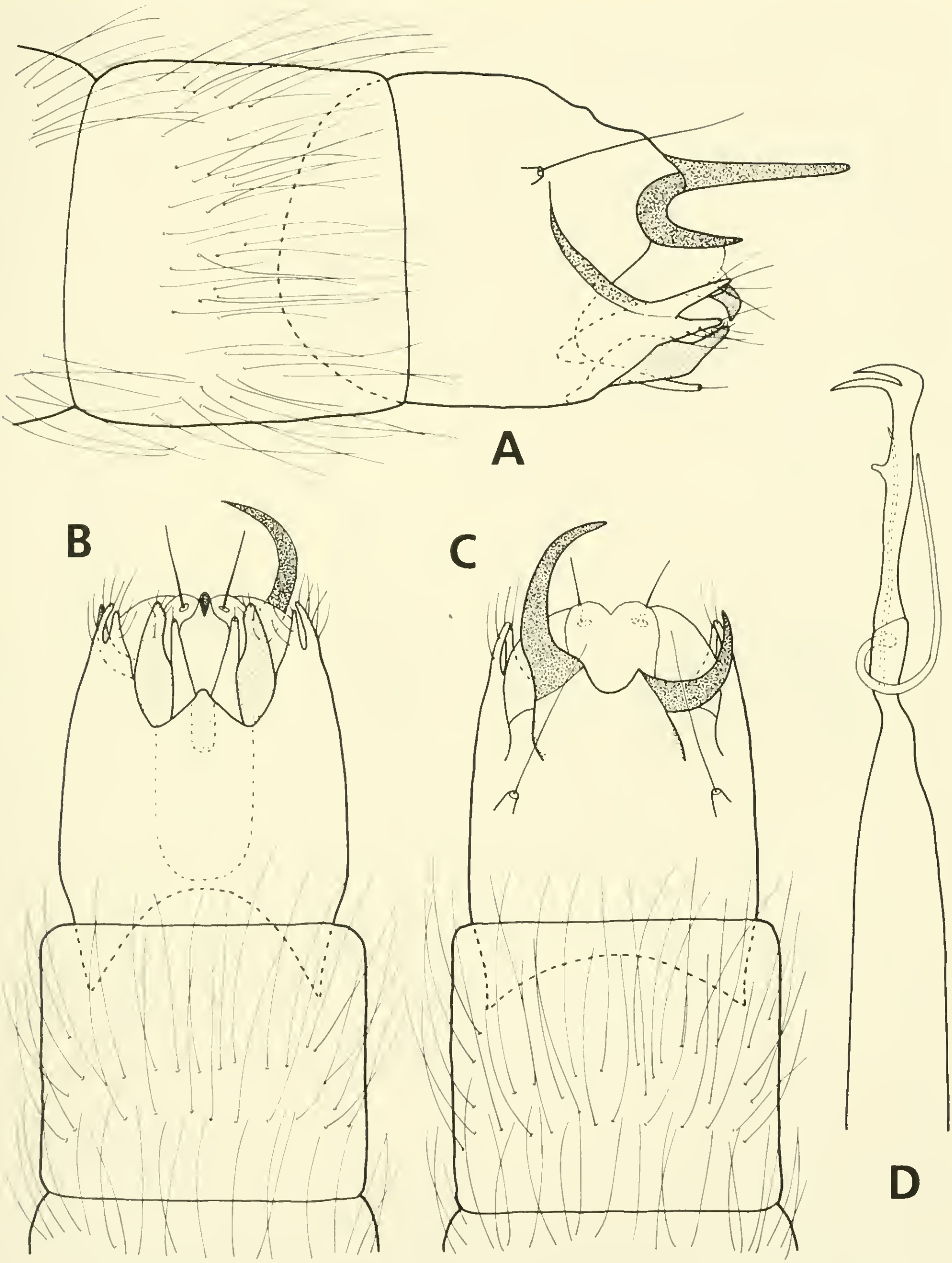


Fig. 2. *Neotrichia malickyi,* male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, lateral view.

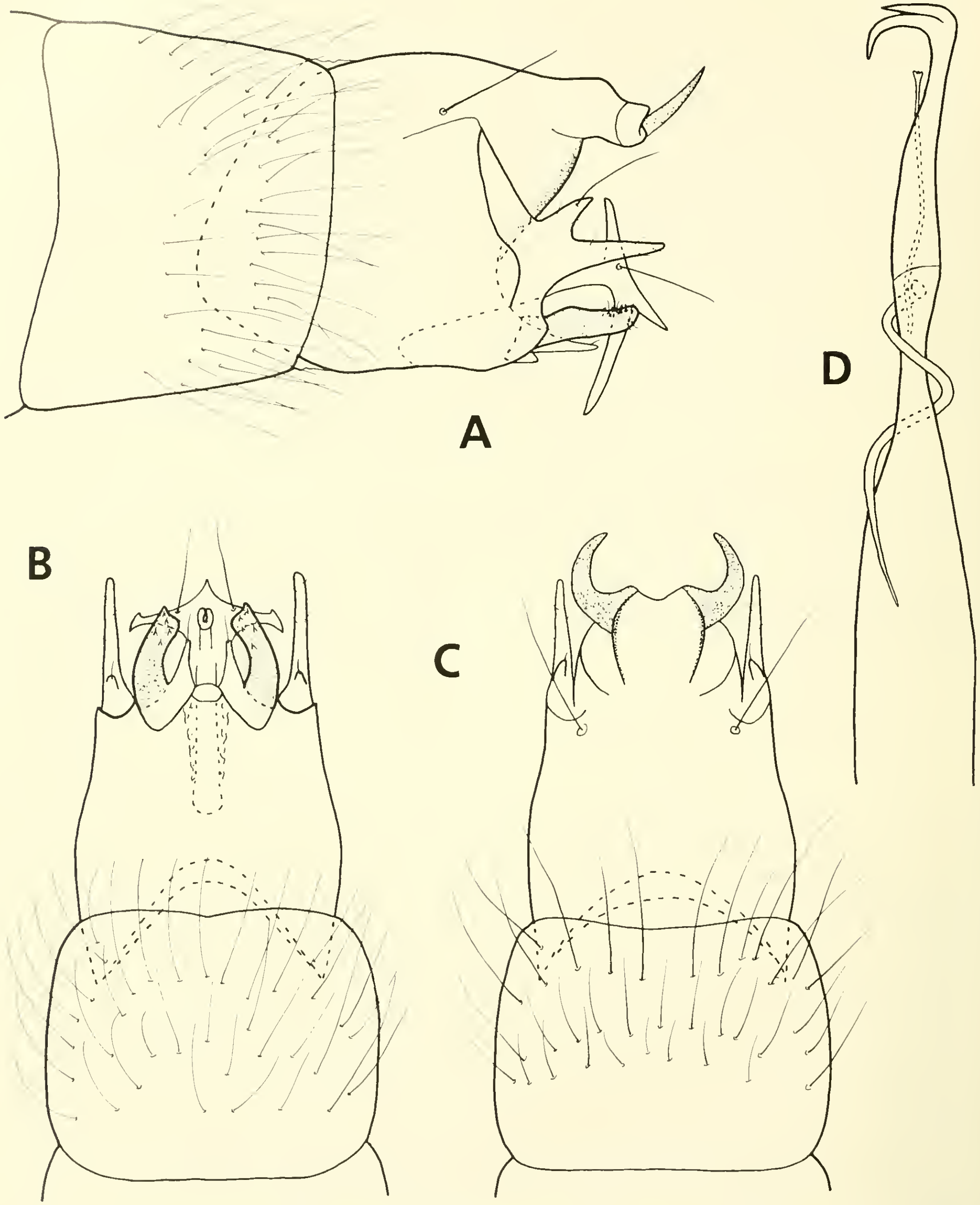


Fig. 3. *Neotrichia tauricornis*, male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, lateral view.

form in width, curving inward, inner process thin and narrowing distally, bearing stout seta at apex. Subgenital plate with 3-pronged apex, lower process elongate and projecting downward, upper process about half length of lower, bearing elongate seta at base, middle process acute apically and projecting ventrad; in ventral view narrow

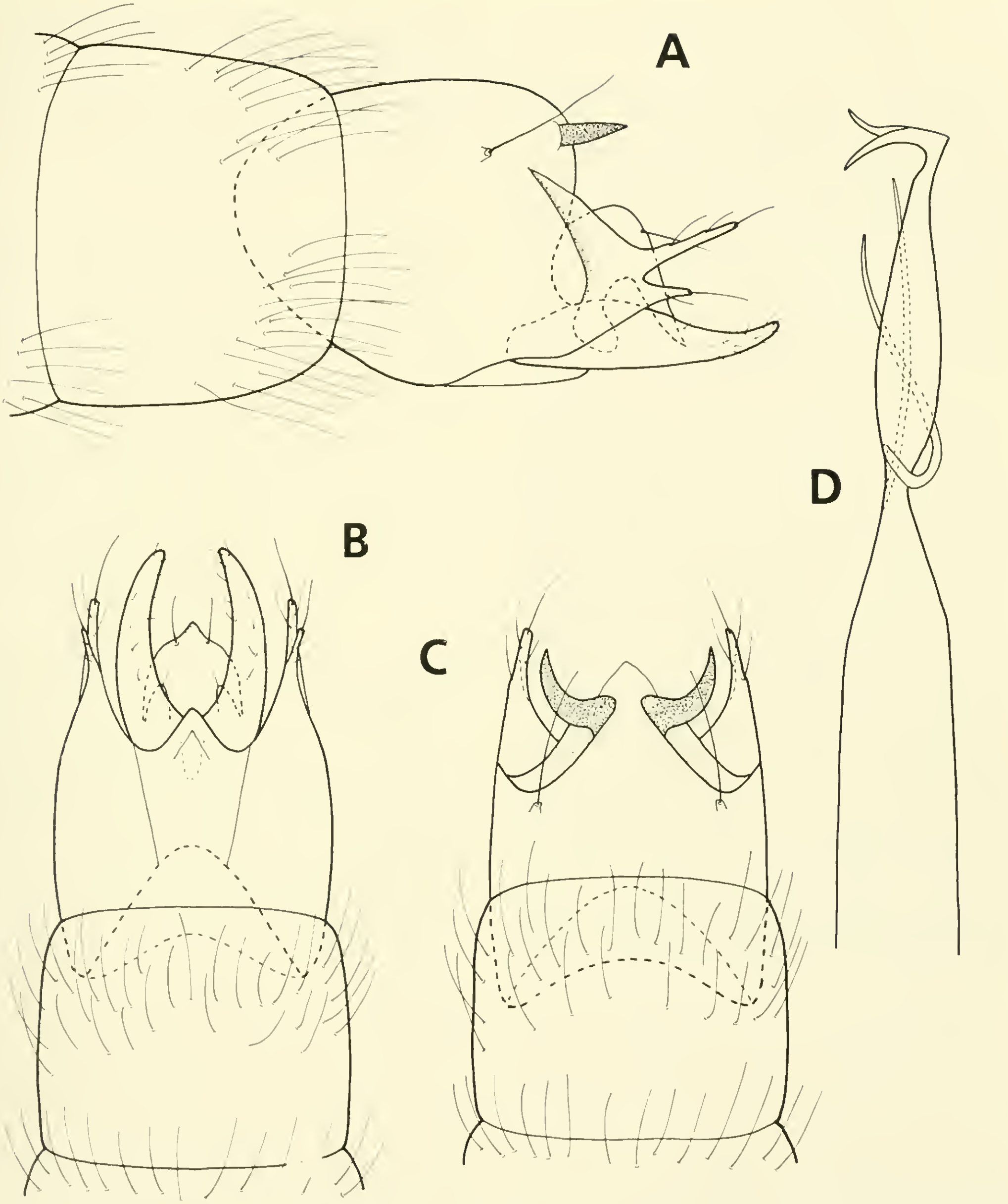


Fig. 4. *Neotrichia corniculans*, male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, lateral view.

basally, elongate lateral arms subapically, each bearing long seta, apex acute. Phallus wide basally, tubular distally, pair of bent processes at apex, lower process curving downward; thin paramere encircling shaft at midlength.

Specimens examined.—Trinidad, Paria River, March 1985, V. Jones, 1 ♂; Panama, Barro Colorado Island, Lutz, February–March 1986, H. Malicky, 1 ♂; Colombia, Dpto. Antioquia, Quebrada la Cebolla, El Retiro (trap A), 3 July 1983, U. Matthias, 1 ♂, Quebrada la Jimenez, Sopetran (trap C), 2 June–1 October 1983, 2 ♂.

Neotrichia corniculans Flint
Fig. 4

Neotrichia corniculans Flint, 1968: 50.

Diagnosis.—In overall genitalic features, *N. corniculans* resembles *N. maria.* The short sclerotized horns of the tenth tergum and structure of the inferior appendages are distinctive in *N. corniculans.*

Redescription.—Male. Length 1.7 mm. Antennae broken, but more than 15 segments. Silvery gray in color. Ninth abdominal segment in lateral view with anterior margin rounded, bracteole from posteroventral margin developed into forked process, lower arm about half length of elongate upper arm; in ventral view lateral processes thin and elongate, anterior margin emarginate; dorsally with pair of small setiferous lobes. Segment X fused with IX, tergum developed as pair of short, sclerotized horns, which project slightly laterad. Inferior appendages in lateral view wide basally, tapering to rounded, slightly upturned apex; in ventral view tapering distally to rounded apices, curving inward, short setiferous lobe at base. Subgenital plate in lateral view wide at base, narrowing distally and curving ventrad; in ventral view rounded, with mesal projection, pair of setae subapically. Phallus wide basally, pair of bent processes at apex, upper process curving upward; thin paramere encircling shaft at narrow midlength.

Specimen examined.—Paratype; Dominica, D'leau Gommier, 15 February 1965, W. W. Wirth, 1 ♂ (USNM).

ACKNOWLEDGMENTS

Dr. Oliver S. Flint, Jr. of the National Museum of Natural History kindly provided a paratype of *N. corniculans* and representatives of *N. tauricornis.* Dr. Hans Malicky of Austria graciously made available collections of *Neotrichia* from Panama for this study. Steve Moulton of the University of North Texas made available the series of *N. juani* from Johnson County, Texas for inclusion in this paper. The Geological Survey of Alabama provided facilities and support to SCH during the paper preparation.

LITERATURE CITED

Flint, O. S., Jr. 1968. Bredin-Archbald-Smithsonian biological survey of Dominica, 9. The Trichoptera (caddisflies) of the Lesser Antilles. Proceedings of the United States National Museum 125: 1–86.

Malicky, H. 1980. Vier neue Kocherfliegen von der Insel Guadeloupe (Kleine Antillen, Mittelamerika) (Trichoptera). Entomofauna, Zeitschrift für Entomologie 1: 219–225.

Marshall, J. E. 1979. A review of the genera of the Hydroptilidae (Trichoptera). Bulletin of the British Museum (Natural History), Entomology Series 39: 135–239.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 293–295

Book Reviews

The Hemiptera. By W. R. Dolling. Oxford University Press, Oxford. 1991. ix + 274 pp. $70.00 (cloth).

One must admire the British: they do not deign to put the name of their country on their postage stamps (having invented them); their natural history museum is *The* Natural History Museum, as if there were no other; a book restricted entirely to the British Hemiptera (2% of the world's fauna) is not only entitled *The Hemiptera,* but is reviewed in the Times Literary Supplement (June 12, 1992), cheek by jowl with books on the death of Kit Marlowe. The insular coziness of the English is reflected also in the author's statement (end of Ch. 5), that "Mr. R. Belshaw is preparing a new handbook on the" Tachinidae. Mr. Belshaw is never mentioned again, but one assumes The Club knows who he is.

Unique in many ways, this blessed plot, this England is not unique in its hemipteran fauna. Therefore a book on its bugs ought not to be of wide appeal. Luckily for hemipterists, the book is by W. R. Dolling (who—unluckily for heteropterists—was recently "superannuated" from The Museum of Natural History). Dolling brings to the book a vast knowledge of the British Hemiptera (Heteroptera, Auchenorrhyncha, and Sternorrhyncha, each a suborder), as well as a thorough knowledge of the world fauna. This knowledge, and his ease with it, allows him to separate the important from the trivial, and to choose the appropriate examples for the points he wishes to make. More, he brings to the book an ability to write: that is, an ability to present complexity clearly, to present details without obscuring broad patterns, and to present those patterns without ignoring supporting details. Still more, he writes an engaging straightforward prose that carries the reader (hemipterist or not) along and keeps him or her interested. This should not be so rare a quality as to require mention in a review; but it is.

After a very brief introduction, Chapters 2–9 consider the biology of Hemiptera. These chapters are quite short, but contain a remarkably large amount of useful information. The brevity is achieved by omitting references, and by the author's fine ability to write.

Chapter 2, "Food," is organized by systematic group; sections are headed "Algae, fungi, and lichens," "Mosses and liverworts," etc., and the British hemipterans feeding thereon are discussed; further sections in this chapter considers such things as the part of the plant fed on, animal food (including vertebrates), and how appropriate food and habitat are found. "Symbiotic Relations" covers "Internal symbionts," "Transmission of [plant] diseases," and "Relationships with ants" (the last exclusively about Sternorrhyncha). "Diseases" and "Natural Enemies" are also organized by systematic group, from microorganisms through vertebrates. "Defence" mentions defenses secreted by hemipterans (e.g., scales), behavioral defenses, and the various uses of color and pattern (including mimicry). "Biorhythms" deals principally with these insects' responses and adaptations to seasonal changes; and, in "Distribution" and "Dispersal," the author considers how the insects move about, and how rich the various parts of Britain are in them. A final section discusses changes in the British fauna from the last glaciation, changes caused by warming, deforestation, and the introduction of non-native plants.

In Chapter 10, the author characterizes briefly those hemipteran families not found in Britain. He makes here (Table 2) an interesting comparison between the British and world faunas. Overall, 2% of the world's species inhabit the British Isles, but the countries (the book includes Ireland) have more than 2% of certain groups: Leptopodomorpha, Psylloidea, and Aphidoidea most notably. It also has less than 2% of other groups: Pentatomomorpha and all the Auchenorrhyncha groups. The former doubtless are insects that radiated (and arose?) in the Old World temperate Regions, and the latter are tropical—although the author does not advance this explanation.

This chapter is complemented by Chapter 12, "Classification," with a complete classification of the world Hemiptera, to family. This classification combines the generally accepted textbook arrangements with a few more recent changes of Štys: Malcidae is recognized, as a family in the Lygaeoidea; and Idiostoloidea and Piesmatoidea are recognized as superfamilies, instead of lygaeoid families. However, Štys' sinking of Coreoidea, Pyrrhocoroidea, and Lygaeoidea into an enlarged Coreoidea, is not adopted here. In the Auchenorrhyncha, Dolling recognizes two infraorders, Fulgoromorpha and Cicadomorpha; and, in Sternorrhyncha, the superfamilies Psylloidea, Aleyrodoidea, Adelgoidea, Aphidoidea (with 11 families) and Coccoidea (with 20 families); and he treats Coleorrhyncha as a fourth suborder. Chapter 13 is a key to British suborders, and Chapters 14, 15, and 16 (each on a different suborder) open with keys to the families found in the British Isles.

The "Morphology" chapter (Chapter 11) perhaps best exemplifies the author's ability to present detail clearly, briefly, and completely. This is the best brief discussion of hemipteran structure I know (and, *mirabile scriptu,* it does not include the ubiquitous drawing by H. H. Knight). Dolling describes the features of the order and its suborders with fine clarity. For example, the paragraph on venation presents the recent work of Betts and Wootton (on venation of Heteroptera) so well that illustrations are not needed, and yet the complexities are not obscured. All hemipterists should read this 17-page chapter.

The family accounts (the bulk of the book, Chapters 14–16) are wonderfully concise and filled with information, including fascinating comments. For example, of the Miridae (whose 10,000 world species makes it the largest heteropteran family), Dolling writes, "much of [their] success . . . may be attributable to the ease with which they can walk on leaves. Contact with varying kinds of leaf surfaces seems to have been a mainspring of adaptive radiation in the family. . . ." (p. 123). Again, commenting (in understatement) on the tendency for fragmentation in work on Sternorrhyncha, he writes that "specialists have often elected to work only on Coccoidea (sometimes with the addition of Aleyrodoidea, though both groups have their exclusive devotees) or Aphidoidea and Adelgoidea" (p. 163); an unfortunate state of affairs (in this reviewer's opinion) that has led to an inflation of taxonomic categories (some consider the Coccinea an order) and a lack of interest in phylogenetic relationships at the highest levels.

The families in this section are arranged phylogenetically: an inconvenience. To find the account of a particular family, the reader must use the index, because the families are not listed in the table of contents, nor are page numbers given in the keys.

These family accounts are mostly concerned with the British fauna, of course. Each opens with the identifying features of the family, and then considers the general ecology and biology of its members. Species of particular importance or interest are treated next, sometimes in some detail, and the account ends with mention of any comprehensive work(s) on the British, European, or Palearctic fauna.

Although brief (the longest account, on Cicadellidae, is 5.5 pages of text), each account leaves the reader with a clear understanding of the family, and of its significance in the British fauna.

Chapter 17 describes methods of collecting and preserving. It is a detailed chapter, with clear excellent instructions from using a net to preparing and preserving genitalia.

Necessary precautions, and advantages and disadvantages of various sorts of preservation, are presented clearly.

This chapter is followed by a Glossary, with definitions of many entomological and hemipterological terms (*emphalium, synthlipsis,* and doubtless a few others, are missing). It is designed to serve the nonprofessional entomologist, which is an important part of this books' audience.

The final chapter, Information Sources (oddly, placed after the Glossary), describes abstracting sources, British entomological journals, and the several newsletters devoted to various hemipteran groups. It is unfortunate the book appeared too late to mention a major contribution of the author himself: Stonedahl and Dolling, "Heteroptera identification: A reference guide, with special emphasis on economic groups" (J. Nat. Hist. 25 [1991]).

The book concludes with about 500 references cited in the text, and with an inadequate index. The index lists only families and higher taxa, their common names, and important words (e.g. "phloem," "diapause") from the chapters on biology. Genera are not included, nor any references to the biology of specific bugs mentioned in the family accounts. Thus, for example, one wishing to know which British hemipterans are brachypterous, must read through all the family accounts.

The book is illustrated by excellent line drawings (by J. H. Martin), and by glorious color (or colour) photographs of the living bugs: these photographs alone would make the book worthwhile, were it not also so fine an account of Britain's Hemiptera. All hemipterists should have this book, despite its overweening title.

Adults of the British Aquatic Hemiptera Heteroptera: A Key with Ecological Notes. By A. A. Savage. Freshwater Biological Association Scientific Publication No. 50, Ambleside, Cumbria, U.K. 173 pp. £10 (paper).

This, like Dolling's, is another book on British bugs; this one on aquatic bugs (Gerromorpha, Nepomorpha). The book comprises two parts, thoroughly and well illustrated keys to the adults of Britain's aquatic bugs, and a section on the group's ecology and biology. The keys are to both sexes; this treatment renders the key to corixids difficult, and the author has published separately an easier key, to males only (Field Studies 7 [1990]); another, to the nymphs, is in preparation. Each structure mentioned in the keys is illustrated and a dorsal view is provided of at least one species from each family. Throughout the keys, difficult couplets are briefly discussed, to guide the user (who is not assumed to be a heteropterist). (One error: the families Dipsocoridae and Leptopodidae are not the same [p. 18].)

The section "Ecology," although only some 50 pages long, is remarkably detailed, with subsections on Life Cycles; Geographical and Ecological Distribution; Eco-Physiology and Behaviour; Feeding and Diet; Predation; Parasitism; Flight Polymorphism, Ovogenesis and Migration; and Community Studies. What makes the author's treatment remarkable is his concise presentation of the research literature on individual species (not all of them British) to derive general statements about the British fauna. Much of the information is presented in graphs and tables, and these allow the reader to see general trends and tendencies. The generalizations are not swamped by the details, and the details are given clearly and with a minimum of technical jargon.

As a result, the nonheteropterist audience for which the book is designed, need not be put off by the details on the ecology of these bugs. Moreover, any heteropterist will find these details—and the generalizations derived therefrom—of great interest, and the keys useful as well.

Carl W. Schaefer, *Department of Ecology and Evolutionary Biology, University of Connecticut, U-43, Storrs, Connecticut 06269-3043.*

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, p. 296

Diversity in the Genus Apis. Edited by Deborah Roan Smith, with 13 contributors, 265 pp. Westview Press, Boulder, CO. 1991. $63.50 (cloth).

A friend to farmers since Roman times for its recognized value as a pollinator, the honey bee has been a prehistorical provider of sweets and fermentable sugars to societies throughout the Old World, a companion of colonists, a darling of behaviorists, physiologists, and sociobiologists, a symbol of selfless industry, and a reliable source of tales of stinging and bravery among school-age children everywhere. More journal pages and books have been devoted to research involving the honey bee than for perhaps any other insect. What distinguishes this slim volume from most of the others on its burgeoning library shelf is its comparative perspective, for the "honey bee" of the Americas, Africa, Europe and Australia is but one species, *Apis mellifera,* of a small genus of closely-related bees native to tropical Asia.

Over half of the book is devoted to three taxonomic quests. One is a search for relationships among the four tribes of bees that have traditionally comprised the Apidae, being the honey bees, bumble bees, stingless bees and orchid bees. A cladogram sporting four well-defined ingroups and one outgroup hardly seems challenging, a heuristic sort of textbook pencil-and-paper problem, were it not for the paucity of fossil or extant intermediates to link together what are clearly four highly derived, distinctive lineages. Both molecular and morphological methods are used in the search for shared characters, followed by rigorous cladistic analyses. The elusive Beast, the consensus cladogram, supported ideally by many shared derived characters and few character reversals, remains at large when the dust has settled. There is still the tantalizing possibility that highly eusocial behavior arose twice among the bees. The remaining two quests seek order for the 4–8 (or more) species of *Apis* and the innumerable races of *A. mellifera.* The authors have brought morphological, behavioral and molecular data to bear upon questions of taxonomic relationships, biogeography, and evolutionary derivation of characters, such as the abstract dance language employed by returning scouts to direct nestmates to distant resources. Readers seeking definitive or startling conclusions here may be disappointed, but I found the clarity and patient development of background, methodology and interpretation by these authors to be thoroughly educational. In fact, several of the chapters would make fine case studies for a course in modern systematics.

The remaining chapters review and contribute to comparisons of the natural histories of the *Apis* species, their systems of dance communication and mating, and their strategies for defense, energetics and foraging ecology. Caste in this light, the study of *Apis* biology is not an exercise in the tying of loose ends in a field where all the good problems have been resolved, but an adventure wherein major insights and, yes, even new species await. If this book has one oversight, it is the lack of a detailed map of Southeast Asia by which to chart the realms of *Apis* diversity, from the Andaman Islands in the Bay of Bengal to Timor in the Indonesian Archipelago.

James H. Cane, *Department of Entomology, Auburn University, Alabama 36849*

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, p. 297

NOTE

Replacement name for *Sumitrosis championi* (Weise) (Coleoptera: Chrysomelidae, Hispinae)

My reassignment of *Anisostena championi* (Baly, 1885) to *Sumitrosis* (Proceedings of the Entomological Society of Washington 93: 867–878, 1991) created homonymy with *S. championi* (Weise, 1911). According to the International Code of Zoological Nomenclature (1985 ed.) the older name is valid and the more recent name is a junior secondary homonym (Art. 57). *Sumitrosis championi* (Weise) has *S. flavipes* (Champion, 1894) as a synonym but this name is not available because of homonymy with *S. flavipes* (Germar, 1824), a synonym of *S. inaequalis* (Weber, 1801). I hearby propose *Sumitrosis weisei* NOMEN NOVUM to replace *S. championi* (Weise).

C. L. Staines, *3302 Decker Place, Edgewater, Maryland 21037.*

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 298–299

NOTE

Correct application of the nominal genus *Brachista* Walker (Hymenoptera: Trichogrammatidae)

Studies in progress on the North American Trichogrammatidae require clarification of the definition of the genus *Brachista* Walker. This nominal genus has had a tortuous history since its debut in 1851. Presumably intended for one or more European forms, nomenclatural convention mandates that its application be restricted to a New World species currently placed in *Giraultiola* Nowicki.

Brachista was described for one or more unnamed species of Trichogrammatidae by Walker (1851. The Annals and Magazine of Natural History 7: 210–216). Foerster (1856. Hymenopterologische Studien II: 88), erroneously considering the name a junior homonym of *Brachistes* Wesmael, proposed *Brachysticha* as a replacement name. Foerster also failed to tie the new name to nominal species. The first such association was by Ashmead (1894. Journal of the Cincinnati Society of Natural History 17: 170–172) in describing the North American species, *Brachysticha fidiae.* The first association of a European species with the genus (misspelled as *Brachystira*) occurred a decade later upon Mayr's (1904. Verhandlungen der k. k. zoologisch-botanischen Gesellschaft in Wien 54: 559–598) description of *B. pungens.* Mayr's concept of the genus was maintained by Kryger (1918. Entomoligiske Meddelelser 12: 257–354), who also corrected Foerster's unjustified emendation and resurrected the name *Brachista.* Although *Brachysticha fidiae* Ashmead had been acknowledged as the correct type species of *Brachista* (Gahan and Fagan 1923. United States Natural Museum Bulletin 124: 23), its relationship to European representatives was not addressed until 1936 by Nowicki.

Nowicki (1936. Zeitschrift für angewandte Entomologie 23: 114–148) recognized that *fidiae* Ashmead and *pungens* Mayr were not congeneric. Unfortunately he retained Mayr's concept of *Brachista* as based on *pungens,* and transferred Ashmead's species to a new genus, *Giraultiola.* Modern workers have followed Nowicki by recognizing *Giraultiola* as a valid North American genus, and restricting *Brachista* to *pungens* and other related Old World species (e.g., Doutt and Viggiani 1968. Proceedings of the California Academy of Sciences, 4th series 35: 477–586; Yousuf and Shafee 1986. Indian Journal of Systematic Entomology 3: 29–82).

Article 67 of The International Code of Zoological Nomenclature (1985) states that a nominal species cannot be fixed as the type of a nominal genus if it was not included when the nominal genus was established or when nominal species were first subsequently assigned to the nominal genus. Article 69 allows only nominal species that were first subsequently and expressly included in the nominal genus to be considered as type species. This precludes assigning *pungens* or any other European species as the type of *Brachista* because, (1) Walker's description of the genus omitted any reference to species, and (2) the first subsequent reference of a nominal species to *Brachista* (as *Brachysticha*) was Ashmead's description of the North American *fidiae.* Thus, *Brachysticha fidiae* Ashmead is the type species of *Brachista* Walker by subsequent monotypy, and *Giraultiola* Nowicki is an objective junior synonym.

This raises the question of the correct genus name for the European species erroneously assigned to *Brachista.* The next available name would appear to be *Chaetostrichella* Girault (1914. Mitteilungen aus dem Zoologischen Museum in Berlin 7: 147–149). *Chaetostrichella* has been treated as a junior synonym of *Brachista* (*sensu* Nowicki) and its type species, *C. platoni* Girault, is a junior synonym of *pungens* Mayr (Nowicki 1936, Doutt and Viggiani 1968).

Synonymies reflecting this nomenclatural correction are as follows:

Brachista Walker

Brachista Walker 1851: 211.

Brachysticha Foerster 1856: 88 (unjustified emendation, objective junior synonym of *Brachista*). Ashmead, 1894: 171 (establishment of *Brachysticha fidiae* Ashmead as type species by subsequent monotypy).

Giraultiola Nowicki 1936: 136 (*Brachysticha fidiae,* type species by monotypy). Doutt and Viggiani 1968: 552. **NEW SYNONYMY**.

Giraultia: Steffan 1954: 669 (subsequent misspelling of *Giraultiola*).

Included species: *Brachista fidiae* (Ashmead) (= *Lathromeris cicadae* Howard), **NEW COMBINATION**; two undescribed species (Pinto, in prep.).

Chaetostrichella **Girault, RENEWED STATUS**

Brachystira: Mayr 1904: 590 (subsequent misspelling of *Brachysticha* Foerster).

Chaetostrichella Girault 1914: 147 (Type species, *Chaetostrichella platoni* Girault by monotypy).

Brachista: Nowicki 1936: 136. Doutt and Viggiani 1968: 497.

Included species: *Chaetostrichella pungens* (Mayr) [(= *C. platoni* Girault, *C. nigra* (Kryger)], *C. rufina* (Nowicki), *C. similis* (Kryger). **NEW COMBINATIONS**.

Acknowledgments.—I thank John LaSalle (International Institute of Entomology) and Gennaro Viggiani (Università degli Studi di Napoli) for their input. Publication of this note was supported by National Science Foundation Grant L200008 (J. B. Woolley, Texas A&M University, Principal Investigator).

John D. Pinto, *Department of Entomology, University of California, Riverside, California 92521.*

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 300–304

OBITUARY

Barnard DeWitt Burks
1909–1990
President, Entomological Society of Washington, 1974

Dr. Barnard D. "Barney" Burks, retired taxonomist with the USDA's Systematic Entomology Laboratory, died December 15, 1990 in Sun City, Arizona. He was born November 12, 1909 in East Las Vegas, New Mexico. His family later moved to Illinois, and in 1929 he entered the University of Illinois at Urbana where he received his B.A. degree in 1933, M.A. degree in 1934 and Ph.D. degree in 1937. Barney was appointed as a taxonomist for the Illinois Natural History Survey in 1937 and was given the task of preparing a monograph of Illinois mayflies. In 1942, he was commissioned as a first lieutenant in the Army Sanitary Corps and was stationed in Algeria. His knowledge of electricity caused him to be transferred to the Army Signal Corps from which he was discharged as a major in 1946. He returned to the Illinois Natural History Survey until July 1949 when he was hired by the Insect Identification Division, USDA (present Systematic Entomology Laboratory) and assigned research on the parasitic wasp superfamily Chalcidoidea. He served in this capacity until his retirement on June 28, 1974. This early retirement was for medical reasons resulting from a concussion received from a fall at his home. He remained in Washington for a few years working on several unfinished research projects and moved to Arizona with his wife, Kellie O'Neill Burks, in May 1977.

During this virtually uninterrupted 40-year career as a research taxonomist, Barney attained prominence as one of the world's authorities on the systematics of parasitic wasps belonging to the superfamily Chalcidoidea. His earlier taxonomic work on the mayflies of Illinois continues to be the standard reference on those insects. The results of these studies were presented in 81 publications (see attached list). He was also involved in other activities in support of entomology such as consultant on numerous occasions and sponsoring scientist on eight government supported projects in India, Pakistan, Israel and Taiwan. He served as the Hymenoptera Unit Leader of the Systematic Entomology Laboratory, was Editor and President of the Entomological Society of Washington, and in 1945 was elected a Fellow of the Entomological Society of America.

Barney was a very personable individual and was particularly helpful to new hymenopterists that were hired by the laboratory. He enjoyed mountain hiking and often took newly hired staff for a day's hike to Old Rag mountain in Virginia. He was an enthusiastic hobbyist having interests in electronics

Barney in his office at the National Museum in Washington, 1949.

Barney at his home in Sedona, Arizona working on herbarium specimens, 1978.

and gardening, and was a lover and authority on classical music of all periods. In fact, music was his chief pleasure throughout his life. As a high school student in Illinois Barney studied voice and began his extensive classical record collection. His beautiful tenor voice earned him a few extra dollars as soloist with various church choirs while a graduate student in Urbana. Unfortunately, wartime injuries put an end to his singing voice. His gardening expertise was always evident where he lived in the Washington, DC suburb of Silver Spring, Maryland. His first home boasted very fine examples of *Franklinia* and *Cunninghamia*; at his second home he grew *Oxydendron, Pieris, Buddleia* and many kinds of gesneriads under lights. After moving to Sedona, Arizona, he continued his interests in music, hiking and gardening. He hiked with Sedona Westerners as long as he was able, always at the leader's heels. Barney and Kellie set up a herbarium of native plants for the Forest Service office in Sedona; he succeeded in growing Colorado blue spruce in the unsuitable climate of central Arizona, and he grew the only edible-fig tree then in Sedona. He frequently shared his knowledge of biological pest control with local garden clubs. Always interested in nature, he took up astronomy in his last few years, encouraged by the clear night skies of Sedona.

Barney died after a brief illness and his ashes were inurned with those of his fellow soldiers in Arlington National Cemetery.

Paul M. Marsh, *Systematic Entomology Laboratory, USDA, % National Museum of Natural History, NHB-168, Washington, D.C. 20560.*

Bibliography

Barnard D. Burks

1. Burks, B. D. and V. G. Milum. 1934. Diseases of adult bees. Ann. Rpt. Ill. State Beekeepers Assn. Vols. 34–35, pp. 70–79.
2. Burks, B. D. 1934. Food plant studies of the chinch bug. J. Econ. Entomol. 28: 1100–1101.
3. Burks, B. D. 1936. The Nearctic Dirhinini (Hymenoptera, Chalcididae). Proc. Natl. Acad. Sci. 22: 283–287.
4. Burks, B. D. 1936. The Illinois species of *Brachymeria* (Hymenoptera, Chalcididae). Trans. Ill. Acad. Sci. 29: 251–254.
5. Burks, B. D., T. H. Frison, and H. H. Ross. 1938. An economical, portable light for collecting insects. J. Econ. Entomol. 31: 316–318.

6. Burks, B. D. 1938. A study of chalcidoid wings (Hymenoptera). Ann. Etomol. Soc. Amer. 31: 157–161.
7. Burks, B. D. 1939. A new genus of Chalcidini from Central America (Hymenoptera, Chalcidoidea). Arb. Morph. Tax. Entomol. 6: 184–187.
8. Burks, B. D. 1939. Two new species of *Platychalcis* from Costa Rica (Hymenoptera, Chalcidoidea). Arb. Morph. Tax. Entomol. 6: 275–278.
9. Burks, B. D. 1939. A new species of *Chalcis* from the Dominican Republic. Amer. Mus. Nov., no. 1039, 2 pp.
10. Burks, B. D. 1940. Revision of the chalcid-flies of the tribe Chalcidini in America north of Mexico. Proc. U.S. Natl. Mus. 88: 237–354.
11. Burks, B. D. 1940. The host of another Illinois species of *Brachymeria* (Hymenoptera). Trans. Ill. Acad. Sci. 33: 208.
12. Burks, B. D. 1943. The North American parasitic wasps of the genus *Tetrastichus*—A contribution to biological control of insect pests. Proc. U.S. Natl. Mus. 93: 505–608.
13. Burks, B. D. 1946. New Heptagenine mayflies. Ann. Entomol. Soc. Amer. 39: 607–615.
14. Burks, B. D. 1947. Nearctic species of the genus *Dirhinus* (Hymenoptera, Chalcididae). Proc. Entomol. Soc. Wash. 49: 136–140.
15. Ross, H. H. and B. D. Burks. 1947. On the status of the name *Clavellarius* Olivier, 1789. Bul. Zool. Nomencl. Feb. 1947, pp. 201–202.
16. Burks, B. D. 1947. New reared species of *Tetrastichus* (Hymenoptera, Chalcidoidea). Entomol. News 58: 85–89.
17. Burks, B. D. 1947. New species of *Ephemerella* from Illinois (Ephemeroptera). Can. Entomol. 79: 232–236.
18. Burks, B. D. 1951. Bembecini (pp. 995–1000), Philanthini (pp. 1000–1004), Oxybelini (pp. 1029–1034), Bombini (pp. 1247–1255). *In* Muesebeck et al., Hymenoptera of America North of Mexico, Synoptic Catalog. U.S. Dept. Agr., Agr. Monogr. 2. 1420 pp.
19. Burks, B. D. 1952. A review of the Nearctic genera of the tribe Mesoleiini with descriptions of two new genera and a revision of the Nearctic species of *Perilissus* and *Labrossyta* (Hymenoptera, Ichneumonidae). Ann. Entomol. Soc. Amer. 45: 80–103.
20. Burks, B. D. 1952. A new mealybug parasite (Hymenoptera, Encyrtidae). J. New York Entomol. Soc. 60: 179–182.
21. Burks, B. D. 1952. The North American species of *Syntomosphyrum* (Hymenoptera, Chalcidoidea). Proc. Entomol. Soc. Wash. 54: 258–264.
22. Burks, B. D. 1952. Insects, Enemies of Insects. Yearbook of Agriculture for 1952, pp. 373–380.
23. Burks, B. D. 1953. The genus *Metacolus* in North America (Hymenoptera, Chalcidoidea). Proc. Entomol. Soc. Wash. 55: 44.
24. Burks, B. D. 1953. The mayflies or Ephemeroptera of Illinois. Bul. Ill. Nat. Hist. Sur. Vol. 16, Art. 1, 216 pp.
25. Burks, B. D. 1954. Parasitic wasps of the *Catolaccus* group in the Americas. U.S. Dept. Agr. Tech. Bull. 1093, 23 pp.
26. Burks, B. D. 1955. A redefinition of the genus *Zatropis*, with descriptions of three new species (Hymenoptera, Pteromalidae). Proc. Entomol. Soc. Wash. 57: 31–37.
27. Burks, B. D. 1955. A new species of the genus *Halticoptera* (Hymenoptera, Pteromalidae). Proc. Entomol. Soc. Wash. 57: 81–82.
28. Burks, B. D. 1956. The species of *Chryseida* (Hymenoptera, Eurytomidae). Bull. Brooklyn Entomol. Soc. 51: 109–116.
29. Burks, B. D. 1957. A new *Profenusa* from the California plane tree. Entomol. News 68: 207–210.
30. Burks, B. D. 1958. A new *Bruchophagus* from a liliaceous plant, with a host-plant list for the genus (Hymenoptera-Eurytomidae). Proc. Entomol. Soc. Wash. 59: 273–277.
31. Burks, B. D. 1958. A new parasite of the Rhodesgrass scale (Hymenoptera, Encyrtidae). Bull. Brooklyn Entomol. Soc. 52: 124–127.
32. Burks, B. D. 1958. A North American *Colotrechnus* (Zanonia) (Hymenoptera, Pteromalidae). Fla. Entomol. 41: 13–16.
33. Burks, B. D. 1958. A recharacterization of the genus *Coelopencyrtus*, with descriptions of two new species (Hymenoptera, Encyrtidae). J. Wash. Acad. Sci. 48: 22–26.
34. Burks, B. D. 1958. Three species of *Eurytoma* important in biological control of weeds (Hymenoptera, Eurytomidae). Entomol. News 69: 177–185.
35. Neilson, E. L. and B. D. Burks. 1958. Insect infestation as a factor influencing seed set in smooth bromegrass. Agron. J. 50: 403–405.
36. Burks, B. D. 1958. Symphyta (pp. 8–18), Chalcidoidea (pp. 62–84). *In* Krombein et al., Hymenoptera of America North of Mexico, Synoptic Catalog. U.S. Dept. Agr., Agr. Monogr. 2, Suppl. 1. 305 pp.
37. Burks, B. D., R. E. Warner, and W. S. Fisher. 1958. Lee L. Buchanan, 1893—1948, obituary and list of publications. Proc. Entomol. Soc. Wash. 60: 292–296.
38. Burks, B. D. 1959. The North American species of *Trigonura* (Hymenoptera, Chalcididae). Ann. Entomol. Soc. Amer. 52: 75–81.
39. Burks, B. D. 1959. The species of the genus *Herbertia* (Hymenoptera, Pteromalidae). Proc. Entomol. Soc. Wash. 61: 249–255.
40. Burks, B. D. 1960. The establishment of *Brachy-*

meria intermedia (Nees) in North America (Hymenoptera, Chalcididae). Entomol. News 71: 62.

41. Burks, B. D. 1960. A *Spilochalcis* parasitic on flies that infest bird nests (Hymenoptera, Chalcididae). Acta Hymenopt. 1: 95–97.
42. Burks, B. D. 1960. A revision of the genus *Brachymeria* Westwood in America north of Mexico (Hymenoptera, Chalcididae). Trans. Amer. Entomol. Soc. 86: 225–273.
43. Burks, B. D. 1961. A new Brazilian *Leucospis* parasitic on *Xylocopa,* with a brief review of the South American species of *Leucospis* (Hymenoptera, Leucospidae). Studia Entomol. 4: 537–541.
44. Burks, B. D. 1961. The species of *Pseudometagea* Ashmead (Hymenoptera, Eucharitidae). Entomol. News 72: 253–257.
45. Burks, B. D. 1962. *Tetrastichus* Walker, 1842 (Insecta, Hymenoptera, Chalcidoidea), proposed suppression under the Plenary Powers. Bul. Zool. Nomencl. 19: 306–307.
46. Burks, B. D. 1962. A new *Elachertus* parasitic on a pest of bananas (Hymenoptera, Eulophidae). Entomol. News 73: 233–235.
47. Burks, B. D. 1963. Ten new reared species of *Tetrastichus* (Hymenoptera, Eulophidae). Proc. Biol. Soc. Wash. 76: 47–58.
48. Burks, B. D. 1964. A North American *Phlebopenes* (Hymenoptera, Eupelmidae). Entomol. News 75: 1–5.
49. Burks, B. D. 1964. The Provancher types of Chalcidoidea (Hymenoptera). Can. Entomol. 95: 1254–1263.
50. Burks, B. D. 1964. Some North American parasites of *Aclerda* (Hymenoptera, Encyrtidae). Entomophaga 9: 17–20.
51. Burks, B. D. 1965. L. H. Weld, 1875–1964, obituary and partial publication list. Ann. Entomol. Soc. Amer. 58: 133–134.
52. Burks, B. D. 1965. "*Prosoma* sp." supposed host of *Torymus pilularidis* (Huber) (Hymenoptera, Torymidae). Entomol. News 76: 74–76.
53. Burks, B. D. 1965. The North American species of *Metacolus* (Hymenoptera, Pteromalidae). Proc. Entomol. Soc. Wash. 67: 116–119.
54. Burks, B. D., C. F. W. Muesebeck, and L. Russell. 1965. L. H. Weld, 1875–1964, obituary and list of publications. Proc. Entomol. Soc. Wash. 67: 121–125.
55. Burks, B. D. 1965. The North American species of *Elasmus* (Hymenoptera, Eulophidae). Proc. Biol. Soc. Wash. 78: 201–207.
56. Burks, B. D. 1966. The North American species of *Pediobius* Walker (Hymenoptera, Eulophidae). Proc. Entomol. Soc. Wash. 68: 33–34.
57. Burks, B. D. 1966. The immature stages of *Axima zabriskiei* Howard (Hymenoptera, Eurytomidae). Entomol. News 77: 199–202.
58. Burks, B. D. 1967. A new polyembrionic parasite of the pepper moth (Hymenoptera, Encyrtidae). Proc. Entomol. Soc. Wash. 69: 53–55.
59. Burks, B. D. 1967. Symphyta (pp. 6–17), Chalcidoidea (pp. 213–282). *In* Krombein et al., Hymenoptera of America North of Mexico, Synoptic Catalog. U.S. Dept. Agr., Agr. Monogr. 2, Suppl. 2. 584 pp.
60. Burks, B. D. 1967. The North American species of *Aprostocetus* Westwood (Hymenoptera, Eulophidae). Ann. Entomol. Soc. Amer. 60: 756–760.
61. Burks, B. D. 1967. The North American species of *Anastatus* Motschulsky (Hymenoptera, Eupelmidae). Trans. Amer. Entomol. Soc. 93: 423–431.
62. Burks, B. D. 1968. *Psephenus* (Coleoptera, Psephenidae) parasitized by a new chalcidoid (Hymenoptera, Eulophidae). I. Description of the parasite. Ann. Entomol. Soc. Amer. 61: 450–452.
63. Burks, B. D. 1968. New North American species of *Ceratosmicra* Ashmead (Hymenoptera, Chalcididae). Proc. Entomol. Soc. Wash. 70: 170–174.
64. Burks, B. D. 1968. A new chalcidoid parasite of a ceratopoginid midge (Hymenoptera, Encyrtidae). Entomol. News 79: 236–240.
65. Burks, B. D. 1969. New Perilampidae (Hymenoptera, Chalcidoidea). Proc. Entomol. Soc. Wash. 71: 73–81.
66. Burks, B. D. 1969. Species of *Spalangia* Latreille in the United States National Museum collection (Hymenoptera, Pteromalidae). Smithsn. Contr. Zool., no. 2, 7 pp.
67. Burks, B. D. 1969. Redefinitions of two genera of chalcidoids from figs, with new Florida species (Hymenoptera). Fla. Entomol. 52: 115–122.
68. Burks, B. D. 1969. The North American species of *Arthrolytus* Thomson (Hymenoptera, Pteromalidae). Proc. Entomol. Soc. Wash. 71: 298–303.
69. Burks, B. D. 1971. The Nearctic species of *Horismenus* Walker (Hymenoptera, Eulophidae). Proc. Entomol. Soc. Wash. 73: 68–83.
70. Burks, B. D., C. F. W. Muesebeck, and R. D. Gordon. 1971. Edward Albert Chapin, 1894–1969, obituary and list of publications. Proc. Entomol. Soc. Wash. 73: 99–104.
71. Burks, B. D. 1971. A synopsis of the genera of the family Eurytomidae (Hymenoptera, Chalcidoidea). Trans. Amer. Entomol. Soc. 97: 1–89.
72. Burks, B. D. 1971. A new *Pediobius* parasitic on a thrips (Hymenoptera, Eulophidae). Proc. Entomol. Soc. Wash. 73: 177–180.
73. Burks, B. D. 1971. A new *Tritneptis,* with a revised key to the Nearctic species of the genus (Hymenoptera, Pteromalidae). Proc. Biol. Soc. Wash. 84: 1–6.
74. Burks, B. D. 1971. A North American *Elasmus*

parasitic on *Polistes* (Hymenoptera, Eulophidae). J. Wash. Acad. Sci. 61: 194–196.

75. Burks, B. D. 1971. The name *Tetrastichus incertus* (Ratzeburg) as employed for an introduced parasite of the alfalfa weevil, *Hypera postica* (Gyllenhal) (Hymenoptera, Eulophidae). Proc. Entomol. Soc. Wash. 73: 429–431.
76. Burks, B. D. 1972. The genus *Hexacladia* Ashmead (Hymenoptera, Encyrtidae). Proc. Entomol. Soc. Wash. 74: 363–371.
77. Burks, B. D. 1973. Summary of Symposium on Phylogeny and the Higher Classification of the Ephemeroptera. Proc. 1st Internatl. Conf. Ephemeroptera, pp. 179–181.
78. Burks, B. D. 1973. North American species of *Calosota* Curtis (Hymenoptera, Eupelmidae). J. Wash. Acad. Sci. 63: 26–31.
79. Burks, B. D. 1975. The species of Chalcidoidea described from North America north of Mexico by Francis Walker (Hymenoptera). Bull. Brit. Mus. (Nat. Hist.), Entomol. 34: 137–170.
80. Burks, B. D. 1977. The Mexican species of *Chalcis* Fabricius (Hymenoptera, Chalcididae). Proc. Entomol. Soc. Wash. 79: 383–399.
81. Burks, B. D. 1979. Agaoninae (pp. 748–749), Pteromalidae, Eurytomidae, Chalcididae, Leucospidae, Eucharitidae, Eupelmidae (pp. 768–889), Eulophidae, Mymaridae, Trichogrammatidae, Cynipoidea (pp. 967–1107). *In* Krombein et al., Catalog of Hymenoptera in American North of Mexico, vol. 1. Smithsonian Press, Washington, DC.

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 305–306

REPORTS OF OFFICERS

SUMMARY FINANCIAL STATEMENT FOR 1992

	General Fund	Special Publications Fund	Total Assets
Assets: November 1, 1991	$10,613.96	$104,677.95	$115,291.91
Total Receipts for 1992	77,361.93	6,448.75	83,810.68
Total Disbursements for 1992	75,734.45−	0.00	75,734.45−
Assets: October 31, 1992	12,241.44	111,126.70	123,368.14
Net Changes in Funds	$ 1,627.48	$ 6,448.75	$ 8,076.23

Audited by the Auditing Committee, November 24, 1992, consisting of James Pakaluk, Gregory W. Courtney, and F. Christian Thompson, Chairman. Presented to the membership at the meeting of December 3, 1992.

Respectfully submitted,
Norman E. Woodley, *Treasurer*

CORRESPONDING SECRETARY'S ANNUAL REPORT

Eighteen letters were sent to new members. Nine letters were written thanking our guest speakers. Nine letters were written thanking contributors to the special fund.

Holly B. Williams,
Corresponding Secretary

LIST OF NEW MEMBERS FOR 1992

Kenneth R. Ahlstrom
Robert Patrick Apsey
Richard H. Baker
David Baumgardner
Vicente E. Carapia Ruiz
Tami Carlow
R. Edward DeWalt
Thomas T. Dobbs
Luis M. Gomez-Arias
David Grimaldi
David H. Headrick
Vicente Hernandez
Boris C. Kondratieff
Carol C. Loeffler
Luciane Marinoni
Yue Ming
Goran Nordlander
Gordon F. Pratt
Cibele Stramare Ribeiro-Costa
R. E. Roughley
William D. Shepard
Paul E. Skelly
James A. Slater, II
Bob Zuparko

Total: 24
(includes one member not reported in 1991)

Jeffrey Stibick reinstated as a member in good standing in May 1992; Life membership awarded in June 1992. Notices were received from the families of two members, Ted Tibbetts and William B. Hull, that they had passed away. Announcements were made at the following regular meeting.

Ralph P. Eckerlin,
Membership Chairman

EDITOR'S REPORT

A total of 55 articles, seven notes, seven book reviews, and two obituaries were published in 1992 for a total of 615 pages. The Society defrayed the cost for about three articles per issue.

I thank outgoing editor Robert D. Gordon who served as editor from January 1990 through April 1992. His advice and experience were instrumental in insuring a smooth transition of the editorship.

Gary L. Miller became book review editor in June and A. G. Wheeler, Jr. accepted the newly created position of special publications editor in November. Their help will ease my workload and greatly increase our efficiency in producing future society publications.

I appreciate the efforts of all the people who served as reviewers for the nearly 80 manuscripts received in 1992. Their help is essential in maintaining the high quality of papers published in the Proceedings. Finally, I thank Marie Westfall for her efficient and high-quality assistance in routing manuscripts. Without her help my job would be much more difficult.

Thomas J. Henry, *Editor*

PROC. ENTOMOL. SOC. WASH.
95(2), 1993, pp. 307–311

SOCIETY MEETINGS

978th Regular Meeting–October 1, 1992

The 978th Regular Meeting of the Entomological Society of Washington was called to order by President Wayne N. Mathis at The Naturalist Center in the National Museum of Natural History, Washington, D.C., at 8:00 pm on October 1, 1992. Eleven members and five visitors were present. Minutes of the May meeting were read by President-Elect Russell D. Stewart and approved as read.

Membership Chairman, Ralph P. Eckerlin, read the names of the following applicants for membership: Kenneth R. Ahlstrom, North Carolina Department of Agriculture, Raleigh, North Carolina, USA; Richard H. Baker, IFAS—University of Florida, Vero Beach, Florida, USA; Tami Carlow, Systematic Entomology Laboratory, Washington, D.C., USA; Thomas T. Dobbs, USDA, APHIS, PPQ, Miami, Florida, USA; David Grimaldi, Department of Entomology, American Museum of Natural History, New York, New York, USA; M. S. Vicente Hernandez, Instituto de Ecologia A.C., Veracruz, Mexico; Carol C. Loeffler, Department of Biology, Dickinson College, Carlisle, Pennsylvania, USA; Lucianne Marinoni, Universidade Federal do Paraná, Curitiba, Paraná, Brazil; Paul E. Skelly, Florida State Collection of Arthropods, Gainesville, Florida, USA; and Bob Zuparko, Berkeley, California.

President Mathis announced that an article on Harrison Dyar by Marc Epstein and Pam Hensen, the speakers at this year's banquet, appeared in the American Entomologist, volume 38 (No. 3). Dr. William Bickley announced the death of Honorary Member Theodore L. Bissell on September 22, 1992 and provided a short biography of Dr. Bissell.

President Wayne N. Mathis called for the presentation of notes and specimens. Ralph Eckerlin brought a book entitled "Compilation of the Parasites and Diseases of Wild Mammals of Florida" by Don Forester and published by the University of Florida Press.

Chris Dietrich, Program Chairman, introduced the speaker for the evening, Dr. Paul Gross, Department of Entomology, University of Maryland, College Park, whose talk was entitled "The Role of Natural Enemies in Shaping the Niches of Phytophagous Insects." Dr. Gross reviewed ecological studies on the selective pressures that drive niche diversification with special reference to the effects of enemy-free space on the structure of herbivore communities. An ecological niche is how the insect uses resources, such as plant feeding preferences, feeding behavior in general, oviposition and pupation sites, etc. Herbivores must eat and live on the plants, that is, they experience differences in plant quality, but they must also be safe from predators, parasites and diseases. Historically, competition was the theory to explain niche diversification, but later other theories were proposed and tested such as protection from parasites, predators, and diseases known as the enemy-free space hypothesis. That is, predation pressure can drive insect diversification. Dr. Gross reviewed the studies that support this hypothesis, although there are very little experimental data. Most of the studies have dealt with parasitoids because they are believed to be very important in insect diversification.

Two different questions can be asked: "What are the effects of enemy-free space on populations of herbivores?" and "what are the effects on the structure of herbivore communities?" Enemy-free space effects on populations are based on the idea that natural selection will modify an organism's niche to minimize vulnerability to predators, parasites, and diseases. It is clear that it occurs, but how important is it? There are several predictions that can be examined: safety should be preferred even though food quality is less than it could be, unsafe niches will be avoided even if food quality is greater, some insects have other and better defenses against enemies such as armour, hairiness, evasive behaviors, and niche shifts should occur after introduction of exotic natural enemies.

His work with two lepidopteran species of the family Gelechiidae showed that natural selection modifies an organism's niche to minimize vulnerability to parasites. Pressure from natural enemies will select for modifications, but they will be influenced by the types of niches occupied by other herbivores that live in the same area. Natural selection favors individuals whose niches overlap the least with other herbivores. As a result, niches have evolved to be different from their neighbors or rather the niches are partitioned. The results of partitioning would appear the same as the result from competition for food and is therefore called apparent competition or parasite mediated competition. Although it is difficult to test because of the similarity to competition, it can be tested based on the assumptions that many natural enemies must be specific to ecological niches and taxon generalists and if the herbivore moves to a new niche already searched by enemies, the herbivore should be attacked by the enemies. The studies concerning the first assumption both support and contradict the predictions, but his own work on two leaf-mining gelechiid species supports the latter. One species has feeding behavior typical for gelechiids, forming blotch mines with silk tube out of leaf mine and moving freely from mine to mine; the other species stays in one leaf mine during its entire lifetime. The latter behavior is probably derived and is a modification in response to the stellate trichomes on the solanaceous leaf. The latter species also had a far greater proportion of successful ectoparasitism.

Our visitors were introduced and the meeting was adjourned. After the meeting refreshments were provided by Ralph Eckerlin.

M. Alma Solis, *Recording Secretary*

979th Regular Meeting—November 5, 1992

The 979th meeting of the Entomological Society of Washington was called to order by President Wayne Mathis in the Naturalists' Center of the Natural History Building at 8:00 pm on November 5, 1992. Seventeen members and six guests were present. Minutes of the October meeting were read by Recording Secretary Alma Solis and approved as read.

Membership Chairman, Ralph Eckerlin, read the names of the following applicants for membership: Robert Patrick Apsey, Belmont, Michigan; Gordon F. Pratt, Dept. of Entomology and Applied Ecology, University of Delaware, Newark, Delaware; and Vicente E. Carapia Ruiz, Cuautla, Morelos, Mexico.

Nominating Committee Chairman, Don Davis, provided a slate of officers produced by the Nominating Committee that included Dave Smith and Warren Steiner. All existing officers were renominated with the exception of Paul Spangler for President-Elect. The slate will be voted on at the Annual Meeting on December 3.

President Mathis called for notes and specimens. Ted Spilman gave a list and defined forty-one words having INSECT as part of the word. The words were collected from various English language dictionaries, including the Oxford English Dictionary. Words with INSECT as the stem: Insecta, insectan, insectarian, insectarianism, insectarium, insectary, insectean, insectic, insecticidal, insecticide, insecticolous, insectiferous, insectiform, insectifuge, insectile, insectine, insectistasis, insectival, insective, Insectivora, insectivore, insectivorous, insectization, insectize, insectizing, insectlike, insectocution, insectocutor, insectologer, insectologist, insectology, insectophobia, insectorubin, insectoverdin, insectual, insectuous, insecty. Words having INSECT in the middle: disinsection, disinectization, noninsecticidal. Nathan Schiff brought a yellow jacket, *Vespula germanica,* with its nematode parasite (Mermithidae) that were sent to him for identification. Dave Smith had a vial with the rather rare *Merope tuber* (Mecoptera: Meropidae). Photographic slides of the following were shown: Nathan Schiff showed a specimen of *Nalachius americana* (Neuroptera: Dilaridae) that he collected in a malaise trap at Beltsville Agricultural Research Center; Ed Barrows showed sawfly larvae (*Eriocampa juglandis* (Fitch)) that secrete long waxy structures and feed on walnut; Alma Solis showed three Wurthiinae species that superfically appear to be zygaenoid dalcerids, but are really pyraloids whose larvae live and feed on arboreal ants in southeast Asia.

Chris Dietrich, Program Chairman, introduced the speaker for the evening, Dr. Mark Epstein, Department of Entomology, Smithsonian Institution, whose talk was entitled "Rolling Waves and Fishtail Spinnerets: A Video on Caterpillars of the Limacodid Group." The Limacodidae, the Megalopygidae, and the Dalceridae are members of the Zygaenoidea. Dr. Epstein showed slides of the often spectacular and urticating larvae that feed on older, leathery leaves. The limacodids and their sister group, the dalcerids, share the complete loss of prolegs. The major portion of his presentation was with the use of a video to show the various behaviors of locomotion and cocoon spinning. The limacodid was seen feeding, with its head tucked under the prothorax from the end of the leaf inward to the petiole. Dr. Epstein was able to film silk production through glass. In megalopygids, he showed the early instar silk placement to be highly disorganized and to become more organized as the caterpillar aged. Limacodid caterpillars lay down semi-fluid silk to be able to move on smooth surfaces like leaves. The spinneret is highly modified, a V-shaped, brush-like structure. The spinneret produces solid silk for cocoon production and Dr. Epstein showed with time-lapse photography how the pupa turned as it secreted silk and produced the cocoon. During the final stage of construction, the larva sprayed calcium oxalate, which is secreted by the malpighian tubules, giving the cocoon a marzipan look when dry.

Dr. Epstein also discussed various other characters in the evolution of zygaenoids from the basal Megalopygidae to the more derived Dalceridae and Limacodidae. He especially discussed the changes occurring ventral to the spiracles to increase contact with the substrate and their adaptive significance in Lepidoptera for moving and feeding on smooth leaf surfaces. Finally, he passed around some live slug caterpillars captured by the fearless Don Davis at Cedarville State Forest, Maryland.

Our visitors were introduced and the meeting was adjourned at 9:28 pm. After the meeting refreshments were provided by Diane Mathis.

M. Alma Solis, *Recording Secretary*

980th Annual Meeting—
December 3, 1992

The 980th Annual Meeting of the Entomological Society of Washington was called to order by President Wayne Mathis in the Naturalists' Center of the Natural History Building at 8:00 pm on December 3, 1992. Twenty-two members and 14 guests were present. Minutes of the November meeting were read by Recording Secretary Alma Solis and approved as read.

President Mathis called for officers' reports. Membership Chairman, Ralph P. Eckerlin, read the names of two applicants for membership, Sarah A. Donahue, Systematic Entomology Laboratory, USDA, Washington, D.C. and Lawrence M. Hanks, Department of Entomology, University of

California, Riverside, California, and reported a total of 24 new members for 1992. Thomas Henry's editor report was read by Holly Williams. Fifty-five articles were published for a total of 615 pages. Gary L. Miller became Book Review Editor in June and A. G. Wheeler, Jr. became Special Publications Editor in November. Henry thanked the reviewers of the journal articles and outgoing editor Robert D. Gordon and Marie Westfall for assistance. Natalia Vandenberg's Custodian report was read by Wayne Mathis. During 1992 $3010.81 was received from sales of special and miscellaneous publications. Vandenberg thanked Sarah Donahue and Ed Brodie who helped with mailings and record keeping. In addition Ed Brodie cleaned, sorted, and inventoried the society's publications. Corresponding Secretary, Holly Williams, reported writing a number of letters on behalf of the society. President-Elect Russ Stewart reported on the annual banquet. Seventy-three members and guests attended the annual banquet on June 12, 1992. Net cost to the society was $101.70. President Mathis read the financial report by Treasurer Norman Woodley that showed the society to be solvent. Outgoing President Mathis thanked the officers and the society, especially Don Anderson who helped set up for the meetings. Due to a vacancy for Honorary Member the Executive Committee nominated Dr. Karl V. Krombein for the honorary position. It was voted upon and unanimously accepted by the membership.

The slate of officers for 1992 was presented by Nominating Committee Chairman, Donald R. Davis:

President—Russell D. Stewart
President-Elect—Paul J. Spangler
Recording Secretary—M. Alma Solis
Corresponding Secretary—Hollis B. Williams
Treasurer—Norman E. Woodley
Program Chairman—Christopher H. Dietrich
Membership Chairman—Ralph P. Eckerlin
Custodian—Natalia J. Vandenburg
Editor—Thomas J. Henry

The slate was voted upon and unanimously accepted by the members present.

President Mathis called for notes and specimens. Ted Spilman had a new book entitled *Insect Potpourri, Adventures in Entomology,* edited by J. Adams. Ralph Eckerlin had a copy of the journal *Banisteria* of the Virginia Natural History Society and a vial with cimicids that he found in cliff swallow nests.

Honorary President Curtis Sabrosky introduced the speaker for the evening, Dr. Conrad Labandeira, Department of Paleobiology, Smithsonian Institution, whose talk was entitled "What Does the Fossil Record of Plant–Insect Interactions Tell Us About the Ecological Dominance of Insects?" Dr. Labandeira pointed out that many new taxa in the fossil record are being discovered despite a belief to the contrary. The origin and time when insects became dominant on land can be traced to the Paleozoic, specifically the Carboniferous, and by the early and late Permian orthopteroid and hemipteroid orders became more evident in the fossil record. There is evidence for a Permian extinction, an early Mesozoic radiation, and by the middle Mesozoic insects came to resemble modern insects. By the late Jurassic 70% of the extant insect families were present. With the appearance of angiosperms in the early Cretaceous there appears to be a decrease in insect diversity and there is evidence to suggest that interactions with plants began much earlier. For his doctoral work Dr. Labandeira classified recent hexapod mouthparts into 34 structural types, based on an analysis of 1365 extant hexapod species representing all orders and 70% of the families. He found that 85% of the mouthpart classes were established during the Early and Middle Mesozoic before the appearance of angiosperms in the early Cretaceous. The Cretaceous/Tertiary extinction had no obvious effect on insects.

Dr. Labandeira also spoke specifically about insect–vascular plant interactions in the fossil record. Insects have been found to be doing interesting things in the Paleozoic, much earlier than expected. For example, there is evidence of sucking insects in the Lower Devonian. Evidence for insect–plant interactions includes not only feeding damage such as boring, chewing, and leaf-mining, but also coprolites or fossilized fecal pellets. In addition, the fossil record has shown that pollination mechanisms preceded the arrival of angiosperms and studies have suggested that insects were pollinating gymnosperms.

Our visitors were introduced and President Wayne Mathis transferred the gavel to President-Elect Russell Stewart. Russell Stewart adjourned the meeting at 9:50 pm and refreshments were provided by Diane Mathis, Holly Williams, and Ralph Eckerlin.

M. Alma Solis, *Recording Secretary*

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld. 124 pp. 1959	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld. 35 pp. 1960	3.00
Both papers on cynipid galls	6.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver. 25 pp. 1951	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney. 15 pp. 1976	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal. 35 pp. 1977	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal. 61 pp. 1979	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff. 85 pp. 1990	10.00

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
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00

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.

CONTENTS

(*Continued from front cover*)

NORRBOM, ALLEN L.—New species and phylogenetic analysis of *Euaresta* Loew (Diptera: Tephritidae), with a key to the species from the Americas south of Mexico 195

PAGANELLI, CELUTA H. and CURTIS W. SABROSKY—*Hippelates* flies (Diptera: Chloropidae) possibly associated with Brazilian purpuric fever 165

PALMER, W. A.—On the host range of the delphacid planthopper *Stobaera pallida* Osborn (Homoptera) 241

PEMBERTON, ROBERT W. and NATALIA J. VANDENBERG—Extrafloral nectar feeding by ladybird beetles (Coleoptera: Coccinellidae) 139

SKELLEY, PAUL E.—A method of genitalia preparation and dry preservation for Coleoptera 131

SOBHIAN, R.—Two biotypes of *Bangasternus orientalis* (Coleoptera: Curculionidae) found in Greece 163

VARGAS V., MARIO, J. V. VARGAS, AND J. RAMÍREZ-PÉREZ—*Simulium* (*Psilopelmia*) *travisi* (Diptera: Simuliidae), a new black fly species from Costa Rica 175

YOUNG, DAVID A.—New genus and five new species of mileewine leafhoppers from New Guinea (Homoptera: Cicadellidae) 228

WOODLEY, NORMAN E.—A remarkable new species of *Paradejeania* from the Dominican Republic (Diptera: Tachinidae) 182

NOTES

PINTO, JOHN D.—Correct application of the nominal genus *Brachista* Walker (Hymenoptera: Trichogrammatidae) 298

STAINES, C. L.—Replacement name for *Sumitrosis championi* (Weise) (Coleoptera: Chrysomelidae, Hispinae) 297

BOOK REVIEWS

CANE, JAMES H.—*Diversity in the Genus Apis* 296

SCHAEFER, CARL W.—*The Hemiptera* and *Adults of the British Aquatic Hemiptera Heteroptera: A Key with Ecological Notes* 293

OBITUARIES

MARSH, PAUL M.—Barnard DeWitt Burks, 1909–1990 300

MISCELLANEOUS

REPORTS OF OFFICERS 305

SOCIETY MEETINGS 307

VOL. 95 JULY 1993 NO. 3
(ISSN 0013-8797)

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY of WASHINGTON

PUBLISHED
QUARTERLY

CONTENTS

BRAILOVSKY, HARRY—New genera and new species of Colpurini (Heteroptera: Coreidae) from the Fiji Islands and New Guinea 435

BUTLER, LINDA—Parasitoids associated with the Macrolepidoptera community at Cooper's Rock State Forest, West Virginia: a baseline study 504

DIETRICH, CHRISTOPHER H.—A new genus of Neotropical Agalliinae (Homoptera: Cicadellidae) 468

DIETRICH, CHRISTOPHER H.—A new genus of Iassinae from southeastern Brazil (Homoptera: Cicadellidae) 475

FOOTE, B. A.—Biology of *Hyadina albovenosa* (Diptera: Ephydridae), a consumer of Cyanobacteria 377

FROESCHNER, RICHARD C.—The Neotropical lace bugs of the genus *Vatiga* (Heteroptera: Tingidae), pests of Cassava: New synonymies and key to species 457

GOEDEN, RICHARD D.—Analysis of known and new host records for *Tephritis* from California, and description of a new species, *T. joanae* (Diptera: Tephritidae) 425

GRIMALDI, DAVID A. and WAYNE N. MATHIS—Fossil Periscelididae (Diptera) 383

HENRY, THOMAS J. and RICHARD C. FROESCHNER—*Dieuches armatipes* (Walker) (Heteroptera: Lygaeidae) newly discovered in the Western Hemisphere 449

HERNÁNDEZ-ORTIZ, VICENTE—Description of a new *Rhagoletis* species from tropical Mexico (Diptera: Tephritidae) 418

HICKS, ANDREW L. and ROBERT F. WHITCOMB—The genus *Laevicephalus* (Homoptera: Cicadellidae): Hosts, biogeography, and three new species 481

MACDONALD, JOHN F.—Review of the genus *Chelipoda* Macquart of America north of Mexico (Diptera: Empididae; Hemerodromiinae) 327

MACDONALD, JOHN F. and WILLIAM J. TURNER—Review of the genus *Neoplasta* Coquillett of America north of Mexico (Diptera; Empididae; Hemerodromiinae) 351

(*Continued on back cover*)

THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

ORGANIZED MARCH 12, 1884

OFFICERS FOR 1993

RUSSELL D. STEWART, *President*
PAUL J. SPANGLER, *President-Elect*
M. ALMA SOLIS, *Recording Secretary*
HOLLIS B. WILLIAMS, *Corresponding Secretary*
NATALIA J. VANDENBERG, *Custodian*
NORMAN E. WOODLEY, *Treasurer*
CHRISTOPHER H. DIETRICH, *Program Chairman*
RALPH P. ECKERLIN, *Membership Chairman*
WAYNE N. MATHIS, *Past President*

THOMAS J. HENRY, *Editor*
GARY L. MILLER, *Book Review Editor*

Publications Committee
DONALD R. DAVIS
TERRY L. ERWIN
F. CHRISTIAN THOMPSON
A. G. WHEELER, JR., *Special Publications Editor*

Honorary President
CURTIS W. SABROSKY

Honorary Members
LOUISE M. RUSSELL
ALAN STONE
KARL V. KROMBEIN

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, % 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 $25.00 (U.S. currency).

PROCEEDINGS.—The *Proceedings of the Entomological Society of Washington* (ISSN 0013-8797) are published quarterly beginning in January by The Entomological Society of Washington. POSTMASTER: Send address changes to the Entomological Society of Washington, % Department of Entomology, NHB-168, Smithsonian Institution, Washington, D.C. 20560. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember U.S. subscriptions are $60.00 per year and foreign subscriptions are $70.00 per year, payable (U.S. currency) 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. 218 OF THE JANUARY, 1991 ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Editor: Thomas J. Henry, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Books for Review: Gary L. Miller, Systematic Entomology Laboratory, ARS, USDA, Building 046, BARC-West, Beltsville, MD 20705.

Special Publications: A. G. Wheeler, Jr., Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, PA 17110-9408

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 28 July 1993

Second Class Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

THIS PUBLICATION IS PRINTED ON ACID-FREE PAPER.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 313–320

CANADA MOONSEED VINE (MENISPERMACEAE): HOST OF FOUR ROUNDHEADED WOOD BORERS IN CENTRAL OHIO (COLEOPTERA: CERAMBYCIDAE)

Foster Forbes Purrington and David J. Horn

Department of Entomology, The Ohio State University, Columbus, Ohio 43210.

Abstract.—The lamiine longicorn beetles *Hyperplatys aspersa, Urgleptes querci, Psenocerus supernotatus,* and *Eupogonius pauper* (Coleoptera: Cerambycidae: Lamiinae) were reared from dead vines of Canada moonseed, *Menispermum canadense* (Menispermaceae), collected at a gallery forest site in central Ohio. Except for that of *Psenocerus supernotatus,* these constitute new host plant association records for larvae of these cerambycids. *Hyperplatys aspersa* was also reared from dead stems of common burdock, *Arctium minus* (Compositae).

Key Words: Cerambycidae, Lamiinae, *Hyperplatys,* ecology, Canada moonseed, Menispermaceae

The Menispermaceae consists largely of Neotropical twining lianas and lianoid shrubs, many containing pharmacologically potent isoquinoline alkaloids such as the Amerindian arrow poison curare (D-tubocurare) obtained from *Chondrodendron tomentosum* Ruiz & Pav. (Staff of the Liberty Hyde Bailey Hortatorium 1976). Canada moonseed, *Menispermum canadense* L., is a counter-clockwise twining woody vine widely distributed in lowland forests in moist rich soils along streams in the eastern United States and west to Manitoba and Oklahoma (Fernald 1950). In this habitat it attains modest heights (ca. 6 m) in the understory and is commonly found associated with grape which its leaves closely resemble. MacDermott (1986) reports moonseed as a noxious weed in commercial vineyards. Stems and rhizomes contain several toxic alkaloids; eating of fruits has resulted in human fatalities due to the curare-like action of dauracine (Foster 1989).

We collected dead moonseed vines (decayed for several months to a year) in early March 1992 from a gallery forest dominated by cottonwoods (*Populus deltoides* Marsh.), box elders (*Acer negundo* L.) and grape along the Olentangy River in central Ohio (Whetstone Park, Columbus, Franklin Co.). Wherever moonseed vines grew some had been severed above ground, presumably during winter by cottontail rabbits [*Sylvilagus floridanus* (Allen)]. Some clipped dead vines eventually became oviposition sites for cerambycids. Dead distal portions of other unsevered unfallen vines also contained borer larvae although more proximal sections were still living. Dead vines in the litter also contained borers.

From these vines we removed several dozen late stage lamiine cerambycid larvae and held them at room temperature for eclosion. We report herein a new host plant association for three of the four roundheaded wood borer species we found in Canada moonseed, and note a longstanding taxonomic confusion in published literature which has contaminated host records for one of them.

Voucher specimens of all four cerambycid species are held in the personal collection of the first author at Columbus.

Discussion

From Canada moonseed vines collected on 7 March 1992 several cerambycid pupae had formed within 36 h, and ca. 5 d later the first of many adult *Psenocerus supernotatus* (Say) eclosed (Fig. 1). These beetles (Lamiinae: Apodasyini) (Chemsak and Linsley 1982) formed their pupal cells in the central pithy core of host vines. A second apodasyine species, *Eupogonius pauper* LeConte (Fig. 2), also formed pupal cells within the pith core and eclosed during this period but it was one tenth as common.

Larvae of two additional cerambycid species began pupating about a week later, after forming more flattened pupal cells paralleling the epidermis, away from the pithy core. We identified emerging adults as *Urgleptes querci* (Fitch) (Fig. 3) and *Hyperplatys aspersa* (Say) (Fig. 4) (Lamiinae: Acanthocini). *Urgleptes querci* occurred ca. four times more often than *H. aspersa*; neither species was numerous.

The degree of species packing evidenced by this guild of four longicorn beetles in Canada moonseed vines reflects the array of larval food resources and complex internal architecture of the host plant. Larvae of the two apodasynine species form short cylindrical pupation cells in the central pithy core. Their cylindrical pupae reflect this microsite preference. Conversely, the two acanthocine species with more flattened pupae have larvae that excavate longer pupation cells with more elliptic cross section in outer woody zones near the epidermis. While characteristic defensive twisting pupal motions of all four species are similar, the two acanthocines move farther and more rapidly, both forward and backward, perhaps in response to their relatively greater accessibility by parasitic Hymenoptera. Further resource partitioning along tribal lines is evidenced in distinct phenologies and larval feeding site (nutritional) preferences. We suggest that vines like these function as platforms of adaptive radiation in the insects that use them, much as Zwölfer (1982) has shown for Cardueae (Compositae) flower head insects.

According to Carlquist (1991) lianas and vines, much more so than self-supporting woody plants, are characterized by cambial variants novel among dicotyledons: vessel elements are typically very long and wide with large perforation plates, and cell walls lack lignification. Twining vines like those in *Menispermum* are limber due to reduced secondary xylem and lignin, to large intercalated pith rays, to a large central pithy core, and to a small stem diameter. Acceptability of vines to suites of generalist borers may in part be due to their structural complexity, and partly a consequence of their favorable ratio of labile to recalcitrant dietary components. We note a disproportionately high incidence of vines among those plants reported as hosts for Cerambycidae (e.g. Knull 1946).

None of the four borers we found in moonseed is a host specialist. *Psenocerus supernotatus* is found in plants of 17 genera (Linsley and Chemsak 1984), including seven vines in five families, *E. pauper* in plants of 19 genera, including two vines in as many families. Knull (1946) lists 11 host plant genera for *U. querci,* including two vines in different families. Herein we also record *H. aspersa* in Canada moonseed vines. In addition, several adults of this species have been reared (Columbus, Ohio, 1992) from larvae found in weathered, twice-overwintered standing canes of common burdock, *Arctium minus* (Hill) Bernhardi (Compositae), a new host plant record.

Taxonomic Confusion in *Hyperplatys*

Published host plant records for *H. aspersa,* according to Gardiner (1961), are

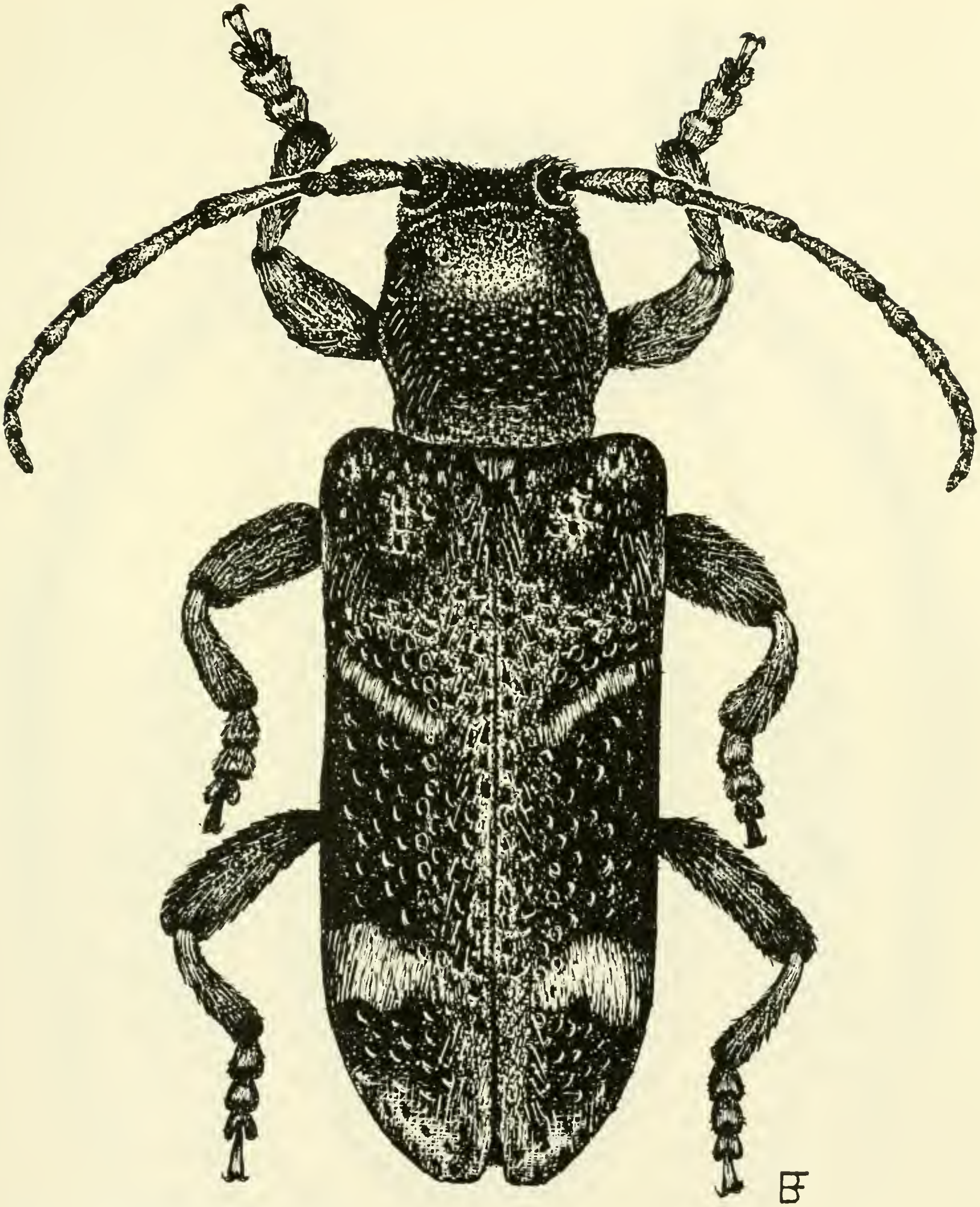


Fig. 1. *Psenocerus supernotatus* (Say).

"completely misleading" due to a long history of taxonomic confusion between this species and *H. maculata* Haldeman. In an article describing only immature stages and biology of these two sympatric eastern North American *Hyperplatys,* he stated that adults were misdetermined by Blatchley (1910), Felt (1924), Knull (1946), "and others," and

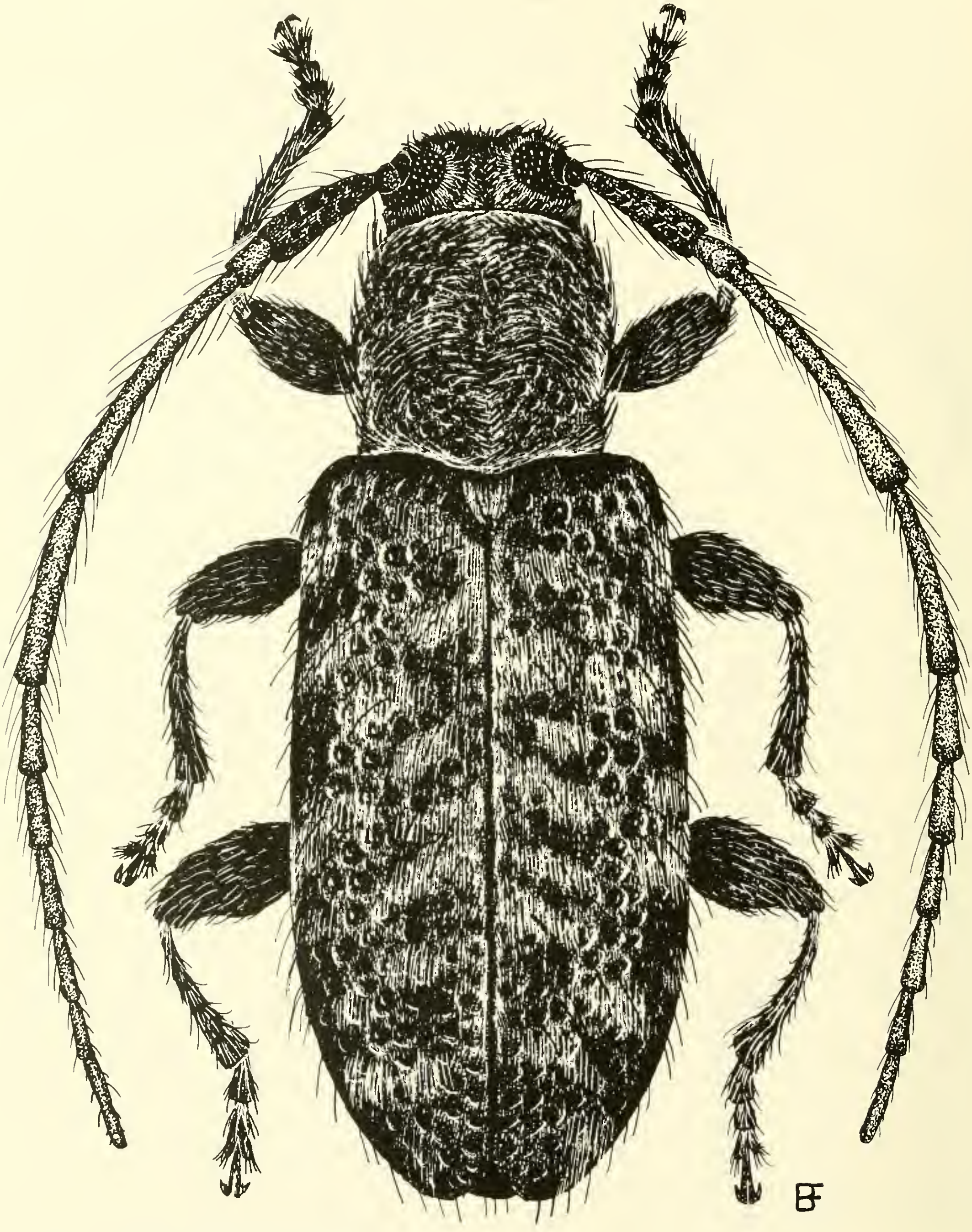


Fig. 2. *Eupogonius pauper* LeConte.

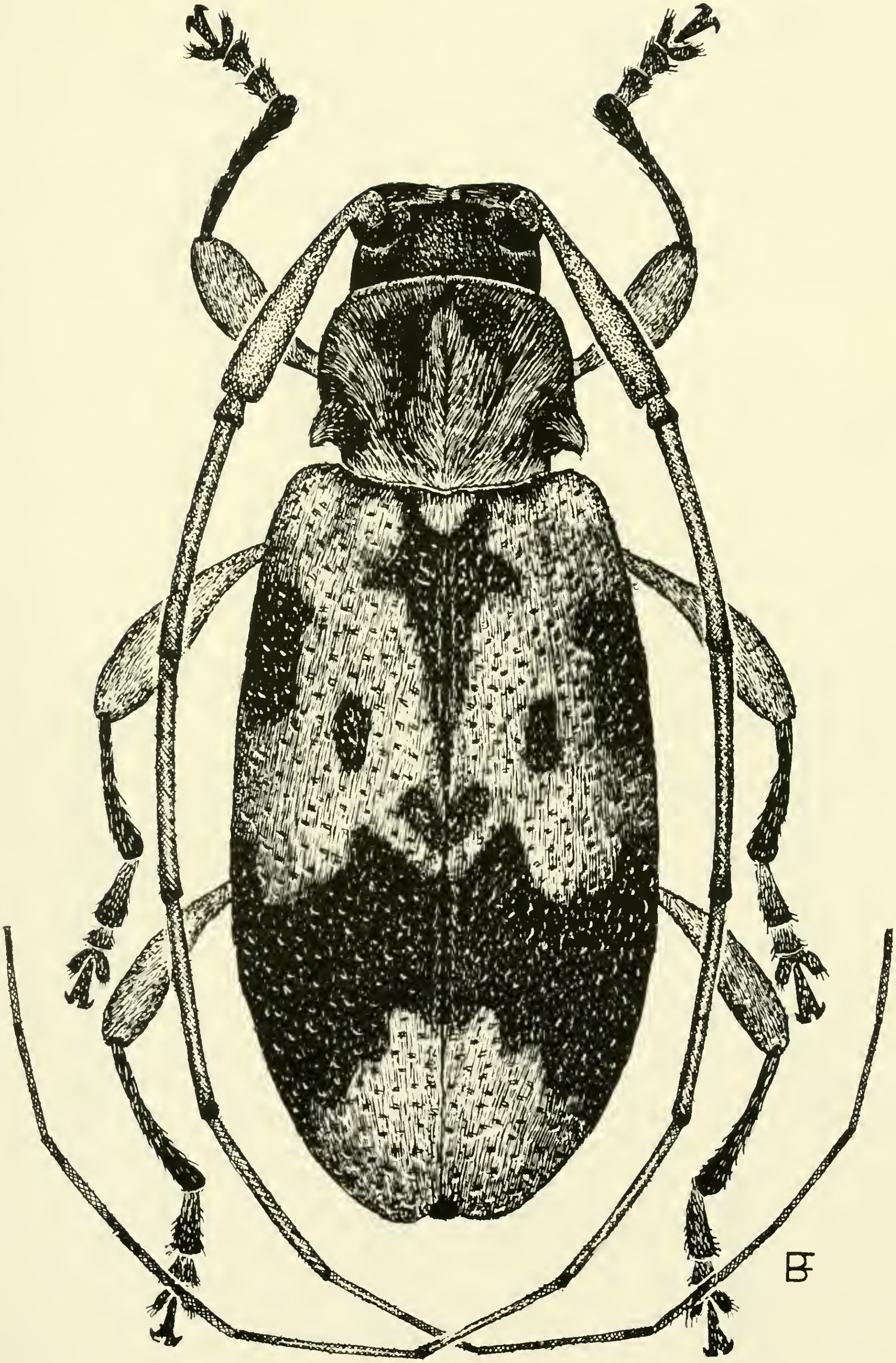


Fig. 3. *Urgleptes querci* (Fitch).

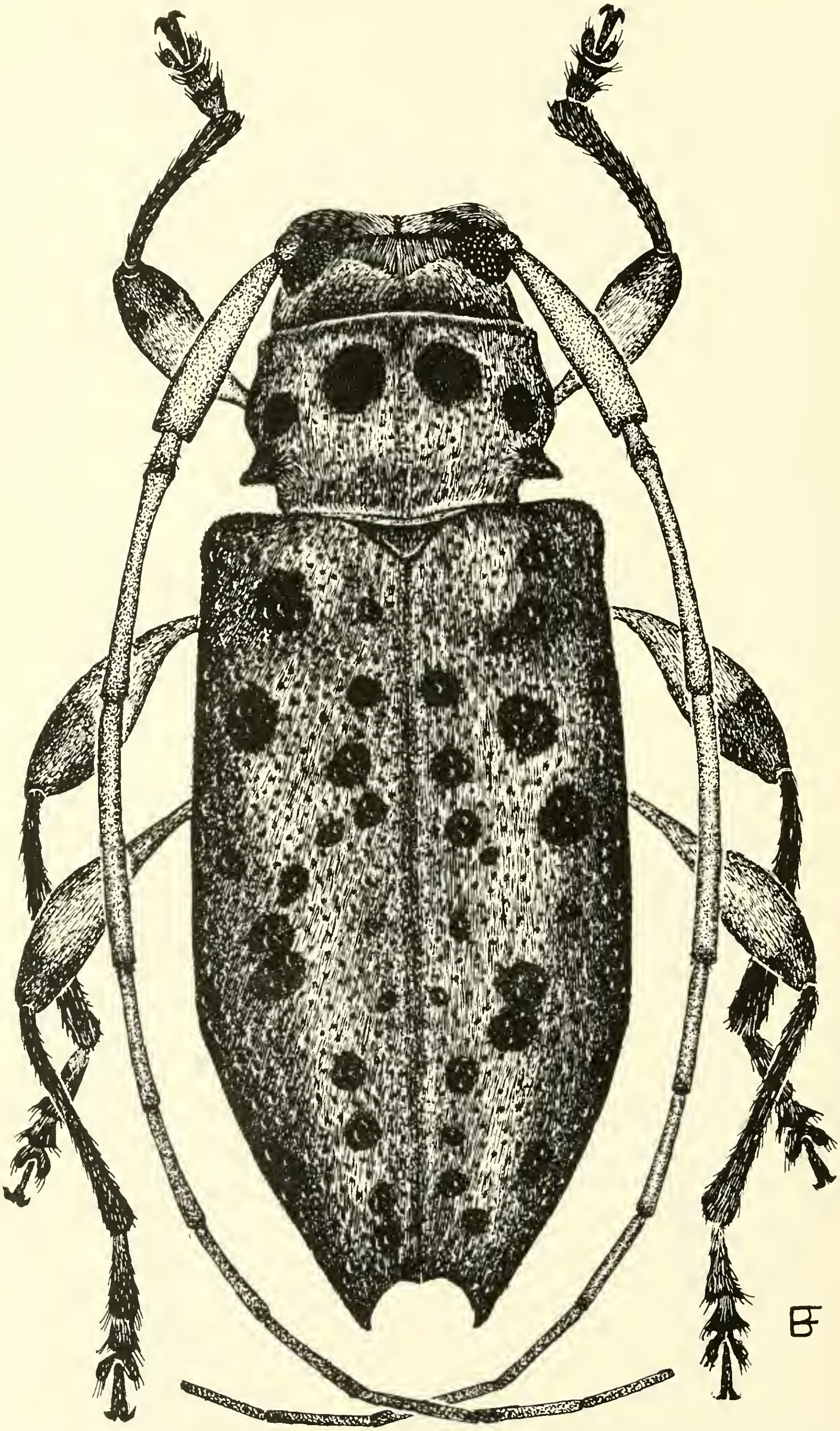


Fig. 4. *Hyperplatys aspersa* (Say).

the larvae by Craighead (1923). Gardiner seems to have borrowed some of his criticism from similar comments made in a revision of the Acanthocini by Dillon (1956a, b). Stein and Tagestad (1976) list both species from North Dakota but their photo figures both appear to show *H. aspersa.* Dillon and Dillon (1972) mix some diagnostic characters in synopses, but their included key and habitus sketches seem essentially correct. Gardiner makes no comment on the accuracy of Dillon's treatment of *Hyperplatys* adults in the 1956 revision of Nearctic Acanthocini (Dillon 1956). Dillon's diagnoses therein of *H. maculata* and *H. aspersa* seem adequate and proper to us. Gardiner does, however, cite Dillon's distribution records for both species, albeit circumspectly in quotes. Unfortunately, no series of Gardiner's reared adult *Hyperplatys,* if any ever existed, could be located in Canadian collections (B. Gill, pers. comm.).

Say's (1824) description of *H. aspersa* is inconclusive, as is Haldeman's (1847) of *H. maculata,* both authors relying on characters which are variable, inconsistently present, or common to both species. Perhaps Say had before him a mixed series: he mentions variation that leans toward the *H. maculata* facies. It is our understanding that none of Say's Cerambycidae type specimens exist today.

We examined the *Hyperplatys* in the LeConte Collection at Harvard University's Museum of Comparative Zoology (MCZ) in hopes of unambiguously resolving the identity of our reared specimens, in the way that John L. LeConte's interpretations of the Say names are often used (e.g. Lindroth and Freitag 1969). This large and well-known collection, however, contains mixed series of these species; indeed, some non-*Hyperplatys* are included. We could not locate the type of *H. maculata* Haldeman; the United States National Museum claimed that Haldeman's types had been transferred to Harvard University. This assertion has been disputed by the MCZ (C. Graham, pers. comm.). The Philadelphia Academy of Natural Sciences does not hold any Haldeman insect collections (D. Azuma, pers. comm.).

Gardiner found his *H. aspersa* only in "sumac" and his *H. maculata* only in "red oak, basswood, and butternut." Despite the confusion over names and weakness of an accredited host plant list it is clear that *H. aspersa* also is a generalist borer, with records of hosts in three unrelated plant families, including one vine.

ACKNOWLEDGMENTS

We are indebted to Cleone Graham, Museum of Comparative Zoology (Harvard), for her interest and gracious hospitality.

John A. Chemsak, University of California, Berkeley, kindly aided our determination of *Hyperplatys aspersa* by sharing elements from his forthcoming key to the genus. We thank Bruce Gill of Agriculture Canada, Nepean, Ontario and Robert Androw, Columbus, for fruitful discussion. The professional support of Bruce Leach and the Biological Sciences Library staff at The Ohio State University is greatly appreciated. Kip Will and Elizabeth Morgan reviewed drafts of the manuscript.

Brendon M. Farley of Columbus executed the original habitus drawings.

LITERATURE CITED

Blatchley, W. S. 1910. An illustrated descriptive catalogue of the Coleoptera or beetles known to occur in Indiana. Bulletin of the Indiana Department of Geology and Natural Resources 1: 1–1386.

Carlquist, S. 1991. Anatomy of vine and liana stems: A review and synthesis. *In* Putz, F. E. and H. A. Mooney, eds., The Biology of Vines. Cambridge University, London. 526 pp.

Chemsak, J. A. and E. G. Linsley. 1982. Checklist of the Cerambycidae and Disteniidae of North America, Central America and the West Indies (Coleoptera). Plexus, Medford, New Jersey. 138 pp.

Craighead, F. C. 1923. North American cerambycid larvae. Canada Department of Agriculture Bulletin No. 27, new series (Technical). 239 pp.

Dillon, L. S. 1956a. The Nearctic components of the tribe Acanthocinini (Coleoptera: Cerambycidae).

Part I. Annals of the Entomological Society of America 49: 134–167.

———. 1956b. The Nearctic components of the tribe Acanthocinini (Coleoptera: Cerambycidae). Part III. Annals of the Entomological Society of America 49: 332–355.

Dillon, E. S. and L. S. Dillon. 1972. A Manual of Common Beetles of Eastern North America. Dover, New York. 894 pp.

Felt, E. P. 1924. Manual of Tree and Shrub Insects. Macmillan, New York. 382 pp.

Fernald, M. L. 1950. Gray's Manual of Botany, 8th Edition. American Book Co., New York. 1632 pp.

Foster, S. 1989. Phytogeographic and botanical considerations of medicinal plants in eastern Asia and eastern North America, pp. 115–144. *In* Craker, L. E. and J. E. Simon, eds., Herbs, Spices, and Medicinal Plants: Recent Advances in Botany, Horticulture, and Pharmacology, Vol. 4. Oryx, Phoenix.

Gardiner, L. M. 1961. Immature stages and biology of *Hyperplatys* spp. (Coleoptera: Cerambycidae) in eastern Canada. Canadian Entomologist 93: 1011–1016.

Haldeman, S. S. 1847. Materials toward a history of Coleoptera Longicornia of the United States. Transactions of the American Philosophical Society (Series 2) 10: 27–66.

Knull, J. N. 1946. The long-horned beetles of Ohio (Coleoptera: Cerambycidae). Ohio Biological Survey Bulletin 39, 7(4): 133–354.

Lindroth, C. H. and R. Freitag. 1969. North American ground-beetles (Coleoptera, Carabidae, excluding Cicindelinae) described by Thomas Say: Designation of lectotypes and neotypes. Psyche 76: 326–361.

Linsley, E. G. and J. A. Chemsak. 1984. The Cerambycidae of North America, Part VII, No. 1: Taxonomy and classification of the subfamily Lamiinae, tribes Parmenini through Acanthoderini. University of California Publications in Entomology 102: 1–258.

MacDermott, J. 1986. Effects of the rare weed *Menispermum canadense* L. on yield and quality on 'concord' grapes, pp. 373–380. *In* Proceedings of the Southern Weed Science Society, 39th Annual Meeting, Nashville.

Say, T. 1824. Descriptions of coleopterous insects: *Lamia*. Journal of the Academy of Natural Sciences of Philadelphia (Series 1) 3: 329–331.

Staff of the Liberty Hyde Bailey Hortatorium. 1976. Hortus Third, a Concise Dictionary of Plants Cultivated in the United States and Canada. MacMillan, New York. 1290 pp.

Stein, J. D. and A. D. Tagestad. 1976. The long-horned wood-boring beetles of North Dakota (Coleoptera: Cerambycidae). United States Department of Agriculture Forest Service Research Paper RM-171. 58 pp.

Zwölfer, H. 1982. Patterns and driving forces in the evolution of plant-insect systems, pp. 287–296. *In* Proceedings of the 5th International Symposium on Insect-Plant Relationships, Wageningen, 1982.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 321–326

BORKENTHELEA, A NEW PREDACEOUS MIDGE GENUS FROM SUBANTARCTIC ARGENTINA AND CHILE (DIPTERA: CERATOPOGONIDAE)

GUSTAVO R. SPINELLI AND WILLIAM L. GROGAN, JR.

(GRS) Instituto de Limnologia "Dr. Raul A. Ringuelet," Casilla de Correo 712, 1900 La Plata, Argentina; (WLG) Department of Biological Sciences, Salisbury State University, Salisbury, Maryland 21801.

Abstract.—***Borkenthelea nothofagus***, a new genus and species of predaceous midge of the tribe Ceratopogonini, is described and illustrated. This new genus from the temperate subantarctic *Nothofagus* forest of Argentina and Chile is compared with other genera in the Ceratopogonini.

Key Words: Diptera, Ceratopogonidae, Ceratopogonini, predaceous midges, Neotropical, subantarctic, Argentina, Chile

Among the ceratopogonids in the collection of the U.S. National Museum of Natural History (USNM) is a single male of the tribe Ceratopogonini captured by R. C. and E. Shannon during 1926 in the subantarctic *Nothofagus* forest of southwestern Argentina. Our attempts to readily place this enigmatic specimen in a currently recognized genus proved difficult. GRS spent a brief period in 1988 collecting Diptera in the same area of Argentina and captured two females that appear to be conspecific with the male collected by the Shannons. He recently returned to an adjacent area of Chile in November 1992 in an attempt to obtain additional specimens and was only successful in capturing a single female of this species. We have recently examined another female of this species from Chile in the Canadian National Collection (CNCI).

Because these specimens apparently belong to an undescribed genus, we herein propose a new genus for them. For general terminology of the Ceratopogonidae, see Downes and Wirth (1981); for special terms dealing with the tribe Ceratopogonini, see Wirth and Grogan (1988). Specimens are mounted on microscope slides in Canada balsam in the manner of Wirth and Marston (1968) or Borkent and Bissett (1990).

Borkenthelea Spinelli and Grogan, NEW GENUS

Type-species, *Borkenthelea nothofagus* Spinelli and Grogan, new species.

Diagnosis.—The only genus in the tribe Ceratopogonini with the following combination of characters. Eyes pubescent, contiguous. Antenna with sensilla coeloconica on flagellomere 1; small, thin sensilla trichodea present on distal portions of flagellomeres 2–5, variably on 6–7, absent on 8. Palpus 5-segmented; segment 3 with small sensory pit; segment 4 with 2–4 setae. Katepisternum without enlarged setae. Legs unarmed; hind tarsomere 1 with well developed palisade setae; 4th tarsomeres subcordiform; female claws moderately large, unequal sized, hind pair massive and most unequal in size, all without basal inner or outer teeth, male claws small, simple with bifid tips. Wing membrane infuscated with abundant macrotrichia on distal ½; radial veins very thick, two equal sized radial cells; media petiolate with long petiole; costal ratio of female 0.55–0.57, of male 0.55. Distal portion of sternite 8 and most of sternite 9 of female covered with spiculate membrane; sternite 10 of female with two pair of setae, one very large; two large and one small spermathecae. Male tergite 9 very short, triangular, with small bulbous apicolateral processes; aedeagus triangular, very short (length/width = 0.31); parameres fused basally.

Etymology.—This new genus is named in honor of our good friend and colleague, Art Borkent, in recognition of his superb contributions to our knowledge of the systematics of nematocerous Diptera.

Comparison with similar genera.—*Borkenthelea* keys to couplet 36a, *Brachypogon* (*Isohelea*), in Wirth and Grogan (1988) and we originally thought that it could be a highly modified member of that subgenus of *Brachypogon*. However, Spinelli (1990) chose not to include it in his review of the Argentinean species of *Brachypogon* for a number of reasons. Although *Borkenthelea* has a wing with two radial cells like typical members of the subgenus *Isohelea* of *Brachypogon*, species of this subgenus have macrotrichia only along the distal margin of the wing and M2 is often lacking but if present its base is usually interrupted and the petiole of the media is shorter. Furthermore, species of *B.* (*Isohelea*) usually have 2 or less setae on the 4th palpal segment, and females have claws usually with at least basal inner teeth, 1 or 2 spermathecae and sternite 10 has only a single pair of setae.

Recently, Borkent (1992) and Grogan and Borkent (1992) provided some new characters to better differentiate *Brachypogon* from its relatives and other similar genera. They pointed out that *Brachypogon* and its nearest relatives (*Ceratoculicoides, Rhynchohelea, Nannohelea, Sinhalohelea*) all share a synapomorphy of having at least one enlarged katepisternal seta, and thereby form a monophyletic group. This character is absent in *Borkenthelea*, therefore excluding it from this assemblage.

Szadziewski (1984) described *Brachypogon* (*Isohelea*) *surae* from Algeria and consulted WLG on its generic status. This species differs from typical *Brachypogon* (*Isohelea*) by having two large and one very small spermathecae, female sternite 10 with one large and one small pair of setae, and the male antenna has only flagellomeres 2–9 (?10) fused. Borkent (1992) recently noted that this species lacks large katepisternal setae and that it probably belongs to an as yet undescribed genus. Regardless, it differs from *Borkenthelea* in having a wing with macrotrichia only on the distal margin, thinner radial veins, the female claws have basal inner teeth, the 4th palpal segment has 1–2 seate, and the male tergite 9 is longer and expanded distally.

Borkenthelea resembles several other genera of the tribe Ceratopogonini by having sensilla coeloconica on flagellomere 1 and a wing with two radial cells. Most notable of these is *Macrurohelea*, a southern hemisphere genus known from southern South America and Australia. It differs from *Borkenthelea* by its wing with the 2nd radial cell of females 2–4 times longer than the 1st, costal ratio of females 0.68–0.90 and membrane without macrotrichia, and the female sternite 10 is elongated and bent forward ventrally (Wirth and Grogan 1988).

The Holarctic *Ceratopogon* differs from *Borkenthelea* in lacking a hind tibial spur (Borkent 1992). The Afrotropical *Congohelea* differs from *Borkenthelea* by having a single spermatheca, a spinose fore femur, the 2nd radial cell is much longer than the first and the costal ratio is 0.81 (Wirth and Grogan 1988). The pantropical and subtemperate *Echinohelea* differs from *Borkenthelea* in having a single spermatheca, female claws with basal inner teeth, spinose legs, long slender radial cells and a costal ratio of 0.75 or more (Wirth and Grogan 1988). *Notiohelea*, known only from 2 species from subantarctic Chile and Argentina, differs from *Borkenthelea* by its wing membrane lacking microtrichia, 2nd radial cell 2–3 times longer than 1st, costal ratio 0.77 or more, tarsomeres 1 and 2 of fore leg with palisade setae, and female claws small equal sized (Grogan and Wirth 1979, Spinelli and Grogan 1990). *Washingtonhelea,* known only from a single species from southern California, differs from *Borkenthelea* by its single spermatheca, wing membrane without macrotrichia, M2 complete to base, lacking a hind tibial comb and female claws small with basal inner barbs (Wirth and Grogan 1988).

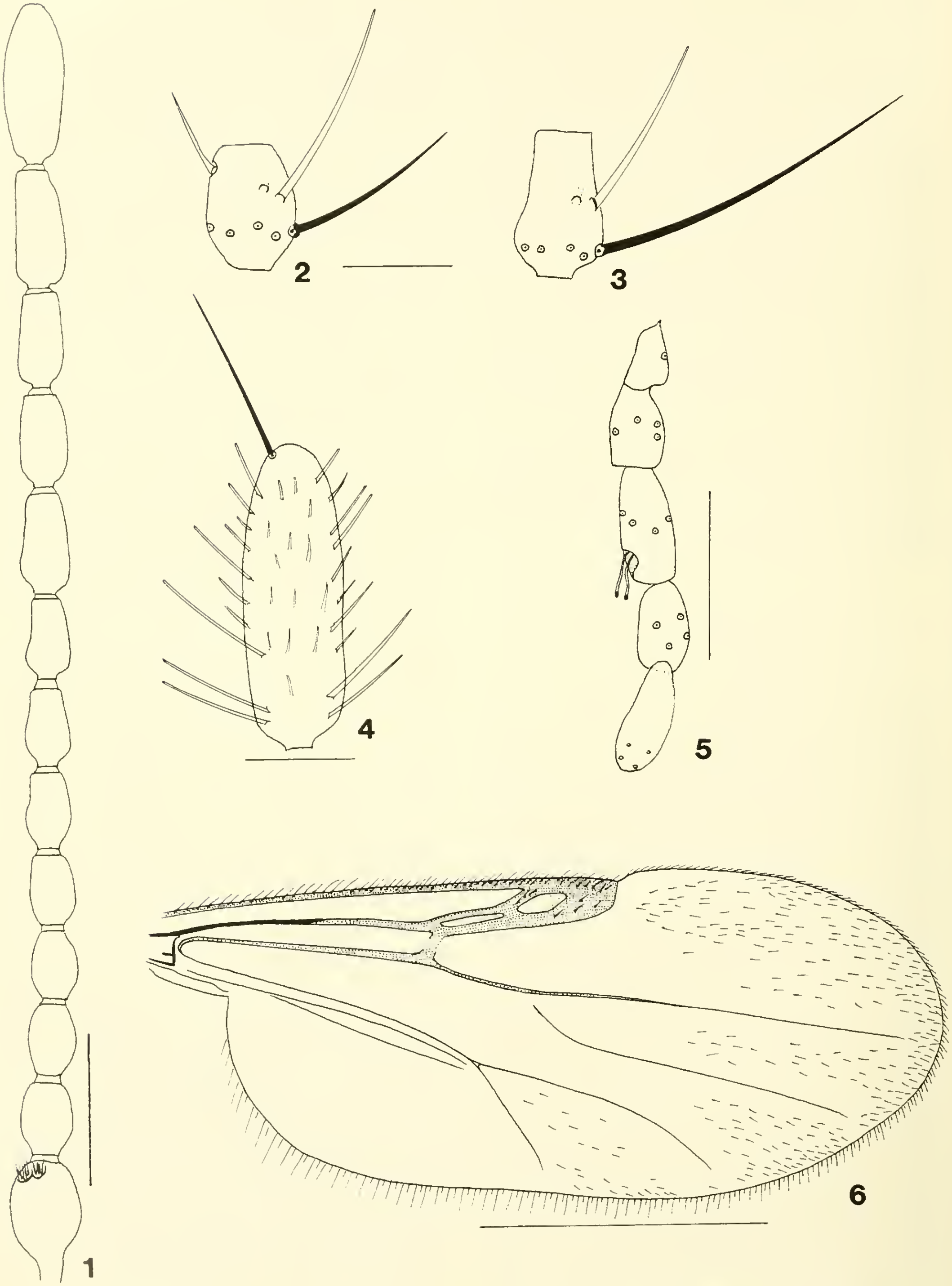
All other genera of the tribe Ceratopogonini differ from *Borkenthelea* by either lacking sensilla coeloconica on flagellomere 1 or in having a single radial cell or none (Wirth and Grogan 1988).

Borkenthelea nothofagus **Spinelli and Grogan, New Species**

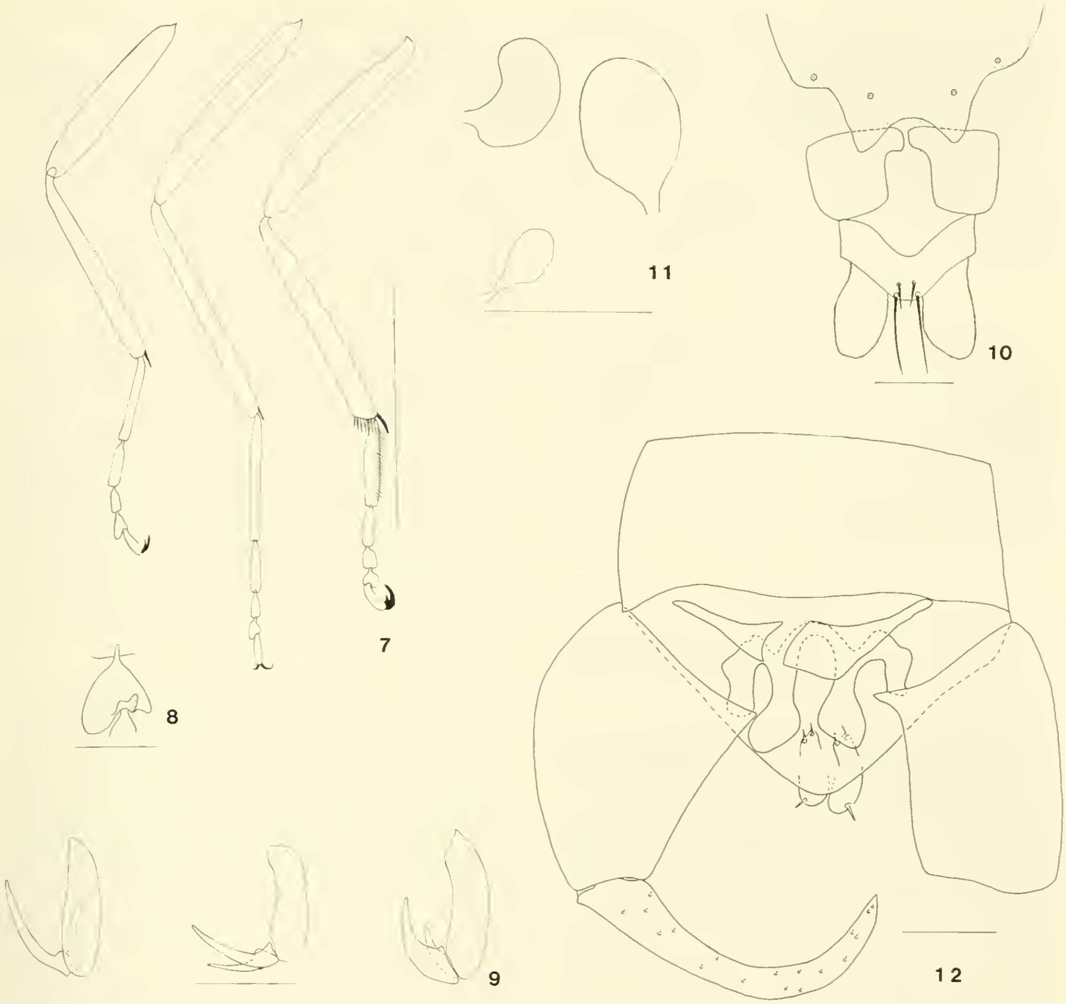
Figs. 1–12

Female.—Wing length 1.00–1.35 mm; breadth 0.46–0.58 mm. *Head:* Dark brown. Eyes pubescent, contiguous for a distance equal to the diameter of 2.5 ommatidia. Antennal flagellum (Fig. 1) brown; flagellomere 1 with 2 subapical sensilla coeloconica, 4–5 sensilla chaetica, and 2 large sensilla trichodea; flagellomeres 2–7 (Fig. 2) with 4–5 sensilla chaetica, 2 large and one small sensilla trichodea; flagellomere 8 (Fig. 3) as in 2–7 but lacking the small sensilla trichodea which are sometimes absent on 2–7; flagellomere 13 (Fig. 4) with one apical sensilla chaetica; lengths of flagellomeres in proportion of 20-12-12-12-12-13-13-13-16-16-16-20-27; antennal ratio 0.88–0.90. Clypeus with 1–3 pairs of setae. Palpus (Fig. 5) brown; segment 3 with small shallow sensory pit; lengths of segments in proportion of 8-11-14-9-14; palpal ratio 2.20–2.30. Mandible with 9–10 teeth. *Thorax:* Dark brown; 4–5 prealar setae, 1 postalar; scutellum with 2 medial and 2 lateral setae. Wing (Fig. 6) membrane infuscated, covered with microtrichia and distal ½ with macrotrichia; wing moderately broad, 2.33 times longer than broad, anal lobe well developed; anterior veins dark brown, posterior veins lighter; 2 well formed radial cells, 1st with elongated narrow lumen, 2nd shorter with broader lumen; radial veins thickened especially distal of the 2nd radial cell; r-m crossvein short, ¼ length of petiole of media; veins M1, M2, CuA1 obsolete at apices, M2 obsolete at extreme base, media with long petiole, branching at level of R2+3, cubitus branching at level of mid-length of 1st radial cell; costal ratio 0.55–0.57. Halter pale. Legs (Fig. 7) brown; femora and tibiae slender, unarmed, hind tibial comb with 8 setae; hind tarsomere 1 with well developed palisade setae; hind tarsal ratio 2.00; tarsomeres 4 (Fig. 8) subcordiform; tarsomeres 5 (Fig. 9) slender with moderately large, unequal sized claws without basal teeth, those of hind leg most massive, claw proportions of fore, mid and hind legs, 21:9, 16:9, 16:9. *Abdomen:* Dark brown; segments 8–10 very heavily sclerotized. Genitalia as in Fig. 10; distal portion of sternite 8 and most of sternite 9 covered with spiculate membrane; sternite 10 with large, smaller pair of setae. Three ovoid spermathecae (Fig. 11) with distinct slender necks; largest 0.048 × 0.036 mm, mid sized partially collapsed in Argentina specimens, 3rd very small.

Male.—Wing length 1.05 mm; breadth 0.46 mm. Similar to female with the following notable sexual differences: Antennal flagellum missing from preparation; mandible vestigial, without teeth; claws small, equal sized, simple with bifid tips; costal ratio 0.55. Genitalia as in Fig. 12. Sternite 9 twice as broad as long, caudal margin nearly straight; tergite 9 very short, nearly triangular, with 4 subapical setae, apicolateral process small bulbous with a single subapical seta, cercus ventrally located with two apical setae. Gonocoxite stout, 1.5 times longer than broad with a slender mediobasal lobe; gonostylus slender covered with small



Figs. 1–6. *Borkenthelea nothofagus*, female. 1, flagellum; 2, flagellomere 2; 3, flagellomere 5; 4, flagellomere 13; 5, palpus; 6, wing. Scale bars = 0.05 mm (Figs. 1–5); 0.5 mm (Fig. 6).



Figs. 7–12. *Borkenthelea nothofagus.* 7–11 female; 12, male. 7, legs from left to right fore, mid, hind; 8, tarsomere 4; 9, 5th tarsomeres and claws, from left to right fore, mid, hind; 10, 12, genitalia; 11, spermathecae. Scale bars = 0.5 mm (Fig. 7); 0.05 mm (Figs. 8–12).

setae arranged as indicated, slightly longer than gonocoxite, distal ½ curved nearly 90°, tip pointed. Aedeagus very short (length/width = 0.31), heavily sclerotized, triangular. Parameres fused basally; basal apodeme recurved, broad distally; distal portions together forming a U-shaped structure, each portion with swollen, divergent tip.

Distribution and bionomics.—Known only from the temperate subantarctic *Nothofagus* forest of southwestern Argentina and Chile. The two females from the type-locality were swept from above a shallow muddy depression at the base of Volcan Tronador.

Types.—Holotype female, paratype female, Argentina, Rio Negro Prov., parque nac. "Nahuel Huapi," Cerro Tronador, 25-I-1988, G. Spinelli, deposited in the Museum de La Plata, Argentina (MLPA); allotype male, Argentina, Rio Negro Prov., Correntoso, XI-1926, R. & E. Shannon

(USNM); paratype female, Chile, Valdivia, Lago Neltume, 26-XI-1992, G. R. Spinelli, sweep net (MLPA); paratype female, Chile, Cautin, 1150 m, Conguillo Nat. Park, 4–5.II. 1988, L. Masner (CNCI).

Etymology.—The specific epithet, a noun in apposition, refers to the *Nothofagus* forest where this species was collected.

ACKNOWLEDGMENTS

We are grateful to A. Borkent, B. Wiegmann and W. Wirth for reviewing an earlier draft of the manuscript, and to George Steyskal for advice about the specific epithet. We also thank the Salisbury State University Foundation, Inc. for providing a publication grant.

LITERATURE CITED

Borkent, A. 1992. A new key to some genera of Ceratopogonini in the Holarctic (Diptera: Ceratopogonidae). Entomologica Scandinavica 22(1991): 433–436.

Borkent, A. and B. Bissett. 1990. A revision of the Holarctic species of *Serromyia* Meigen (Diptera: Ceratopogonidae). Systematic Entomology 15: 153–217.

Downes, J. A. and W. W. Wirth. 1981. Ceratopogonidae, Chapter 28, pp. 393–421. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera. Vol. I. Agriculture Canada Monograph 27, Ottawa. 647 pp.

Grogan, W. L., Jr. and A. Borkent. 1992. *Sinhalohelea,* a new genus of predaceous midge from Sri Lanka (Diptera: Ceratopogonidae). Proceedings of the Entomological Society of Washington 94: 314–319.

Grogan, W. L., Jr. and W. W. Wirth. 1979. *Notiohelea,* a new genus of biting midges of the tribe Ceratopogonini from Chile (Diptera: Ceratopogonidae). The Pan-Pacific Entomologist 54(1978): 283–286.

Spinelli, G. R. 1990. The genus *Brachypogon* in Argentina, with a key to the Neotropical species (Diptera: Ceratopogonidae). Revista brasileira Entomologia 34: 743–755.

Spinelli, G. R. and W. L. Grogan, Jr. 1990. New species of predaceous midges of the tribe Ceratopogonini from subantarctic Argentina (Diptera: Ceratopogonidae). Proceedings of the Entomological Society of Washington 92: 127–134.

Szadziewski, R. 1984. Ceratopogonidae (Diptera) from Algeria. V. *Brachypogon* (*Isohelea*) *surae* n. sp. (Ceratopogonini). Polskie Pismo Entomologiczne 53: 555–558.

Wirth, W. W. and W. L. Grogan, Jr. 1988. The predaceous midges of the world (Diptera: Ceratopogonidae; Tribe Ceratopogonini). Flora and Fauna Handbook no. 4. E. J. Brill, New York. xv + 160 pp.

Wirth, W. W. and N. Marston. 1968. A method for mounting small insects on microscope slides in Canada balsam. Annals of the Entomological Society of America 61: 783–784.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 327–350

REVIEW OF THE GENUS *CHELIPODA* MACQUART OF AMERICA NORTH OF MEXICO (DIPTERA: EMPIDIDAE; HEMERODROMIINAE)

John F. MacDonald

Department of Entomology, 1158 Entomology Hall, Purdue University, W. Lafayette, Indiana 47907-1158.

Abstract.—The genus *Chelipoda* Macquart is reviewed for America north of Mexico. Descriptions of *C. contracta* Melander, *C. elongata* (Melander) (**Lectotype designated**), *C. praestans* Melander, *C. sicaria* Melander, *C. americana* (Melander) (**new combination**), ***Chelipoda limitaria*** n. sp., and ***Chelipoda truncata*** n. sp. are presented. A key to males and females, illustrations of male terminalia, known distributions, and comments on biology and systematics are included.

Key Words: Diptera, Empididae, Hemerodromiinae, *Chelipoda, Phyllodromia*

Adult flies of the genus *Chelipoda* Macquart are very small (body length about 2 mm) and delicate. They possess strong raptorial fore legs, and their legs and body usually are predominantly yellow to yellowish brown. The wings are relatively slender since they lack an anal lobe. *Chelipoda* has been placed in the subfamily Hemerodromiinae, the taxonomy of which was treated by Melander (1902, 1928, 1947). This paper is limited to species of *Chelipoda* of America north of Mexico and includes revised descriptions of known species, descriptions of two new species, a key to male and female adults, known distributions, and comments on biology and systematics. In addition to species treated here, representatives fitting the present concept of *Chelipoda* are reported from: China (Yang and Yang 1990); India, Indonesia, Philippines and Taiwan (Melander 1928); Europe (Chvala and Wagner 1989, Collin 1961, Engel 1956); New Zealand (Collin 1928); and South America (Collin 1933, Lynch Arribalzaga 1878, Smith 1967).

Materials and Methods

The present study was facilitated by examination of the large numbers of *Chelipoda* adults added to North American collections since Melander's (1947) revision. The following institutions (acronyms following) loaned the material upon which this work is based: American Museum of Natural History, New York (AMNH); Canadian National Collection, Biological Resources Division, Agriculture Canada, Ottawa (CNC); California Academy of Sciences, San Francisco (CAS); Cornell University, Ithaca (CU); Florida State Collection of Arthropods, Gainesville (FSCA); Helzinki Zoological Museum (HZM); Purdue University Entomological Research Collection (PERC); Snow Museum, University of Kansas, Lawrence (UKL); United States National Museum of Natural History, Washington, D.C. (USNM); University of Minnesota, St. Paul (UMSP); University of New Hampshire, Durham (UNH); University of Wisconsin, Madison (UWM); and Utah State University, Logan (USU).

Specimens also came from the author's collection (MAC).

Specimen examination took place under fiber optic illumination, with study of vestiture facilitated by use of fluorescent lighting. Since coloration and color patterns are in part a consequence of light incidence, examination of antennae and tarsi under a microscope required rotation of specimens. Body length was measured from front of head (exclusive of antennae) to the apex of female cerci and the most distant margin of male terminalia (not their apex since they project anteriorly over the abdomen). Maceration of body parts during the early phase of the study was conducted in an approximately 15% solution of sodium hydroxide heated to about 80 C, but much better preparations were achieved after maceration in 85% lactic acid heated to about 80 C, as described by Cumming (1992). Some specimens prepared by the latter technique subsequently were passed through an approximately 15% solution of sodium hydroxide heated to about 80 C in order to completely remove soft tissue and to effect additional clearing of heavily sclerotized male terminalia.

Special of *Chelipoda* possess a number of characters of taxonomic value. Among the most important is vestiture, the terminology for which is based on McAlpine (1981). The basic form of macrotrichia is a seta (= hollow, articulated epidermal outgrowth), with the following descriptive terms applied to it: hair (= long, slender seta); bristle (= long, stout seta); and setula (= short, stout seta). Setulae on adults of *Chelipoda* typically are black, and may be sharply pointed or bluntly pointed; the latter assume a peg-like appearance. The color of antennal segments and arista, distal tarsomeres and postgena is also of taxonomic importance. Relative elongation of the thorax, based on the length of the notopleural suture relative to the length of the scutum, is important and among Nearctic species sorts into two forms: 1) thorax relatively long and slender, in which the notopleural suture is ca. ⅔ the length of scutum; and 2) thorax relatively short and compact, in which the notopleural suture is ca. ½ the length of scutum. Length of the female cercus relative to its basal width helps in diagnosing some species.

Male terminalia are distinctive for each species. Interpretation and terminology in general follows McAlpine (1981) and, specifically, the recent interpretation of genitalic homologies outlined in Cumming and Sinclair (1990). Maceration is required to reveal internal features, but at least some of the diagnostic features are visible on many intact dry-mounted males, especially those collected into alcohol and then either prepared by critical point drying, or by passing through cellosolve and then xylene (Sabrosky 1966). Both lateral and dorsal views of male terminalia are illustrated and each includes details of internal structures.

Genus *Chelipoda* Macquart

Chelipoda Macquart 1823: 148. Type species: *Tachydromia mantispa,* misidentification (orig. des.) (= *vocatoria* Fallen, 1816).

Phyllodromia Zetterstedt 1837: 31. Type species: *Empis melanocephala* Fab. (des. Rondani, 1856: 150).

Chiromantis Rondani 1856: 148 (also as *Chyromantis,* p. 148) (preocc. Peters, 1854). Type species: *Tachydromia vocatoria* Fallen 1816 (orig. des.).

Lepidomya Bigot, 1857: 557, 563. Type species: *Tachydromia mantispa* Panzer, 1806 (= *Empis melanocephala* Fab., 1794). Junior synonym of *Phyllodromia* Zetterstedt, 1837.

Thamnodromia Mik 1886: 278. (unnecessary name change for *Phyllodromia* Zett.).

Litanomyia Melander 1902: 231. Type species: *Sciodromyia mexicana* Wheeler & Melander (Coquillett, 1903: 252).

Lepidomyia Kertesz, 1909: 117. (unjustified emendation of *Lepidomya* Bigot, 1857).

Diagnosis.—Adult flies in the genus *Chelipoda* are very small (body length including terminalia usually 1.8 to 2.2 mm, with females slightly larger than conspecific males), delicate, usually yellow to yellowish brown flies that possess strong raptorial fore legs. Differing from those of other Nearctic Hemerodromiinae, adults of *Chelipoda* possess an antennal arista at least twice as long as the flagellum, an unbranched R_{4+5} vein, and bristles on the laterotergite. Characteristic, but not necessarily diagnostic features of *Chelipoda*, are the male terminalia that project anteriorly over the abdomen and the lack of a sclerotized ovipositor in females.

Description.—Nearctic species of *Chelipoda* agree with the detailed generic description presented by Collin (1961). One minor modification to Collin's description pertains to the fore tibia being ridged beneath. Examination of slide-mounted fore legs revealed that the "ridge" actually is formed by a contiguous series of black setulae, each bent at a right angle toward the apex of the fore tibia.

Remarks.—Two arrangements of wing venation occur among species allied with *Chelipoda* and have provided a prior basis for distinguishing two species groups, given either generic or subgeneric rank. Species possessing crossvein dm-cu, and thus a closed cell dm, have been placed in *Chelipoda* Macquart whereas species lacking crossvein dm-cu, which results in an open cell dm, have been placed in *Phyllodromia* Zetterstedt. This latter taxon has been treated as a genus by Steyskal and Knutson (1981), Collin (1961) and Melander (1947). Although treating *Phyllodromia* as a genus, both Collin (1961) and Melander (1947) commented on the doubtful generic importance of crossvein dm-cu. For the same reason, Tuomikoski (1966) considered *Phyllodromia* as a subgenus of *Chelipoda*. However, since no phylogenetic analysis has demonstrated that "*Phyllodromia*" and "*Chelipoda*" are monophyletic groups, formal designation of *Phyllodromia* as a subgenus is not considered warranted, and all species treated here are placed in *Chelipoda*, without subgeneric designation. Two Palearctic species, *C. albiseta* Zetterstedt and *C. vocatoria* Fallen, once included on species lists from the eastern United States, apparently do not occur in North America.

The identification key relies upon vestiture and male terminalia. Important vestiture applicable to both males and females includes: 1) the presence of either one or two ventral rows of some 16–20 black setulae on the fore femur; and, 2) the presence or absence of a prominent basolateral seta (sometimes two) on the fore coxa. Taxonomic components of male terminalia include: degree of fusion between the hypandrium and epandrium, ranging from separate to completely fused; degree of fusion between each cercus and corresponding epandrial lobe, ranging from separate to completely fused; structure and vestiture of cerci; length and shape of the phallus; length and shape of a pair of epandrial lobes; and, if developed, length and shape of a pair of phallic processes.

KEY TO ADULTS OF SPECIES OF *CHELIPODA* MACQUART OF AMERICA NORTH OF MEXICO

1. Crossvein dm-cu lacking, cell dm-cu open (Fig. 1) 2
– Crossvein dm-cu present, cell dm-cu closed (Fig. 2) 3
2. Phallic process extending ca. ½ length of cercus; subepandrial lobe in-turned apically with tip crossing mid-line and ending in 3 black processes (Fig. 3) ..... *C. americana* (Melander)[a]
– Phallic process extending slightly beyond apex of cercus; subepandrial lobe in-turned apically, but tip lacking 3 black processes apically and not crossing mid-line (Fig. 4) .... *C. limitaria*, new species[a]
3. Fore femur ventrally with 2 complete rows of black setulae (outer row usually containing fewer), flanked laterally by row of ca. 4–5 light brown bristles (Fig. 5) 4
– Fore femur ventrally with only 1 complete row

---

[a] Reliable characters for identifying females were not discovered (see diagnosis section under both species).

(inner) of black setulae (outer row of fewer, less prominent setulae may exist), flanked laterally by ca. 4–6 light brown bristles (Fig. 6) 6

4\. Fore coxa with 1 or 2 prominent setae basolaterally (occasionally dislodged) and row of finer setae continuing distally (Fig. 7); male terminalia subequal to pre-genital segment (Fig. 9); female cercus length and basal width subequal (Fig. 10) .... *C. contracta* Melander

– Fore coxa lacking prominent seta basolaterally (Fig. 6); male terminalia distinctly longer than pre-genital segment; female cercus ca. 2× longer than basal width (Fig. 11) 5

5\. Distal tarsomere brown, remaining tarsomeres yellow; postgena, gena, and occiput black; flagellum dark brown; subepandrial lobe pointed, not strongly sclerotized apically; phallic process and phallus subequal in length (Fig. 12) .... *C. elongata* Melander

– Tarsomeres yellow; postgena with distinct pale area on mid-ventral aspect that contrasts with darker gena and occiput (Fig. 8); flagellum yellow (male) or light brown (female); subepandrial lobe truncate, strongly sclerotized apically; phallic process ½ length of phallus (Fig. 13) .... *C. truncata*, new species

6\. Phallus slender in dorsal view, in lateral view distal ⅓ sinuate; subepandrial lobe not apparent in lateral view, extending only ca. 1/10 length of phallus (Fig. 14) ..... *C. praestans* Melander[b]

– Phallus not uniformly slender in dorsal view, in lateral view distal ⅓ abruptly bent; subepandrial lobe well developed, ca. ⅔ length of phallus and bent upward in lateral view (Fig. 15) .... *C. sicaria* Melander[b]

Chelipoda americana (Melander), New Combination

(Figs. 1, 3)

Phyllodromia americana Melander, 1947: 269.

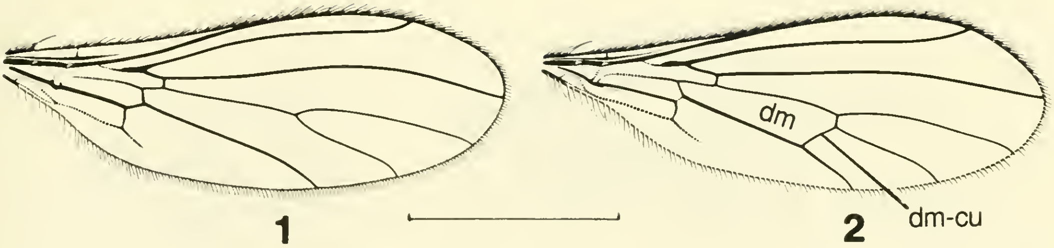
Diagnosis.—Absence of crossvein dm-cu in both wings distinguishes adults of this species and those of *C. limitaria*, newly described below, from other species of *Chelipoda* treated here on which dm-cu very rarely is lacking in one wing. Examination of terminalia is required to separate males of *C. americana* and those of *C. limitaria*. The distinction between them is based on comparative structure of the subepandrial lobes and phallic processes. Males of *C. americana* possess phallic processes that are much shorter than the cerci and acutely inturned subepandrial lobes, the tips of which cross and each of which ends in three black projections. In comparison, males of *C. limitaria* possess phallic processes that are slightly longer than the cerci and lack black, distal projections on the subepandrial lobes, the tips of which do not cross.

Description.—Length including terminalia of male ca. 1.8 to 2.0 mm, of female ca. 1.8 to 2.1 mm. General color of male yellow, of female yellowish brown. Head black, except for yellow mouthparts and palps; bristles yellow. Antennal scape and pedicel yellow; flagellum and arista of male yellowish brown, of female brown. Thorax short, compact; bristles yellow. Legs yellow; distal tarsomere light brown. Fore femur ventrally with 2 rows of black setulae, each row flanked by row of 4–5 yellow bristles (see Fig. 5). Fore coxa lacking prominent basolateral seta, but row of fine setae continuing distally (see Fig. 6). Wing hyaline; crossvein dm-cu lacking; cell dm open (Fig. 1). Abdominal terga of male greyish brown, of female reddish brown; sterna paler than terga in both sexes. Male terminalia (Fig. 3) yellow, compact; hypandrium and epandrium only partially fused medially; cercus and epandrial lobe completely fused; cercus slender distally, ending in 3 strong setulae; subepandrial lobe curved acutely inward with tip crossing mid-line in dorsal view, ending in 3 pointed, black processes of uneven size; phallic process pointed apically, ca. 2× length of phallus and ca. ½ length of cercus. Female cercus short (see Fig. 10); spermatheca more or less reniform, with spermathecal duct arising from center of concave surface.

Type material examined.—HOLOTYPE

---

[b] Females are difficult to identify, with side by side comparison necessary: those of *C. sicaria* possess a brown antennal arista that contrasts with the pale pedicel and brown thoracic setae; those of *C. praestans* possess a tan antennal arista that does not contrast with the pale pedicel and tan thoracic setae.



Figs. 1, 2. 1, *Chelipoda americana* wing. 2, *Chelipoda contracta* wing. dm = cell; dm-cu = crossvein. Scale bar = 1.0 mm.

male, labelled "Mt. Monadnak/ 26 Jul '26 NH/ A L Melander" (USNM). The specimen is in excellent condition, at least some of the diagnostic features of the terminalia are visible without maceration, and the corrected type locality is Mt. Monadnock, New Hampshire. ALLOTYPE. Virginia: Great Falls, June (lacking head) (USNM). PARATYPES. Georgia: 1 female, Burton, May; 1 female, Decatur Co., Jun (USNM). New York: 2 females, 1 male, Millwood, Jun (USNM). Rhode Island: 1 female, Westerly, Jul (USNM). Virginia: 1 specimen (lacking abdomen), Great Falls, Jun (USNM).

Other specimens examined.—CANADA. Ontario: 1 female, 3 km E. Carp, Jul (CNC). UNITED STATES. Georgia: 1 female, Waycross, Mar (CNC). Florida: 1 female, Alachua Co., Apr (USNM). Maryland: 2 males, Bethesda, Jun (USNM). Massachusetts: 1 male, Nonomesset, Jul (USNM). New Hampshire: 1 female, Mt. Madison, Dolly Copp cmpgr., Jul (CNC). New York: 1 male, St. Lawrence Co., Jun (USNM). North Carolina: 1 male, Highlands, May (CNC).

Distribution.—Adult males of this species are known from eastern New York state, New Hampshire, southeastern Maryland, and the mountains of western North Carolina (Fig. 16).

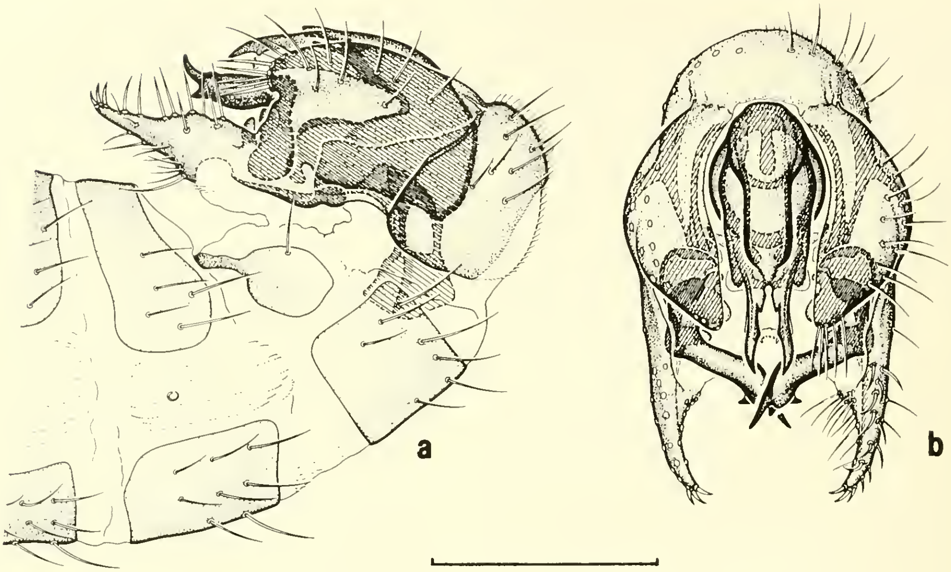
Remarks.—Some of the female paratypes and other females of *C. americana* recorded from the southeastern United States (Fig. 16) probably are females of *C. limitaria.* As mentioned in the identification key, reliable characters for separating females of *C. americana* and *C. limitaria* were not found (therefore the qualification pertaining to distribution records). However, female specimens from the northeastern United States and southeastern Canada, which probably are *C. americana,* are slightly smaller and possess a paler antennal arista than females in the type series of *C. limitaria.*

***Chelipoda contracta* Melander**
(Figs. 2, 5, 7, 9, and 10)

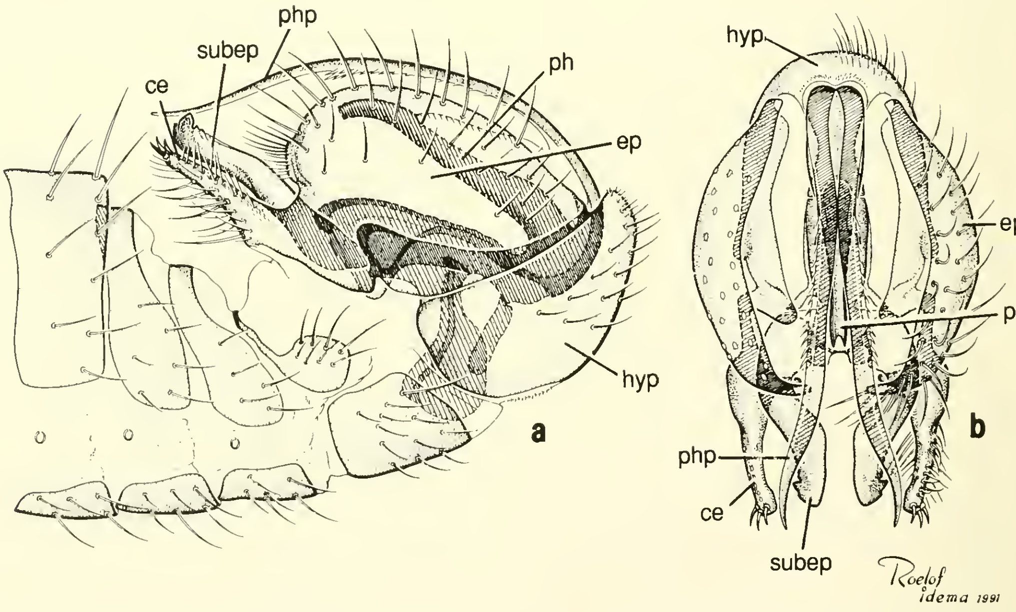
Chelipoda contracta Melander, 1947: 265.

Diagnosis.—Adults are distinguished from those of other species treated here by the combination of two ventral rows of black setulae on the fore femur and at least one prominent seta (sometimes two) basolaterally on the fore coxa. The basolateral seta on the fore coxa usually is prominent, but often is less obvious on males, and occasionally is dislodged from one or both legs. Males are recognized by their delicate yellow bodies and small, compact terminalia. The relatively short, compact thorax of both sexes and the short cercus of females aid in separating adults of *C. contracta* from those of *C. elongata* and *C. truncata,* which also possess two complete rows of black setulae ventrally on the fore femur.

Description.—Length including terminalia of male ca. 1.6–1.8 mm, of female ca. 1.8 to 2.1 mm. General color of males yellow, of females usually yellowish brown.



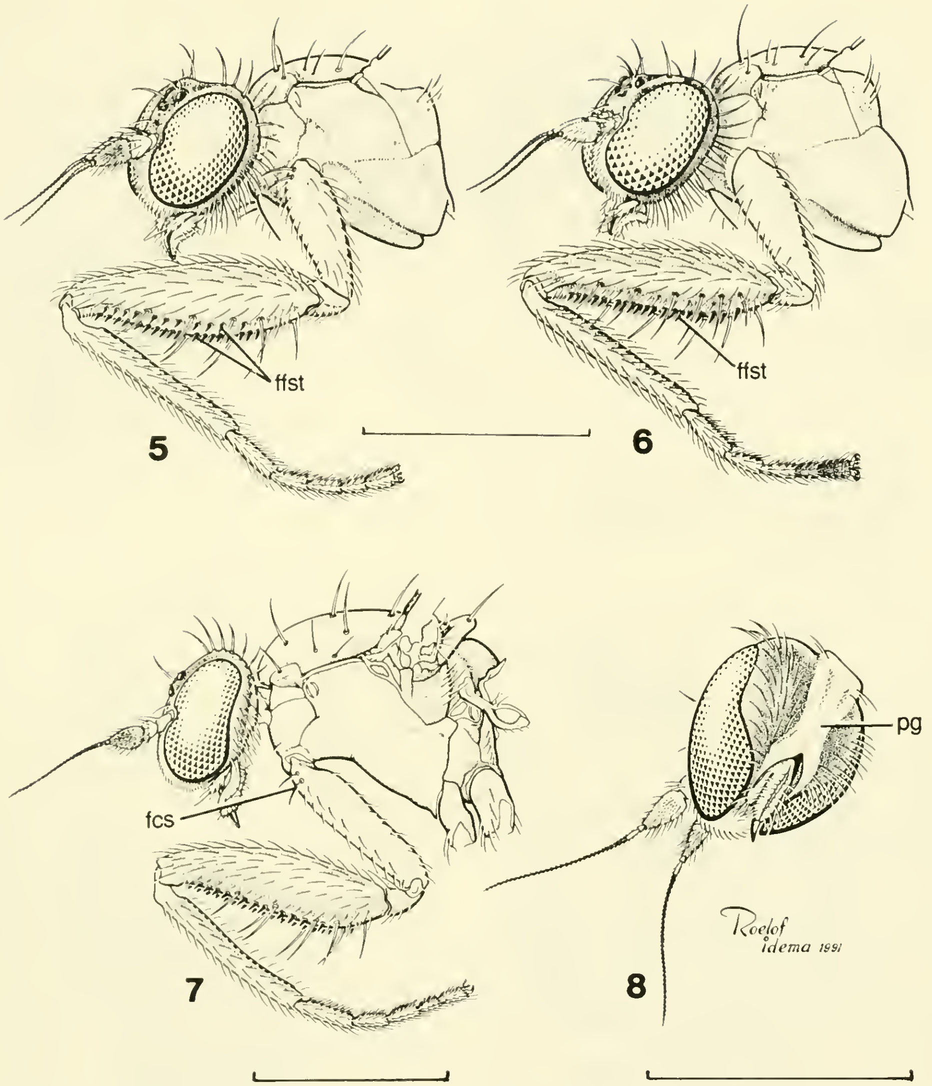
3



4

Figs. 3, 4. 3a (lateral) and b (dorsal), *Chelipoda americana* male terminalia. 4a (lateral) and b (dorsal), *Chelipoda limitaria* male terminalia. ce = cercus; hyp = hypandrium; ph = phallus; php = phallic process; ep = epandrium; subep = subepandrial lobe. Scale bar = 0.25 mm.

Head black, except for grey frons and postgena; mouthparts and palps yellow; bristles yellow. Antennal scape and pedicel yellow; flagellum and arista light brown to brown. Thorax short, compact; yellow to yellowish brown; bristles yellow. Legs yellow; fore femur ventrally with 2 rows of black setulae, each flanked by row of 4–5 light brown bristles (Fig. 5); fore coxa with a prominent basolateral seta (Fig. 7), weaker and less

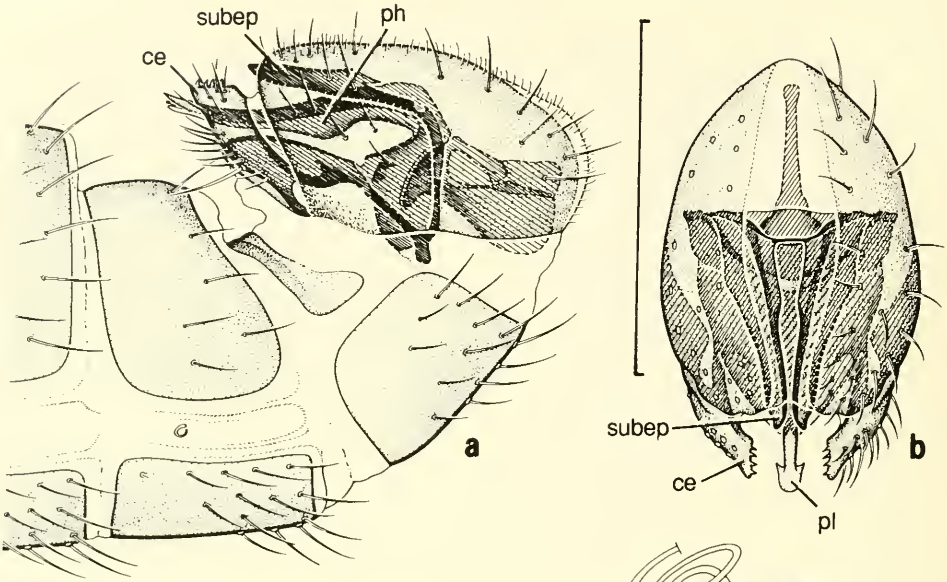


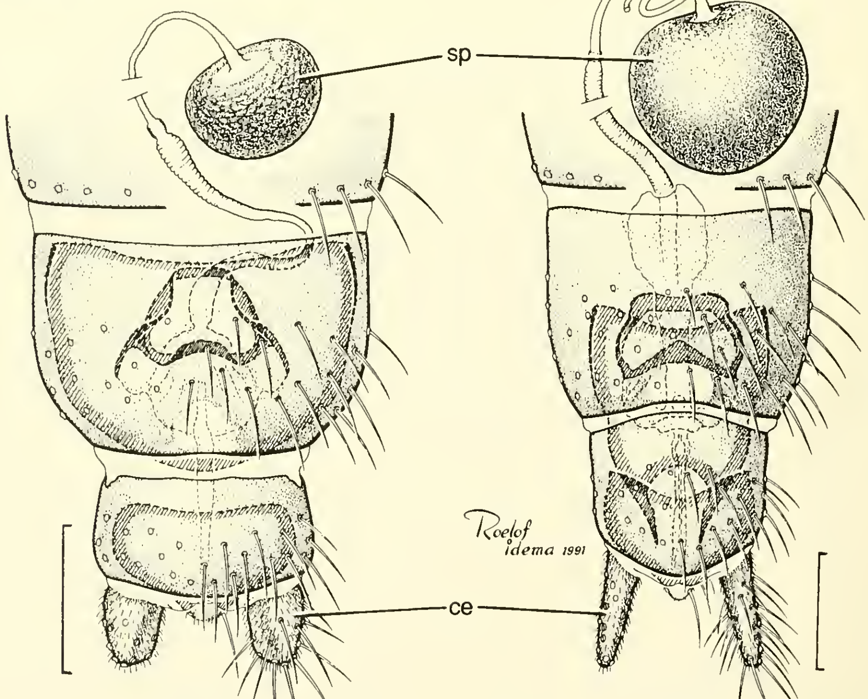
Figs. 5–8. 5, *Chelipoda contracta* fore femur. 6, *Chelipoda praestans* fore femur. 7, *Chelipoda contracta* fore coxa. 8, *Chelipoda truncata* mid-ventral view of postgena. fcs = basolateral seta of fore coxa; ffst = setulae of fore femur; pg = postgena. Scale bars = 0.5 mm.

prominent on male. Wing hyaline; crossvein dm-cu present; cell dm closed (Fig. 2). Abdominal terga yellowish brown, sterna light brown. Male terminalia (Fig. 9) yellow; compact, subequal to pre-genital segment; cercus and phallus projecting anteriorly only slightly beyond the completely fused hypandrium and epandrium; cercus separate from epandrial lobe, nearly rectangular in lateral view; subepandrial lobe sword-shaped, ca. ¾ length of phallus; phallus strongly expanded at apex in dorsal view, subequal in length to cercus; phallic processes lacking. Female cercus short; spermatheca hemispherical, with spermathecal duct arising from center of flat surface (Fig. 10).

Type material examined.—HOLOTYPE

9





10

11

Figs. 9–11. 9a (lateral) and b (dorsal), *Chelipoda contracta* male terminalia. 10, *Chelipoda contracta* female terminalia. 11, *Chelipoda elongata* female terminalia. ce = cercus; ph = phallus; sp = spermatheca; subep = subepandrial lobe. Scale bars = 0.25 mm (Fig. 9a, b) and 0.1 mm (Figs. 10, 11).

male, labelled "Petersham/ MASS 9 vi '32/ A L Melander" (USNM). The specimen is in excellent condition and at least some of the diagnostic features of the terminalia are visible without maceration. A female labelled "ALLOTYPE *C. contracta*" with the same collecting data as the holotype was *C. praestans*. PARATYPES. CANADA. British Columbia: 1 female, Abbotsford, Aug (USNM); 3 females (CU) and 1 female (USNM), Downie Crk., Selkirk Mts., Aug. Ontario: 1 male, 4 females, Waubamich, Jun (USNM). UNITED STATES. Connecticut: 3 females, 5 males, Redding, May–Jun (USNM). Massachusetts: 1 female, 1 male, Boston, Jun; 1 female, 1 male, Petersham, Jul (USNM). Maine: 2 females, Seal Harbor, Jul (USNM). New Hampshire: 4 females, Breton Woods, Jul (USNM). New York: 4 females, 1 male, Ithaca, Jun; 1 female, 2 males, Tuxedo, May (USNM). Washington: 11 females, 12 males, Index, Aug; 2 females, Lake Cushman, Jul; 11 females, Mt. Baker, Skyline Trail, Aug; 4 males, Mt. Constitution, Jul; 1 male, Mt. Vernon, Jul; 1 female, Sultan, Aug (USNM).

Other specimens examined.—CANADA. Alberta: 1 female, Waterton Prk., Jul (CNC). British Columbia: 3 females, 1 male, Cultus Lk., Jun–Aug; 1 female Liard Hot Sprs., Jul; 36 females, 35 males, Terrace, Jun–Aug (CNC, CU, UKL, USNM). Manitoba: 1 female, Brandon, Jul; 1 female, 1 male, Forrest, Jul; 5 females, Ninette, Jul; 8 females, Turtle Mt., Jul–Aug (CNC). New Brunswick: 2 females, Acadia, Jun; 1 female, Chamcock, Jul (CNC). Newfoundland: 1 female, Bay of Islands, Jul; 7 males, 8 females, St. Johns, Aug (AMNH, CNC). Nova Scotia: 29 females, 46 males, Cape Breton Highlands Nat. Prk., Jun–Aug; 14 females, 2 males, Lockport, Jul–Aug; 1 female, Shelburne, Aug; 5 females, Springfield, Aug (CNC). Ontario: 1 male, Atikokan, Jul; 2 females, Ft. Francis, Jul; 1 male, 3 females, Griffith, Jun–Jul; 1 female, Kenora, Aug; 1 female, Mamora, Jul; 2 females, Maynooth, Jun; 2 females, 1 male, Midland, Jul–Aug; 1 male, One-Sided-Lake, Jun; 4 females, 4 males, Ottawa, Jun–Jul; 1 female, S. March, Jun; 2 females, Waubamich, Jun–Jul (CAS, CNC). Quebec: 1 female, Abbotsford, Jun; 1 female, 1 male, Beechgrove, Jun; 3 females, 2 males, Breckenridge, Jun; 1 female Cap Rouge, Jul; 1 female, Corey Hill, Jun; 17 females, 13 males, Old Chelsea; 2 females, Park Reserve, Jul; 1 female, Rivere-du-Loop, Jul; 26 females, 1 male, Wakefield, Jun–Jul (CNC, USNM). Saskatchewan: 1 female, 1 male, Rockglen, Jun; 2 females, 3 males, Scout Lk., Jun (CNC). UNITED STATES. Georgia: 6 females, 5 males, Athens, Apr–May; 1 female, Black Rock Mt., May; 2 females, Rabun Co., Aug (CNC, CU, MAC). Illinois: 1 female, Macomb, May (USNM). Maine: 2 females, Mt. Katahdin, Jul (CNC). Maryland: 1 female, 1 male, Bethesda, May–Jun (USNM). Massachusetts: 1 female, 1 male, Woods Hole, Aug (AMNH). Michigan: 1 male, Cadillac, Jun; 1 female, Crawford Co., Jun; 2 females, Isle Royale, Jul–Aug; 2 females, Manistee, Jul; 3 females, Midland, Jun–Jul; 1 male, Schoolcraft, Jun (CNC, USNM). Minnesota: 8 females, 2 males, Basswood Lk., Jul–Aug; 1 female, Eaglenest, Aug; 2 females, 2 males, Itaska St. Prk., Jun–Jul (AMNH, UMSP). Montana: 2 females, Flathead Lk., Aug (USNM). New Jersey: 1 female, Brookside, Sep (AMNH). New York: 1 female, Essex Co., Jul; 1 female, Orleans Co., Aug (CAS, CNC). North Carolina: 1 female, Coweeta, May; 2 females, 1 male, Highlands, May; 1 female, Looking Glass Pk., Jul; 1 female, Macon Co., Jul (CNC, UNH); 1 female, McDowell Co., Sep (USNM). Pennsylvania: 3 females, Spring Bridge, Jun (USNM). Tennessee: 4 males, Great Smoky Mts. Nat. Prk., E. Gatlinburg, Jun–Jul (USNM). Virginia: 1 female, Alexandria, Jun; 1 female, Big Meadow, Jun; 2 females, Blacksburg, May; 2 males, Brush Mt., May; 2 males, Falls Church, May; 5 females, 1 male, Hawksbill, Jun (CNC, USNM). Washington: 4 females, 1 male, Friday Harbor, Jun–Jul (AMNH, CU, FSCA). Wisconsin: 1 female, Vilas Co., Jun (USNM).

Distribution.—This is the most widespread Nearctic species, occurring across southern Canada and the northern United States, and south into the Appalachian mountains of northern Georgia (Fig. 17).

Remarks.—Adults have been collected at sea level (Puget Sound, Washington) and near 1200 meters in the Appalachian Mountains. Specific habitats in the Appalachian Mountains include mesophytic hardwood, hemlock, and damp fir/spruce forests. Labelled specimens from Manitoba are from a Maple/Elm floodplain, "around a *Populus balsamifera* L. (balsam popular) slough," "in secondary growth vegetation associated with power lines," and a dead cat. Specimens also have been taken off blossoms of *Vaccinium* sp. in Virginia and in "wet, scrubby clearings" near Terrace, British Columbia. Several series consisting of males and females were collected in Malaise traps and yellow pan traps in Cape Breton Highlands National Park, Nova Scotia, by J. R. Vockeroth (Biological Resources Division, Agriculture Canada, Ottawa).

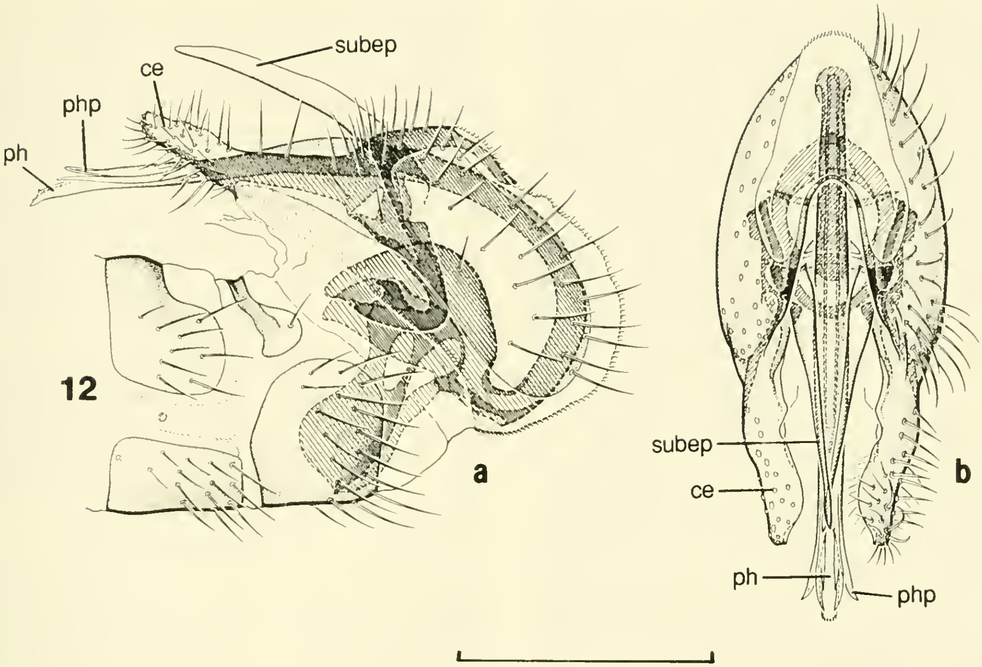
Chelipoda elongata (Melander)
(Figs. 11, 12)

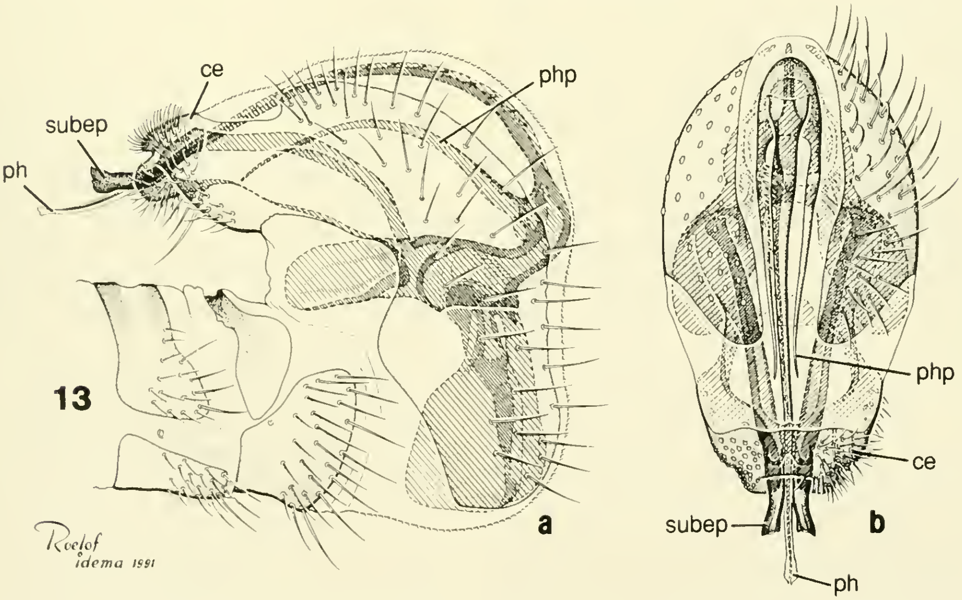
Litanomyia elongata Melander, 1902: 232.
Chelipoda elongata; Melander, 1928: 266.
Chelipoda albiseta (Zetterstedt) *sensu* Melander, 1947: 265 (misident.)

Diagnosis.—Adults of this species, similar to those of *C. contracta,* possess two ventral rows of black setulae on the fore femur, but they are distinguished by the elongated thorax, lack of a prominent basolateral seta on the fore coxa, and a long female cercus. The contrastingly darker distal tarsomere and concolorous postgena, gena and occiput distinguish adults of *C. elongata* from those of *C. truncata,* newly described below. Male terminalia resemble those of *C. truncata,* but differ in possessing pointed subepandrial lobes and phallic processes that are subequal in length to the phallus; males of *C. truncata* have truncate subepandrial lobes and much shorter phallic processes, which are about half the length of the phallus.

Description.—Length including terminalia of male ca. 2.0–2.5 mm, of female ca. 2.5–2.8 mm. General color yellow to yellowish or light reddish brown. Head black, including postgena; mouthparts and palps yellow to light reddish brown; bristles brown. Antennal scape and pedicel yellow; flagellum brownish black; arista brownish black on basal tenth, distally brownish to nearly white in some specimens. Thorax long, slender; yellow to yellowish brown; bristles brown. Legs yellow, except coxa and distal tarsomere light brown. Fore femur ventrally with 2 rows of black setulae, each flanked by row of 4–5 light brown bristles (see Fig. 5). Fore coxa lacking prominent basolateral seta, but row of fine setae continuing distally (see Fig. 6). Wing hyaline; crossvein dm-cu present; cell dm closed (see Fig. 2). Abdominal terga brown, sterna light brown. Male terminalia (Fig. 12) yellow, projecting anteriorly to abdominal segment 6; hypandrium and epandrium completely fused; cercus fused to epandrial lobe, nearly straight, subequal in length to subepandrial lobe; subepandrial lobe slender, slightly curved ventrally and pointed apically; phallus and phallic process nearly straight, subequal in length, extending anteriorly beyond cercus and subepandrial lobe. Female cercus long; spermatheca nearly oval, with spermathecal duct arising from the center of a somewhat flattened pole (Fig. 11).

Type material examined.—LECTOTYPE (here designated from Melander's cotype series number 29182), male labelled "Brookings/ SD" (USNM). The lectotype lacks the head and most of the right front leg, but most of the diagnostic features of terminalia are visible without maceration. The paralectotype series includes a *C. elon-*





Figs. 12, 13. 12a (lateral) and b (dorsal), *Chelipoda elongata* male terminalia. 13a (lateral) and b (dorsal), *Chelipoda truncata* male terminalia. ce = cercus; ph = phallus; subep = subepandrial lobe. Scale bar = 0.25 mm.

gata female with a "Mass" label, a *C. praestans* female with a "Mass" label, and a badly damaged *Chelipoda* specimen with a "Mass" label.

Other specimens examined.—CANADA. Manitoba: 7 females, 4 males, Ninette, Jul; 3 males, Turtle Mt., Jul (CNC). Ontario: 1 male, Ft. Credit, Aug; 1 male, Ft.

Frances, Jul; 21 females, 6 males, Grand Bend, Jul; 2 females, Griffith, Jul; 1 female, Kearny, Jul; 3 females, 6 males, Ottawa, Jul (CNC, USNM). Quebec: 2 males, Wakefield, Jul; 4 females, 1 male, Hull, Aug (CNC). UNITED STATES. Florida: 1 male, Alachua Co., Apr; 1 female, 3 males, Elfers, Apr; 1 male, 1 female, Everglades Nat. Prk., Apr; 1 male, Gainesville, Feb; 4 females, 2 males, Hialeah, Mar; 1 female, Homestead, Apr; 1 female, Jacksonville, Nov; 1 female, Putnam Co., May; 2 females, Royal Palm, Jan; 1 female, Sebring, Jun; 1 male, St. Petersburg, Mar; 1 male, Tarpon Sprs., Apr; 2 males, 5 females, Vero Beach, Apr (AMNH, CNC, UNH, USNM). Georgia: 3 females, Black Rock Mt., May; 1 female, Clayton, Aug; 6 females, 6 males, McIntosh Co., Sapelo I., Apr; 1 female, 1 male, Rabun Co., Jul (CNC, USNM). Indiana: 1 female, 1 male, Lafayette, Jun (USNM). Maryland: 1 male, Glen Echo, May; 1 male, Ft. Washington, May (USNM), Massachusetts: 1 female, Athol, Jul; 1 female, 1 male, Woods Hole, Aug (AMNH, USNM). Michigan: 1 female, Ann Arbor, Sep; 1 female, Bath, Jun; 1 female, Branch Co., May; 1 female, Cheboygan Co., Aug; 2 females, Clinton Co., Jun; 1 female, Detroit, Jun; 1 female, Isle Royale, Aug; 1 female, Manistee, Jul; 3 males, Midland Co., Jun; 1 female, Nottawa, Jun; 1 female, Traverse Co., 1 female, Wayne Co., Jul (CNC, UKL, USNM). Minnesota: 3 females, Basswood Lk., Jul; 1 male, Cass Co., Jul; 2 males, Itaska, Jul; 1 female, White Bear, Jul (UMSP). New Hampshire: 1 male, Dixville, Jul; 1 male, 1 female, White Mts., Stinson Lk., Jul (UNHC, USNM). New Jersey: 1 female, Brookside, Sep (AMNH). New York: 1 male, Canajoharie, Jul; 1 male, 1 female, Ithaca, Jul; 1 female Lk. Sebogan, Aug; 1 female, Ludlowville, Jul; 1 male, Peekskill, Jul; 1 female, Rome, Jun; 1 female, Oneotona, Aug; 1 male, Shokan, Jul; 1 female Thomkins Co., Aug (CNC, CUIC, USNM). North Carolina: 1 male, Bubbling Spr. Crk., Jul; 7 females, 3 males, Highlands, Jun–Jul; 8 females, 2 males, Looking Glass Rock, Jul; 4 males, 8 females, Nags Head, May; 1 female, Wayah Gap, Macon Co., Jul (CNC, USNM). Rhode Island: 1 female, 2 males, Westerly, Jul (USNM). South Carolina: 1 male, Mt. Rest, Oconee Co., Jul (CNC). South Dakota: 2 males, Pierre, Jul (UMSP). Tennessee: 5 females, 2 males, Gatlingburg, Jun–Jul (USNM). Virginia: 2 males, Richmond Co., Jul (USNM). Wisconsin: 1 female, 1 male, Vilas Co., Jul (UWM).

Distribution.—This species is widely distributed in eastern North America, occurring from extreme southern Manitoba and the northern Great Plains of the United States east to the Atlantic coast and south into southern Florida (Fig. 18).

Remarks.—Owing to the nearly white arista on many specimens, *C. elongata* probably was the species considered to be *Chelipoda albiseta,* a Palearctic species included in earlier state lists of insects. Melander (1947) expressed doubt that females, with a "strikenly white arista" were *C. albiseta,* suggesting instead that "when the male with a white arista is discovered a new name probably will be required." My examination revealed that variation exists in arista coloration of males of *C. elongata,* and perception of whiteness or darkness of a given arista is influenced by the incidence of light as specimens are rotated under the microscope.

Specimens of *C. elongata* have been collected from *Betula glandulosa* Michx. (tundra dwarf birch) in Manitoba, during sweeping of foliage of *Quercus laevis* Walt. (Turkey oak) in Florida, and in light traps.

***Chelipoda limitaria* MacDonald,**
NEW SPECIES
(Fig. 4)

Diagnosis.—Absence of crossvein dm-cu in both wings distinguishes adults of this species and *C. americana* from those of other *Chelipoda* treated here. The distinction between *C. limitaria* and *C. americana* is based on comparative structure of male genitalia, as presented in the diagnosis section pertaining to *C. americana,* with males of *C. limitaria* possessing phallic processes that are longer than the cerci and lacking black, distal projections on the subepandrial lobes, the tips of which do not cross.

Description.—MALE: Body length including terminalia ca. 1.8 mm. General color yellow to yellowish brown. *Head:* black, except for yellow mouthparts and palps; bristles yellow. Antennal scape and pedicel yellow; flagellum and arista brown. *Thorax:* short, compact; bristles yellow; scutum yellowish brown, darker brown along notopleural suture and at apex; scutellum and postnotum brown. *Legs:* yellow, except distal tarsomere light brown. Fore femur ventrally with 2 rows of black setulae, each flanked by row of 4–5 yellow bristles (see Fig. 5). Fore coxa lacking prominent basolateral seta, but with row of setae continuing distally (see Fig. 6). *Wing:* hyaline; crossvein dm-cu absent; cell dm open (see Fig. 1). *Abdomen:* terga greyish brown; sterna paler brown. Terminalia (Fig. 4) yellow, compact; hypandrium and epandrium almost completely separate; cercus fused to epandrial lobe, subequal in length to subepandrial lobe, slender and ending in 3 strong setulae; subepandrial lobe horseshoe-shaped in dorsal view; phallus ca. ⅔ length of phallic process, not extending past epandrial lobe in lateral view; phallic process slender, pointed apically, and extending slightly past cercus and subepandrial lobe. FEMALE: length including terminalia ca. 2.1–2.4 mm; general body color darker than male, thorax yellowish brown, darker brown along notopleural suture, with dark brown median stripe on scutum; abdominal terga 1–6 light brown, terga 7–8 yellowish; cercus short (see Fig. 10); spermatheca more or less reniform, with spermathecal duct arising from center of concave surface.

Type material.—HOLOTYPE male, labelled "GA: McIntosh Co./Sapelo Island/ 28. IV.–9. V, 1987: MT/Live Oak Forest/ BRC HYM. TEAM" (CNC, holotype no. 21333). The specimen is in excellent condition and at least some of the diagnostic features of terminalia are visible without maceration. ALLOTYPE labelled "GA: McIntosh Co./ Sapelo Island/28.IV, 1987: MT/Live Oak Forest/BRC. HYM. TEAM," deposited in CNC. PARATYPES. Georgia: 43 females, same collection site as holotype (CNC). North Carolina: 1 male, Fort Bragg, May–Jun (CAS). Texas: 1 male (macerated terminalia in glycerin microvial), 12 females, Montgomery Co., Jones St. For., 8 mi S. Conroe, Apr (CNC).

Distribution.—Males of this species are known only from the coastal plain of southeastern Texas and Georgia, and the inland coastal plain of North Carolina (Fig. 16).

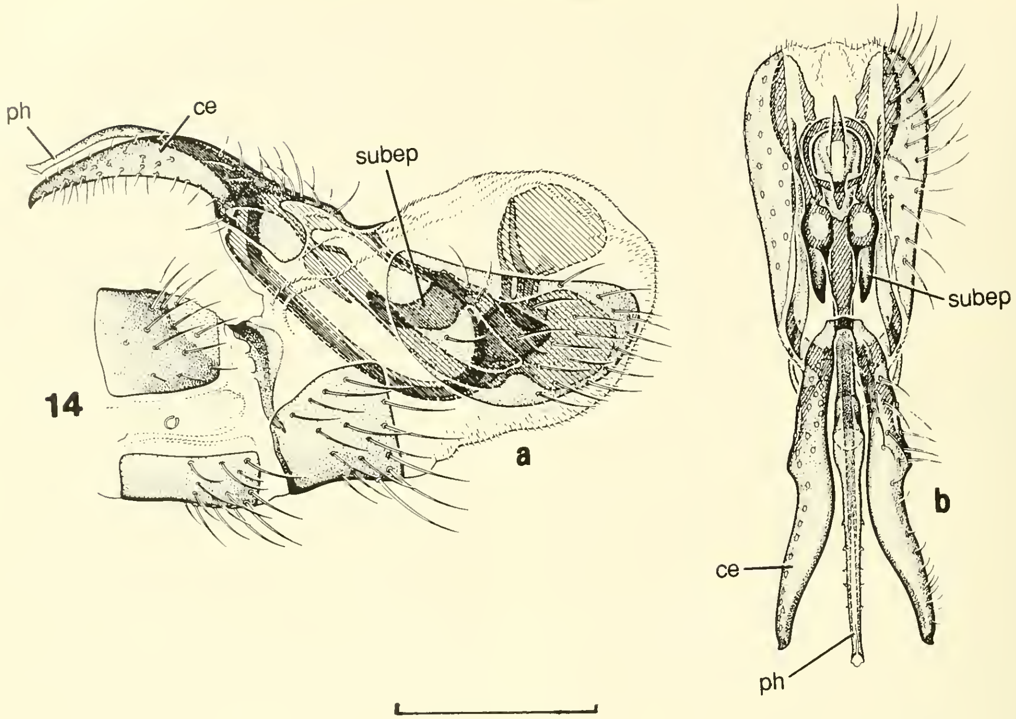
Etymology.—The specific epithet is in reference to the apparent limited distribution of this species.

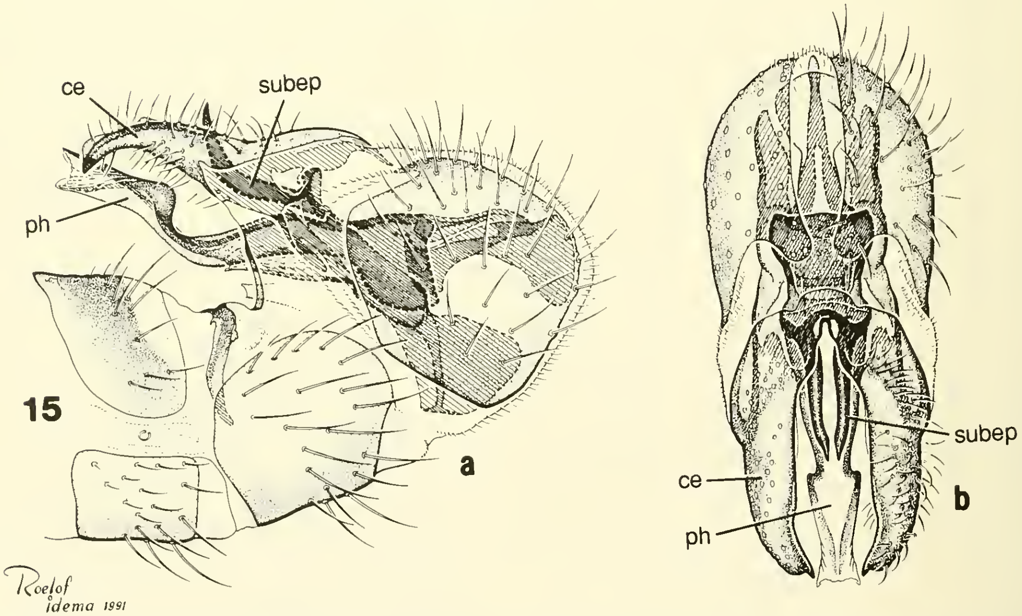
Remarks.—The existence of this new species was brought to my attention by Ralph Idema and Brad Sinclair (Biological Resources Division, Ottawa) after their examination of macerated terminalia of specimens labelled "*americana*" that had been dissected in preparation of the figures for this paper. The holotype and nearly all the paratypes in the type series were taken in Malaise traps set up in a live oak forest by members of the "Hymenoptera team" at the Biological Resources Centre, Agriculture Canada.

***Chelipoda praestans* Melander**
(Figs. 6, 14)

Chelipoda praestans Melander, 1947: 267.

Diagnosis.—Adults resemble those of *C. contracta* in size and coloration, but possess only one ventral row of black setulae on the fore femur and the female cerci are long. Males superficially resemble those of *C. sicaria,* particularly when the anterior portions of the terminalia of the latter project ventrally into the pregenital abdominal segments and are not clearly visible. Macerated terminalia of these two species are distinc-





Figs. 14, 15. 14a (lateral) and b (dorsal), *Chelipoda praestans* male terminalia. 15a (lateral) and b (dorsal), *Chelipoda sicaria* male terminalia. ce = cercus; ph = phallus; subep = subepandrial lobe. Scale bar = 0.25 mm.

tive, however. Those of *C. praestans* possess a uniformly slender phallus in dorsal view and very small subepandrial lobes, whereas those of *C. sicaria* possess a phallus that is distinctly expanded apically and prominent subepandrial lobes that are at least half the length of the phallus. In areas of sympatry, identification of females of these two species is difficult and must be based on close comparison, with the much paler antennal arista and paler thoracic setae being the most reliable characters for distinguishing females of *C. praestans* from those of *C. sicaria.*

Description.—Length including terminalia of male ca. 2.0–2.4 mm, of female ca. 1.8–2.4 mm. General body color yellow to yellowish grey. Head black, except for yellowish grey gena and postgena; mouthparts and palps yellow; bristles light brown. Antennal scape and pedicel yellow; flagellum yellowish brown; arista light brown. Thorax short, compact; yellowish grey, paler ventrally; bristles light brown. Legs yellow. Fore femur ventrally with an inner row of 16–20 black setulae and incomplete outer row of ca. 6–10 weaker black setulae, each such row flanked by row of 5–6 light brown bristles (Fig. 6). Fore coxa with 1 or 2 prominent basolateral setae and row of weaker setae continuing distally (see Fig. 7). Wing hyaline; crossvein dm-cu present; cell dm closed (see Fig. 2). Abdominal terga yellowish grey, sterna yellow. Male terminalia (Fig. 14) yellow, projecting anteriorly nearly to abdominal segment 5; hypandrium and epandrium completely fused; cercus and epandrial lobe separate; cercus slender, curved ventrally distally, subequal in length to phallus; subepandrial lobe ca. $\frac{1}{10}$ length of phallus; phallus slender, strongly curved ventrally over distal $\frac{1}{3}$ in lateral view; phallic processes lacking. Female cercus long (see Fig. 11); spermatheca hemispherical, with spermathecal duct arising from center of flat surface (see Fig. 10).

Type material examined.—HOLOTYPE male, labelled "Redding CT/ 10 June '29/ A L Melander" (USNM). The specimen is in excellent condition and most of the diagnostic features of the terminalia are visible without maceration. Two females on the pin with the holotype and labelled "*C. praestans* ALLOTYPES" were females of *C. contracta.* PARATYPES. CANADA. Ontario: 1 male (lacking head), Waubamick, Jul (USNM). UNITED STATES. Connecticut: 7 females, 6 males (1 pin also includes a *C. contracta* male and another pin also includes 2 *C. contracta* females), Redding, May–Jun (USNM). Massachusetts: 9 females, 1 male (one female labelled "allotype *Chelipoda contracta*"), Petersham, Jul (USNM). Maine: 1 female, Seal Harbor, Jul (USNM). New Hampshire: 1 female, Mt. Monadnock, Jul; 2 females, Mt. Washington, Jul; 1 female, Pinkham Notch, Jul (USNM). New York: 1 female, 2 males, Bear Mt., Jul (USNM). Pennsylvania: 1 female, Chester Co. (USNM).

Other specimens examined.—CANADA. Newfoundland: 2 females, 1 male, St. Johns, Jul (CNC). Nova Scotia: 2 females, 6 males, Cape Breton Highlands Nat. Prk., Jul; 5 females, 4 males, Cranberry I., Jul; 1 female, 11 males, Lockeport, Jul–Aug; 2 females, 6 males, Lone Shieling, Jun–Jul; 1 female, 1 male, Springfield, Jun–Aug; 2 males, 12 females, St. Anne De Ruisseau, Jul (CNC, USNM). Ontario: 3 females, 1 male, Iroquois Falls, Jun (CNC). Quebec: 1 female, Beechgrove, Jun; 1 male, Old Chelsea, Jun (CNC). UNITED STATES. Georgia: 2 males, Rabun Bald, Jul–Aug (CNC). Maine: 12 females, 14 males, Seal Harbor, Mt. Desert I., Jul (CNC). New Hampshire: 4 males, 2 females, Wonalancet, Jul (UNH). New York: 6 females, 8 males, Lake Placid, Jul (CNC). North Carolina: 1 female, Devils Court House, Aug; 36 females, 13 males, Highlands, May–Aug; 1 female, Lake Taxaway, Jul; 1 female, 1 male, Yancey Co., Mt. Mitchell, Jun; 2 females, 1 male, Wayah Gap, Jul (CNC, UKL). Pennsylvania: 1 female, Spring Bridge, Jun; female/male *in*

Fig. 16. Distribution of *Chelipoda americana* and *Chelipoda limitaria.*

copula, Luzerne Co., Bicketts Glen Prk., Jul (UKL). Tennessee: 1 female, Clingman's Dome (CNC); 1 male, Great Smoky Mts. Nat. Prk., Beech Gap, Jul (USNM). Virginia: 1 female, Giles Co., Mt. Lake Biol. Sta., Jun; 1 female, 3 males, Hawksville, Jun (CNC).

Distribution.—This species occurs from

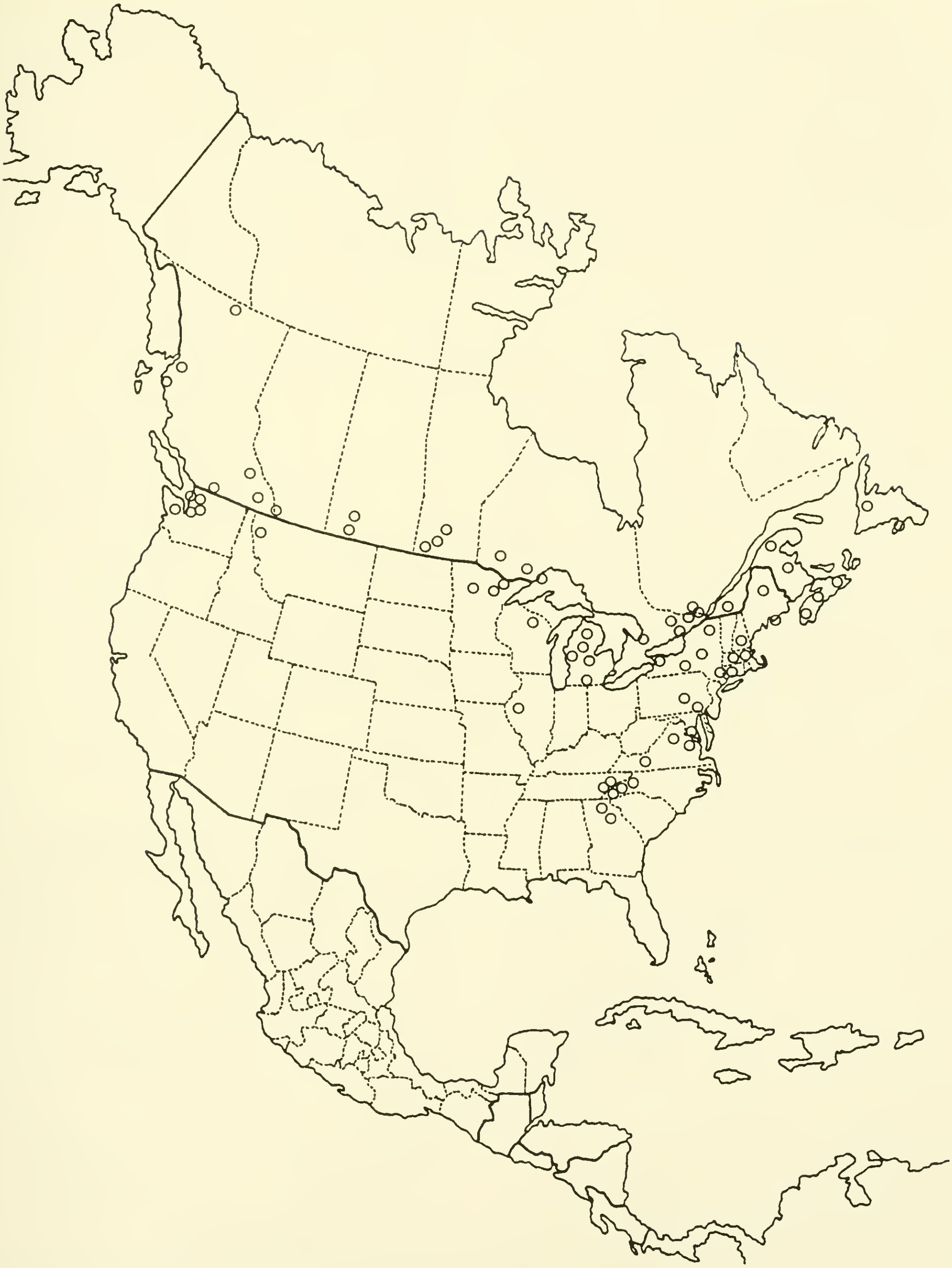


Fig. 17. Distribution of *Chelipoda contracta*.

Fig. 18. Distribution of *Chelipoda elongata* and *Chelipoda truncata*.

Fig. 19. Distribution of *Chelipoda praestans* and *Chelipoda sicaria*.

southeastern and extreme eastern Canada, south along the Appalachian Mountains into northern Georgia (Fig. 19).

Remarks.—Specimens of this species have been taken from flowers of *Castenea pumila* (L.) Mill. (eastern chinquapin) in Great Smoky Mountains National Park and from aphid-infested *Veratrum* sp. near Lake Placid, New York, but no prey records exist.

Chelipoda sicaria **Melander**
(Fig. 15)

Chelipoda sicaria Melander, 1947: 268.

Diagnosis.—Males and females of *C. sicaria* closely resemble those of *C. praestans.* Adults of both species possess only one complete row of black setulae ventrally on the fore femur and the female cerci are relatively long. Identification of males is based on terminalia differences, but females are difficult to place; discussion of the characteristics employed is presented in the diagnosis section pertaining to *C. praestans.*

Description.—Length including terminalia of male ca. 2.0–2.4 mm, of female ca. 2.4–2.8 mm. General body color yellow to dark reddish brown. Head brownish black to reddish black; mouthparts and palps light reddish black; bristles dark brown. Antennal scape and pedicel yellow; flagellum yellowish brown; arista dark brown. Thorax short, compact; yellow to dark reddish brown; bristles dark brown. Legs yellow to light brownish black. Fore femur ventrally with an inner row of 16–20 black setulae and an incomplete outer row of ca. 6–10 weaker black setulae, each such row flanked by row of 5–6 light brown bristles (see Fig. 6). Fore coxa with 1 or 2 prominent basolateral setae and row of weaker setae continuing distally (see Fig. 7). Wing hyaline; crossvein dm-cu present; cell dm closed (see Fig. 2). Abdominal terga brownish to brownish black, sterna light brown to light brownish black. Male terminalia (Fig. 15) yellowish brown to brownish black, projecting anteriorly to abdominal segment 7 or projecting ventrally into pre-genital abdominal segments; hypandrium and epandrium completely fused; cercus and epandrial lobe separate; cercus curved ventrally at apex, subequal in length to phallus; pointed subepandrial lobe upturned in lateral view, ca. ½ length cercus; phallus sinuate in lateral view, prominently expanded laterally at distal ⅓ in dorsal view; phallic processes lacking. Females paler than concurrently collected males; cercus slightly longer than width at base; spermatheca hemispherical, with spermathecal duct arising from center of flat surface (see Fig. 10).

Type material examined.—HOLOTYPE male, labelled "Gt. Smokie NP/Newfnd Ridge/ 11 July '41/A L Melander" (USNM). The specimen is in excellent condition and most of the diagnostic features of the terminalia are visible without maceration; the elaborated type locality is Great Smoky Mountains National Park, Newfound Ridge, along the border of Tennessee and North Carolina. ALLOTYPE, same data as holotype (USNM). PARATYPES. North Carolina: 1 male (lacking head), Great Smoky Mts. Nat. Prk., Andrews Bald, Jul; 1 female, 1 male (lacking head), Great Smoky Mts. Nat. Prk., Newfound Gap, July (USNM).

Other specimens examined.—UNITED STATES. North Carolina: 14 males, 17 females, Great Smoky Mts. Nat. Prk., Balsam Mt., Jun (PERC); 6 males, 9 females, Great Smoky Mts. Nat. Prk., Clingman's Dome (CNC). North Carolina–Tennessee border: 6 males, 8 females, Great Smoky Mts. Nat. Prk., 1 mi S. Newfound Gap, Jun (USNM); 3 males, Great Smoky Mts. Nat. Prk., Newfound Ridge, Jul (USNM). Tennessee: 12 males, 9 females, Great Smoky Mts. Nat. Prk., Gatlinburg, Jun–Jul (USNM).

Distribution.—This species is known only from the higher elevations of Great Smoky Mountains National Park (Fig. 19).

Remarks.—Adults of this species vary greatly in coloration, from nearly concolorous yellow (most specimens in collections) to nearly concolorous dark reddish brown, with males darker in coloration than concurrently collected females. Examination of macerated males representing the range of coloration revealed identical terminalia. Included in the examination were two series collected 33 years apart from near Clingman's Dome, Great Smoky Mountains National Park: males in one series collected June 18, 1957 were dark reddish-brown; males in another series collected June 15, 1990 were yellow to yellowish brown.

Specimens in the June 15, 1990 series, mentioned above, were swept off foliage in late afternoon, in dense, fern undergrowth along a small stream under dense hardwood canopy. Another series, taken June 13, 1990, below Balsam Mt. campground were swept off emergent vegetation in a seepage area along Flat Creek under a hardwood canopy, again in late afternoon.

Chelipoda truncata MacDonald, New Species
(Figs. 8, 13)

Diagnosis.—Adults closely resemble those of *C. elongata,* but differ in having entirely yellow tarsi and in possessing a distinct pale area (usually golden yellow) on the median margins of the postgenae. Male terminalia of these two species are similar superficially, and may require maceration in order to resolve them. Terminalia of males of *C. truncata* include strongly sclerotized, blunt subepandrial lobes and phallic processes that are about two-thirds the length of the phallus, whereas those of male *C. elongata* include pointed subepandrial lobes and phallic processes that are subequal to the length of the phallus.

Description.—MALE: length including terminalia ca. 2.0–2.4 mm. General body color yellow. *Head:* nearly black, except yellow area on frons and yellow area approaching a stripe on mid ventral aspect of postgena (Fig. 6); gena yellow grading into black, with fringe of white hair; vertex and occiput black; mouthparts and palps yellow; bristles yellow. Antennal scape and pedicel yellow; flagellum yellowish brown, slightly darker apically; arista light brown. *Thorax:* long, slender (notopleural suture ca. ½ length of scutum and scutellum); yellowish brown dorsally, paler ventrally; bristles yellow. *Legs:* yellow; fore femur ventrally with 2 rows of black setulae, each flanked by row of 6–8 brown bristles (see Fig. 5); fore coxa lacking prominent basolateral seta, but with row of setae continuing distally (see Fig. 6). Wing hyaline; crossvein dm-cu present; cell dm closed (see Fig. 2). *Abdomen:* yellowish terga, sterna lighter yellow. Male terminalia (Fig. 13) yellowish, projecting anteriorly to abdominal segment 7; hypandrium and epandrium completely fused; cercus and epandrial lobe separate; cercus thicker apically, shorter than epandrial lobe; epandrial lobe slender, truncate and sclerotized apically, longer than cercus and shorter than phallus; phallus and phallic process slender, smoothly curved ventrally in lateral view, phallic process ca. ⅔ length of phallus. FEMALE: length including terminalia ca. 2.2–2.6 mm; flagellum brown, arista light brown; cercus long (see Fig. 11); spermatheca nearly hemispherical, with spermathecal duct arising from center of flat surface.

Type material.—HOLOTYPE male, labelled "Warwomen Cr. GA./Rabun Co. 1500'/31. VII. 1957/J. G. Chillcott" (CNC, holotype no. 21334). The specimen is in good condition and most of the diagnostic features of the terminalia are visible without maceration. ALLOTYPE, labelled "Rabun Bald, GA./Rabun Co. 3000'/14-VII-1957/J. G. Chillcott" (CNC). PARATYPES. CANADA. Ontario: 1 male, Griffith, Jul (CNC). Quebec: 1 male, Hull, Aug (USNM). UNITED STATES. Georgia: 1 male (macerated terminalia in glycerin microvial attached to pin), Rabun Co., Jul (CNC). Kentucky: 2 males, Kentucky Ridge St. For., Jun (USNM). Minnesota: 4 females, 1 male, Basswood Lk., Jul–Aug (UMSP). North Carolina: 1 female, Looking Glass Rock, Pisgah Nat. For., Jul; 2 females, Macon Co., Jul–Aug (CNC). Virginia: 1 male, Alexandria Co., Jun (USNM). Wisconsin: 1 female, Waupaca Co., Aug (UWM).

Distribution.—This species is largely sympatric with *C. elongata,* but it is known only as far south as the mountains of northern Georgia (Fig. 18).

Etymology.—The specific epithet is in reference to the structure of the subepandrial lobes, each of which is truncate and heavily sclerotized at its apex.

Concluding Remarks

Adults of species of *Chelipoda* are thought to be predacious because of their raptorial fore legs, but no records of prey capture exist. Collecting data on labels reveal that numerous specimens have been taken off flowers or foliage of plants infested with aphids. Other specimens have been swept off low vegetation, usually in forested areas, and some labels make reference to swampy areas and sloughs. In addition, specimens have been taken in Malaise traps, in yellow pan traps, and at lights. During the present study, adults of *C. sicaria* were swept and aspirated from understory foliage at higher elevations in Great Smoky Mountains National Park, where they appeared to be active only during mid- to late afternoon.

Larvae and pupae of only one species, the Palearctic *Phyllodromia melanocephala Fab.,* are described, having been collected in moist humus under beech trees in Europe (Trehen 1969). No immature stages of Nearctic species of *Chelipoda* have been described, but Harper (1980) presented indirect evidence that the larvae of three Nearctic species may be aquatic. During his study of insects in a Laurentian stream system in Quebec, Canada, Harper collected a few small series of *C. contracta, C. elongata* and *C. praestans* in emergence traps placed over streamlets, including one that was intermittent.

The findings by Harper (1980) and the discovery of relatively large numbers of adults of *C. sicaria* in a specific habitat in Great Smoky Mountains National Park, reported above in the remarks section pertaining to this species, could encourage future biological studies of this group which has received little attention. Awareness of an afternoon period of adult activity in a specific habitat, namely understory foliage, could facilitate study of both reproductive and predatory behavior. Knowledge of a probable larval developmental site for Nearctic species of *Chelipoda,* namely streamlets (including intermittent ones), will allow focused efforts to collect the immature stages, but special techniques will be required for specimens of such small size in order to pinpoint a specific microhabitat, if one exists.

Relatively few phylogenetically important characters have been revealed in the Hemerodromiinae, but components of male terminalia and shape of the female spermatheca appear to be of value. For example, preliminary evaluation suggests that *Chelipoda americana* and *C. limitaria* comprise a monophyletic group distinct from other *Chelipoda* treated here. This contention is not founded upon wing venation. Instead, it stems from their shared possession of a reniform spermatheca, lack of complete fusion of the hypandrium and epandrial lobes, and fusion of each cercus to a corresponding epandrial lobe. Importantly, adults of *Phyllodromia melanocephala,* the type species of *Phyllodromia* Zetterstedt established primarily on the basis of the lack of crossvein bm-cu, differ in other respects from those of *C. americana* and *C. limitaria.* Females of *P. melanocephala* lack the reniform spermatheca characteristic of *C. americana* and *C. limitaria,* and males of *P. melanocephala* possess a hypandrium and epandrium that are completely fused. The latter feature is characteristic of males of other Nearctic *Chelipoda* treated here and of males of other Palearctic *Chelipoda.* Consideration of these characters, together with awareness of variation in wing venation of other hemerodromine species, supports the contention that the present concept of "*Phyllodromia*" based on wing venation is most likely invalid. Such awareness also leads to the conclusion that the present taxonomic status of other genera included in the "Chelipodini" (for example, *Afrodromia* Smith, *Chelipodozus* Collin, *Doliodromia* Collin, *Monodromia* Collin, and *Ptilophyllodromia* Bezzi) might be questioned also, since they too are based largely on minor differences in venation. Drawing upon the interpretations of homologies of male terminalia outlined in Cumming and Sinclair (1990), taxa presently allied with *Chelipoda* and *Phyllodromia* appear to constitute the sister group of the remainder of the subfamily Hemerodromiinae, but the groundplan of the subfamily has yet to be established.

ACKNOWLEDGMENTS

I thank the following individuals for the loan of material: P. H. Arnaud, Jr. (CAS); R. W. Brooks (UKL); D. S. Chandler (UNH); P. J. Clausen (UMSP); W. J. Hanson (USU); L. Knutson (USNM); S. Krauth (UWM): J. K. Liebherr (CU); B. Lindeberg (HZM); R. T. Schuh (AMNH); H. J. Teskey and J. M. Cumming (CNC); and H. V. Weems (FSCA).

Sincere appreciation is extended to dipterists at the Biological Resources Division, Agriculture Canada, Ottawa who initially facilitated this study, and especially to J. M. Cumming and B. J. Sinclair who not only shared their interpretation of the homology of male terminalia but assisted me in understanding the genitalic components of males of *Chelipoda*. Special thanks go to R. Idema and B. J. Sinclair for bringing to my attention the undescribed species from Texas. In addition, R. Idema not only prepared the excellent illustrations, but provided color-coded figures of individual components of male terminalia. I also thank R. Wagner (Max Planck Instituts für Limnologie, Schlitz, Germany) for sharing copies of his illustrations of Palearctic *Chelipoda*. This paper is Purdue Agricultural Experiment Station journal no. 11, 511.

LITERATURE CITED

Bigot, J. M. F. 1857. Essai d'une classification generale et synoptique de l'ordre des Insectes Dipteres. Annales de la Societe Entomologique de France 5: 517–564.

Chvala, M. and R. Wagner. 1989. Family Empididae. Vol. 6, pp. 228–335. *In* Soos, A. and L. Papp, eds., Catalogue of Palaearctic Diptera. Elsevier, Amsterdam.

Collin, J. E. 1928. New Zealand Empididae. British Museum (Natural History), London. 110 pp.

———. 1933. Diptera of Patagonia and South Chile. Part IV, Empididae. British Museum (Natural History), London. 334 pp.

———. 1961. Empididae. Vol. VI, pp. 1–782. *In* Verrall, G. H., ed., British Flies. Cambridge University Press, London.

Coquillett, D. W. 1903. The genera of the dipterous family Empididae, with notes and new species. Proceedings of the Entomological Society of Washington 5: 245–272.

Cumming, J. M. 1992. Lactic acid as an agent for macerating Diptera specimens. Fly Times 8: 7.

Cumming, J. M. and B. J. Sinclair. 1990. Fusion and confusion: Interpretation of male genitalic homologies in the Empidoidea (Diptera). Abstract of the second International Congress of Dipterology, Bratislava, third supplement, p. 334.

Engel, E. O. 1956. 28. Empididae. IV, part 4, pp. 119–132. *In* Linder, E., ed., Die Fliegen der palaearktischen Region. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

Fallen, C. F. 1816. Empidiae Sveciae. Lundae: 17–34.

Harper, P. P. 1980. Phenology and distribution of aquatic dance flies (Diptera: Empididae) in a Laurentian watershed. American Midland Naturalist 104: 110–117.

Lynch Arribalzaga, F. 1878. Apuntes sobre los Empides del Baradero. El Naturalista Argentino 1: 292–295.

Macquart, J. 1823. Monographie des Insectes Dipteres de la famille des Empides, observes dans le nord-ouest de la France. Memoires de la Societe des Sciences et Agriculture et des Arts, Lille 1822: 137–165.

McAlpine, J. F. 1981. Morphology and terminology—Adults, 2, pp. 9–63. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera. Vol. 1. Monograph No. 27. 674 pp. Research Branch, Agriculture Canada.

Melander, A. L. 1902. A monograph of the North American Empididae. Part I. Transactions of the American Entomological Society 28: 195–367.

———. 1928. Diptera, Family Empididae. Fascicle 185, pp. 1–434. *In* Wytsman, P., ed., Genera Insectorum. Louis Desmet-Verteneuil, Bruxelles.

———. 1947. Synopsis of the Hemerodromiinae (Diptera: Empididae). Journal of the New York Entomological Society 55: 237–273.

Mik, J. 1886. Dipterologische Miscellen. II. Wiener entomologische Zeitung 5: 276–279.

Rondani, C. 1856. Dipterologiae Italicae prodromus. Vol. 1: Genera Italica ordinis dipterorum ordinatim disposita et distincta et in familias et stirpes aggregata. 228 pp.

Sabrosky, C. W. 1966. Mounting insects from alcohol. Bulletin of the Entomological Society of America 12: 349.

Smith, K. G. V. 1967. Family Empididae, 39, pp. 39–44. *In* A Catalogue of the Diptera of the Americas South of the United States. Departmento de Zoologia, Secretaria da Agricultura, Sao Paulo, Brazil.

Steyskal, G. C. and L. V. Knutson. 1981. Empididae, 47, pp. 607–624. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera. Vol. 1. Monograph No. 27. 674 pp. Research Branch, Agriculture Canada.

Trehen, P. 1969. Description des stades preimaginaux et donnees sur la biologie de *Phyllodromia melanocephala* Fabricius, 1794 (Dipteres-Empididae). Revue d' Ecologie et de Biologie du Sol 6: 41–52.

Tuomikoski, R. 1966. Mitteilungen uber die Empididen (Dipt.) Finnlands VIII. Die Gattung *Chelipoda* Macq. Annals of the Entomological Society of Finland 32: 321–326.

Yang, D. and C. Yang. 1990. (In Chinese; English summary) Eight new species of the genus *Chelipoda* from China (Diptera: Empididae). Acta Zootaxonomica Sinica 15: 483–487.

Zetterstedt, J. W. 1837. Conspectus familiarum, generum et specierum dipterorum, in fauna insectorum Lapponica descriptorum. Isis, Leipzig 1: 28–67.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 351–376

REVIEW OF THE GENUS *NEOPLASTA* COQUILLETT OF AMERICA NORTH OF MEXICO (DIPTERA; EMPIDIDAE; HEMERODROMIINAE)

JOHN F. MACDONALD AND WILLIAM J. TURNER

(JFM) Department of Entomology, 1158 Entomology Hall, Purdue University, W. Lafayette, Indiana 47907-1158; (WJT) Department of Entomology, Washington State University, Pullman, Washington 99164.

Abstract.—The genus *Neoplasta* Coquillett is reviewed for America north of Mexico. A generic description and new descriptions of three previously known species, *Neoplasta hebes* Melander, *N. scapularis* (Loew), and *N. megorchis* Melander (**new status**), are presented. Nine new species are described from America north of Mexico: ***Neoplasta bifida***, ***N. chrysopleura***, ***N. concava***, ***N. deyrupi***, ***N. hansoni***, ***N. octoterga***, ***N. parahebes***, ***N. paramegorchis*** and ***N. scapuliformis***. A key to males, illustrations of male terminalia, known distributions, and concluding remarks on biology and systematics are included.

Key Words: Diptera, Empididae, Hemerodromiinae, *Neoplasta*, dance flies

Adult flies of the genus *Neoplasta* Coquillett are similar to other genera of Hemerodromiinae in being small (body length from 2.0 to 4.0 mm) and slender, and in possessing raptorial fore legs; also, their wings lack an anal lobe and are relatively slender. Species fitting the present concept of *Neoplasta*, described below, are restricted to the Nearctic and Neotropical Regions; Nearctic taxa of *Neoplasta* have been treated taxonomically by Melander (1902, 1928, 1947). This paper is limited to species of *Neoplasta* of America north of Mexico, and includes a generic description, descriptions of three previously described taxa and nine new species, a key to males, known distributions, and concluding remarks on biology and systematics. In addition to species of *Neoplasta* treated in this paper, 21 species are reported from the Americas south of the United States (Smith 1967), including from Mexico and Costa Rica (Melander 1947), Brazil (Smith 1962), and Patagonia and southern Chile (Collin 1933).

MATERIALS AND METHODS

The present study was facilitated by the examination of the large numbers of adults of *Neoplasta*, including many from the southwestern and western United States, added to North American collections since Melander's (1947) revision. The following institutions (acronyms following) provided material upon which this work is based: American Museum of Natural History, New York (AMNH); California Academy of Sciences, San Francisco (CAS); Canadian National Collection, Biological Resources Division, Agriculture Canada, Ottawa (CNC); Cornell University, Ithaca (CU); Florida State Collection of Arthropods, Gainesville (FSCA); James Entomological Collection, Washington State University, Pullman (WSU); Purdue University Entomological Research Collection (PERC); Snow Museum, University of Kansas, Lawrence (UKL); United States National Museum of Natural History, Washington D.C. (USNM); University of California, Riverside (UCR);

University of Minnesota, St. Paul (UMSP); University of New Hampshire, Durham (UNH); and Utah State University, Logan (USU).

The methods employed in this study, including terminology pertaining to vestiture (McAlpine 1981), interpretation of male terminalia (Cumming and Sinclair 1990), and methods of specimen preparation (Cumming 1992) and examination, follow those reported in a review of the genus *Chelipoda* Macquart (MacDonald 1993).

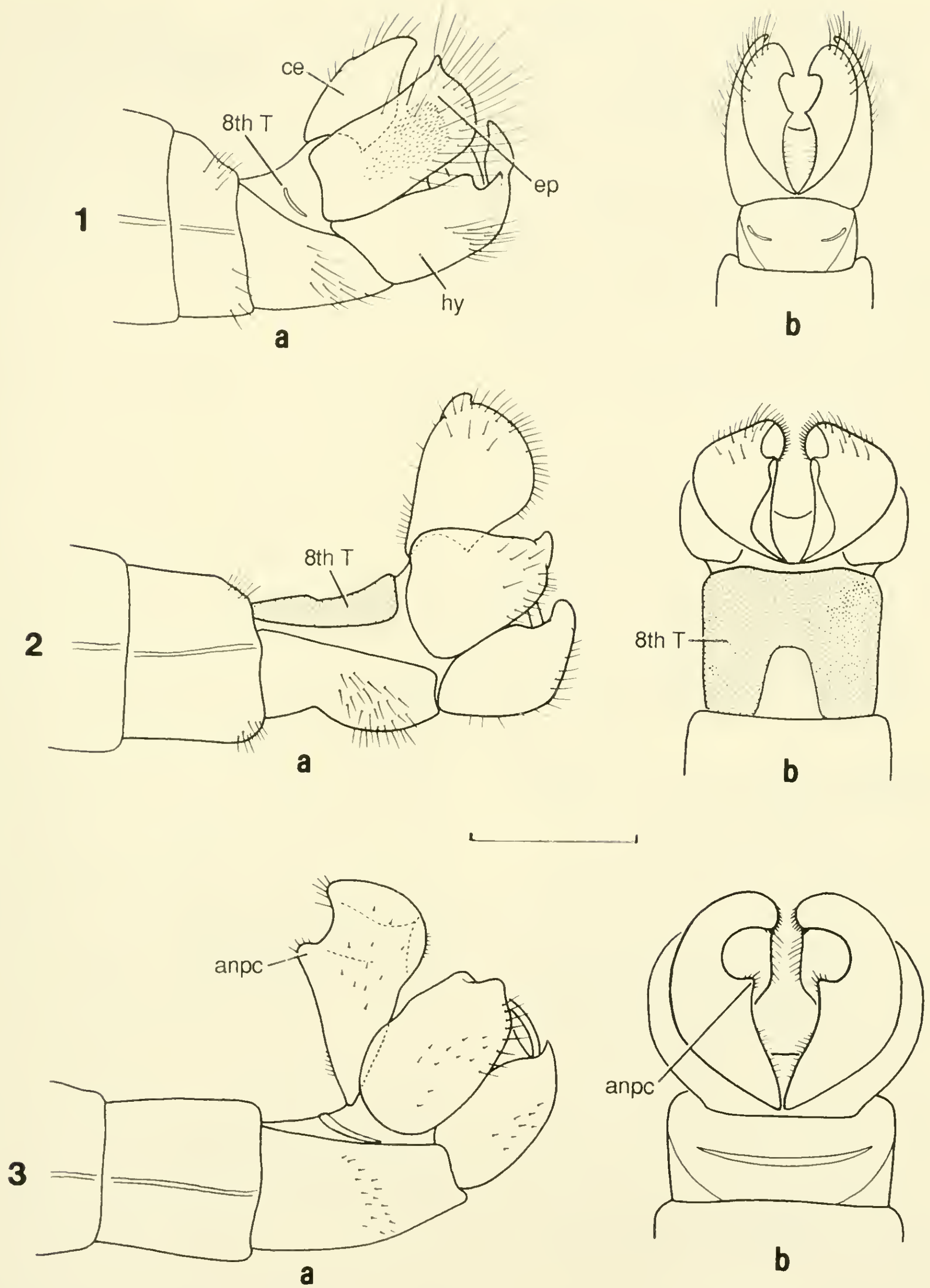
Genus *Neoplasta* Coquillett

Neoplasta Coquillett, 1895: 392. Type species, *Hemerodromia scapularis* Loew (orig. des.).

Diagnosis.—Adult flies in the genus *Neoplasta* are distinguished from those of other genera of Hemerodromiinae in America north of Mexico by a combination of features. The fore femur is much less enlarged (diameter ca. 2× greater than fore tibia, compared to at least 3× greater in other genera) and is lined ventrally by only a single row of black setulae. The fore tibia lacks both black setulae along the ventral surface and a distal bristle. Crossvein bm-cu is lacking, and three separate veins, M_1, M_2, and CuA_1, arise from apex of confluent cell bm + dm (Figs. 12, 13). Abdominal sclerotization is relatively reduced, with abdominal terga 1–7 of male and 1–6 of female being covered only by a very small, median plate.

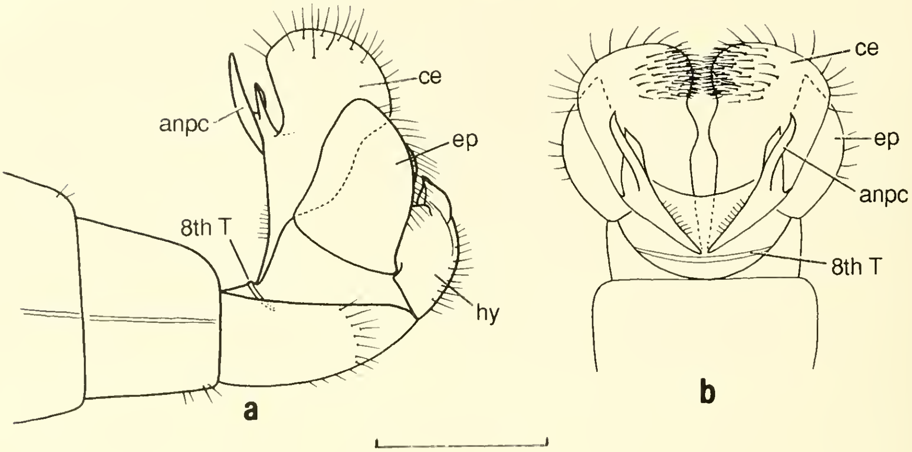
Description.—Slender, mostly black flies with yellowish white pruinescence. Body length including terminalia of males 2.0–3.5 mm, of females 2.5–4.0 mm. Mouthparts and palps yellow. Antennal style microscopic. Thorax slender, humeral area strongly differentiated. Propleural coloration ranging from yellow to black. Legs yellow, except distal 1–3 tarsomeres dark brown. Fore femur ventrally bearing row of black setulae and single larger setula (ranging in position from basal ⅓ to about midway), flanking bristles lacking, 3–4 yellow bristles on each side basally, dense yellowish white hair fringe present on inner surface. Fore tibia with dense yellowish white hair fringe on inner surface. Mid femur of male with basoventral swelling of varying development (Figs. 6, 7) bearing 4–9 yellow bristles. Mid tibia of male bearing black setulae apicoventrally. Female lacking mid leg development and vestiture of male. Macrotrichiae reduced, yellow. Prominent head bristles including pair of ocellars and several inner and outer verticals. Prominent thoracic macrotrichiae including uniserial acrostichal and dorsocentral setae, pair of notopleural setae, pair of supraalar bristles, and small pair of scutellar setae with flanking pair of hairs. Wings hyaline, stigma lacking; humeral crossvein present; anal cell developed; crossvein bm-cu lacking; cells bm and dm confluent, giving rise apically to separate veins M_1, M_2 and CuA_1. Abdominal segments 1–7 of male and 1–6 of female weakly sclerotized. Male terminalia (see Fig. 4) including hypandrium with apicodorsal projection of differing structure and orientation; pair of epandrial lobes; pair of cerci of differing structure. Macrotrichiae on terminalia ranging from hairs to strong bristles, the latter restricted to inner surface of cercus. Female abdominal segment 8, fused tergum 9 + 10 and cerci forming an elongated, sclerotized ovipositor.

Remarks.—The species of *Neoplasta* treated here can be placed into three informal species groups. The *N. hebes* Melander group includes *N. hebes* and two new species described here, *N. hansoni* and *N. parahebes.* The *N. scapularis* Loew group includes *N. scapularis, N. megorchis* Melander and six species newly described here, *N. bifida, N. concava, N. deyrupi, N. octoterga, N. paramegorchis* and *N. scapuliformis.* A third informal species group is represented by *N. chrysopleura,* newly described here; additional species appearing to belong to this group occur in the Neotropical Region. No phylogenetic analysis has demonstrated the monophyly of these informal species groups,

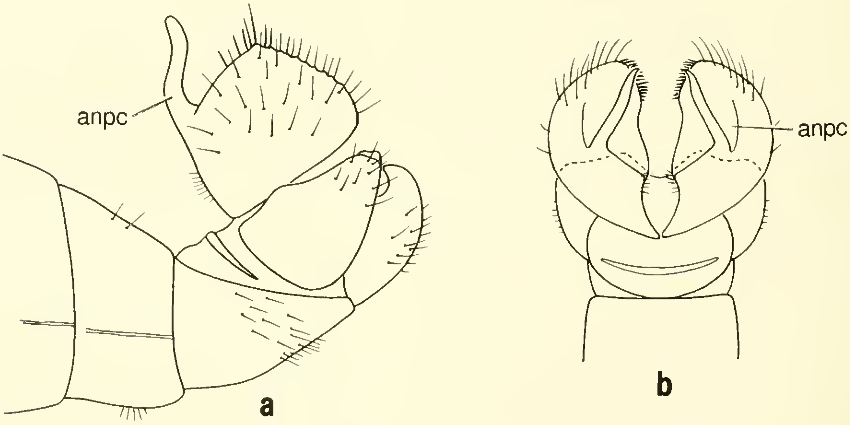


Figs. 1–3. 1a (lateral) and b (dorsal), *Neoplasta chrysopleura* n. sp., male terminalia. 2a (lateral) and b (dorsal), *Neoplasta octoterga* n. sp., male terminalia. 3a (lateral) and b (dorsal), *Neoplasta scapuliformis* n. sp., male terminalia. anpc = anterior process of cercus; ce = cercus; ep = epandrial lobe; hy = hypandrium; 8th T = eighth abdominal tergum. Hypandrium removed in dorsal view. Scale bar = 0.25 mm.

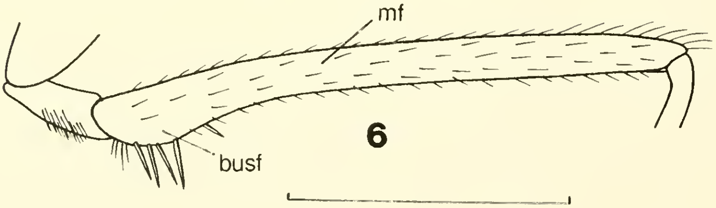
4



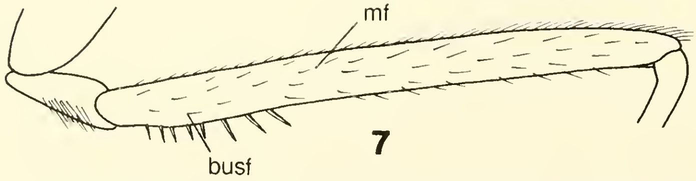
5



6



7



Figs. 4–7. 4a (lateral) and b (dorsal), *Neoplasta bifida* n. sp., male terminalia. 5a (lateral) and b (dorsal), *Neoplasta deyrupi* n. sp., male terminalia. 6, *Neoplasta megorchis* mid leg of male; outer surface. 7, *Neoplasta scapularis* mid leg of male; outer surface. anpc = anterior process of cercus; bvsf = basoventral swelling of mid femur; ce = cercus; ep = epandrial lobe; hy = hypandrium; mf = mid femur; 8th T = eighth abdominal tergum. Hypandrium removed in dorsal view. Scale bars = 0.25 (Figs. 4, 5) and 0.5 mm (Figs. 6, 7).

but they are included to facilitate presentation in this paper and to serve as a basis for future research.

Recognition of the informal species groups is based on a combination of body size, venation, structure of abdominal tergum eight, degree of development of a basoventral swelling on the male mid femur, and male terminalia. The latter two structural features require explanation to facilitate use of the identification key.

The degree of development and number and arrangement of bristles on the basoventral swelling of the male mid femur is employed in the key, in part to obviate the need to macerate male terminalia. However, it may be difficult to interpret in the absence of specimens possessing alternative character states. Three descriptive terms are used to describe the structure: prominent, diffuse, and inapparent. Prominent (see Fig. 6) refers to a strongly developed swelling, with a swelling length to a mid femur diameter ratio of ca. 0.3/0.2. A prominent swelling is associated with an arched mid femur and possesses relatively few (usually 4–6) yellow bristles that are spaced closely together; one modification includes the distal bristle being off-set posterolaterally. Diffuse (see Fig. 7) refers to a less developed swelling with a swelling length to a mid femur ratio of ca. 0.5/0.2. A diffuse swelling is associated with a mid femur that is only weakly arched and possesses relatively more (usually 6–9) yellow bristles that are more widely spaced. Inapparent refers to virtually no development of a swelling and a mid femur that is nearly straight. An inapparent swelling possesses 8–9 yellow bristles of relatively weaker development and even wider spacing than found on a diffuse swelling.

Several taxonomically important structures of male terminalia, which are revealed in macerated specimens, often are visible without maceration and are employed in the key below. Included among such characteristics are the general orientation and shape of the terminalia, the relative size and positional orientation of the cerci, and the structure of the anterior process on each cercus and the distal projection of the hypandrium. The orientation and shape of the cercus of nearly all species sorts into two forms: 1) oriented with long axis in a horizontal plane, more or less triangular apically in lateral view, and lacking an anterior process (Figs. 14–16); and 2) oriented with the long axis in a dorsal to anterodorsal plane, more or less broadly lobed in lateral view and possessing an anterior process (Figs. 4, 5, 8–11). The size of the cercus relative to that of the epandrial lobe and the shape of the anterior process of each cercus are useful in distinguishing species in the *N. scapularis* group. Within the *N. hebes* group, the shape and orientation of the distal projection of the hypandrium usually is discernable on specimens, but locating the structure often requires rotating the specimen and examining it from several angles.

KEY TO MALE ADULTS OF SPECIES OF *NEOPLASTA* COQUILLETT OF AMERICA NORTH OF MEXICO

1. Mesopleuron and metapleuron golden yellow (*N. chrysopleura* group) . . . *N. chrysopleura* n. sp.
– Mesopleuron and metapleuron black 2
2. Relatively small species, body length 2.0–2.4 mm; cercus elongated in a horizontal plane in lateral view, more or less triangular apically and lacking an anterior process (Figs. 12–14) . . . .(*N. hebes* group) . . . 11
– Relatively large species, body length 2.8–3.5 mm; cercus elongated in a dorsal plane, smoothly lobed dorsally in lateral view and bearing an anterior process . . . .(*N. scapularis* group) . . . 3
3. Abdominal tergum 8 elongated and sclerotized (Fig. 2), terminalia distinctly separated from abdominal segment 7 in dried specimens . . . . *N. octoterga* n. sp.
– Abdominal tergum 8 weakly developed, reduced to a thin crescent (see Fig. 3), terminalia and abdominal segment 7 closely associated in dried specimens 4
4. Epandrial lobe strongly convex, expanded dorsally to partially overlap cercus; anterior

process of cercus divided into two, sharply pointed projections (Fig. 4) ..... *N. bifida* n. sp.

– Epandrial lobe not strongly convex, not expanded dorsally and not overlapping cercus; anterior process of cercus undivided, not sharply pointed apically 5

5. Anterior process of cercus broad and short, weakly differentiated from body of cercus; cercus appearing broadly excised over distal third along dorsal margin in lateral view (Fig. 3) .... *N. scapuliformis* n. sp.

– Anterior process of cercus strongly differentiated from body of cercus; cercus not appearing broadly excised over distal third along dorsal margin in lateral view 6

6. Anterior process of cercus recurved posteriorly in lateral view, slender throughout (Fig. 5) .... *N. deyrupi* n. sp.

– Anterior process of cercus straight in lateral view, usually broad basally and narrower apically 7

7. Mid femur with prominent basoventral swelling (Fig. 6) 8

– Mid femur with diffuse basoventral swelling (Fig. 7) 10

8. Setae on outer, dorsolateral surface of cercus longer than anterior process (Fig. 8) .... *N. megorchis* Melander

– Setae on outer, dorsolateral surface of cercus shorter than anterior process (see Fig. 10) .. 9

9. Body of cercus nearly rectangular, ca. 1.5–2.0× larger than epandrial lobe in lateral view; cercus internally excavated along medial margin (Fig. 10) .... *N. concava* n. sp.

– Body of cercus broadly triangular in lateral view, subequal in size to epandrial lobe (Fig. 9); cercus not excavated along medial margin .... *N. scapularis* (Loew), in part

10. Cercus 1.5–2.0× larger than epandrial lobe in lateral view; anterior process of cercus usually clearly visible in unmacerated material, smoothly truncate apically (Fig. 11) .... *N. paramegorchis* n. sp.

– Cercus and epandrial lobe subequal in size; anterior process of cercus in unmacerated material, narrowly lobed apically (Fig. 9) .... *N. scapularis* (Loew), in part

11. Apicodorsal lobe of cercus elongated, ca. ½ length of cercus, slender; distal projection of hypandrium extending anterodorsally in lateral view; phallic process inapparent (Fig. 14) .... *N. parahebes* n. sp.

– Apicodorsal lobe of cercus relatively short and broad, ca. ⅓ length of cercus; distal projection of hypandrium extending posterodorsally in lateral view; phallic process prominent, ending in 2 hooks 12

12. Apex of epandrial lobe turned ventrolaterally; distal projection of hypandrium pointed, not expanded laterally in posterior view (Fig. 15) .... *N. hebes* Melander

– Apex of epandrial lobe turned dorsolaterally; distal projection of hypandrium anchor or shovel shaped, distinctly expanded laterally in posterior view (Fig. 16) .... *N. hansoni* n. sp.

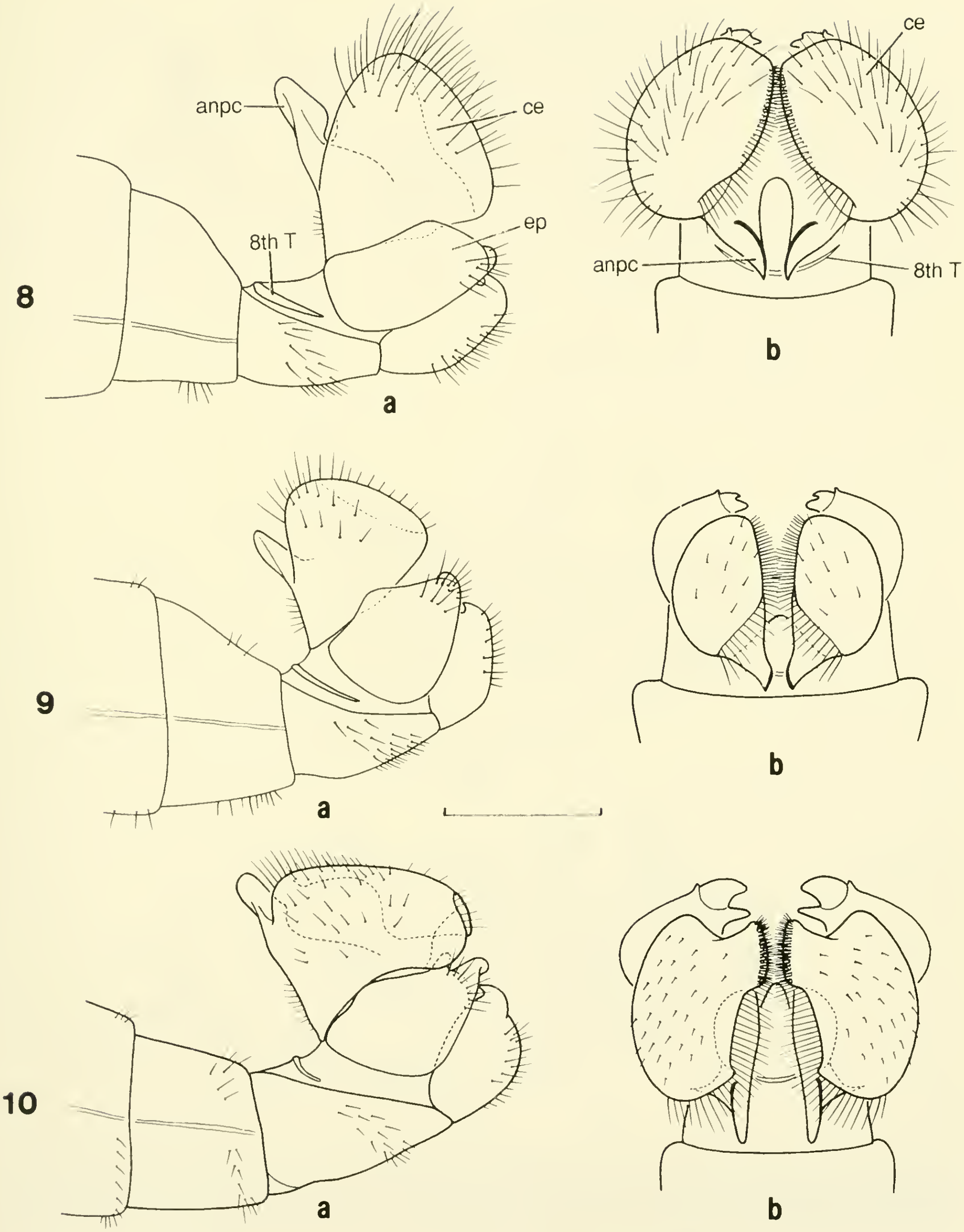
THE *N. HEBES* SPECIES GROUP

Adults of species in this informal species group share several features. They are relatively small (body length including terminalia of male 2.0–2.4 mm, of female 2.6–3.0 mm), the propleuron is black, and vein R_{2+3} usually is strongly curved anteriorly and joins C about 0.25 distance between R_1 and R_4 (Fig. 13). Males are characterized by terminalia with the long axis in a horizontal plane (Figs. 14–16), each cercus being more or less triangular apically and lacking an anterior process, the hypandrium bearing a pair of phallic processes, abdominal tergum 8 being split into two lateral plates (Figs. 14–16), and the basoventral swelling on the mid femur being weakly developed (see Fig. 7). Species can be identified by their male terminalia, but females appear inseparable. The group is restricted to western North America, with representatives extending into the Neotropical Region.

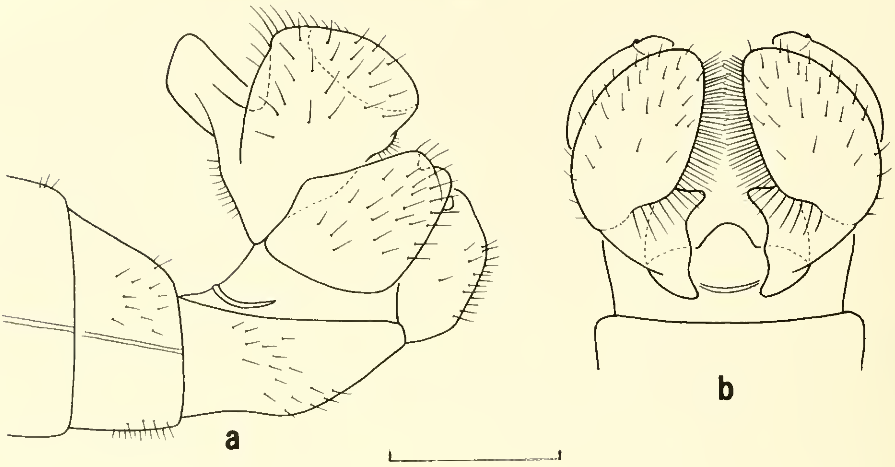
***Neoplasta hansoni* MacDonald & Turner, NEW SPECIES**

(Fig. 16)

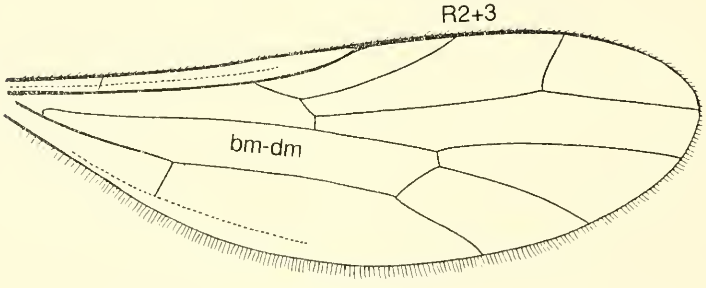
Diagnosis.—Male terminalia resemble those of males of *N. hebes,* but differ in the following respects: the apex of the epandrial lobe is in-turned posterodorsally and the distal projection of the hypandrium is expanded laterally, resulting in a more or less shovel shaped structure. Similar to macerated terminalia of males of *N. hebes,* those of *N. hansoni* possess a pair of phallic processes surrounding the phallus, each of which ends in two hook-like structures; in com-



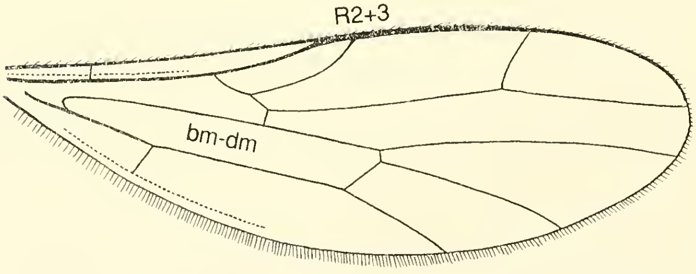
Figs. 8–10. 8a (lateral and b (dorsal), *Neoplasta megorchis,* male terminalia. 9a (lateral) and b (dorsal), *Neoplasta scapularis,* male terminalia. 10a (lateral) and b (dorsal), *Neoplasta concava* n. sp., male terminalia. anpc = anterior process of cercus; ce = cercus; ep = epandrial lobe; hy = hypandrium. Hypandrium removed in dorsal view. Scale bar = 0.25 mm.



11



12

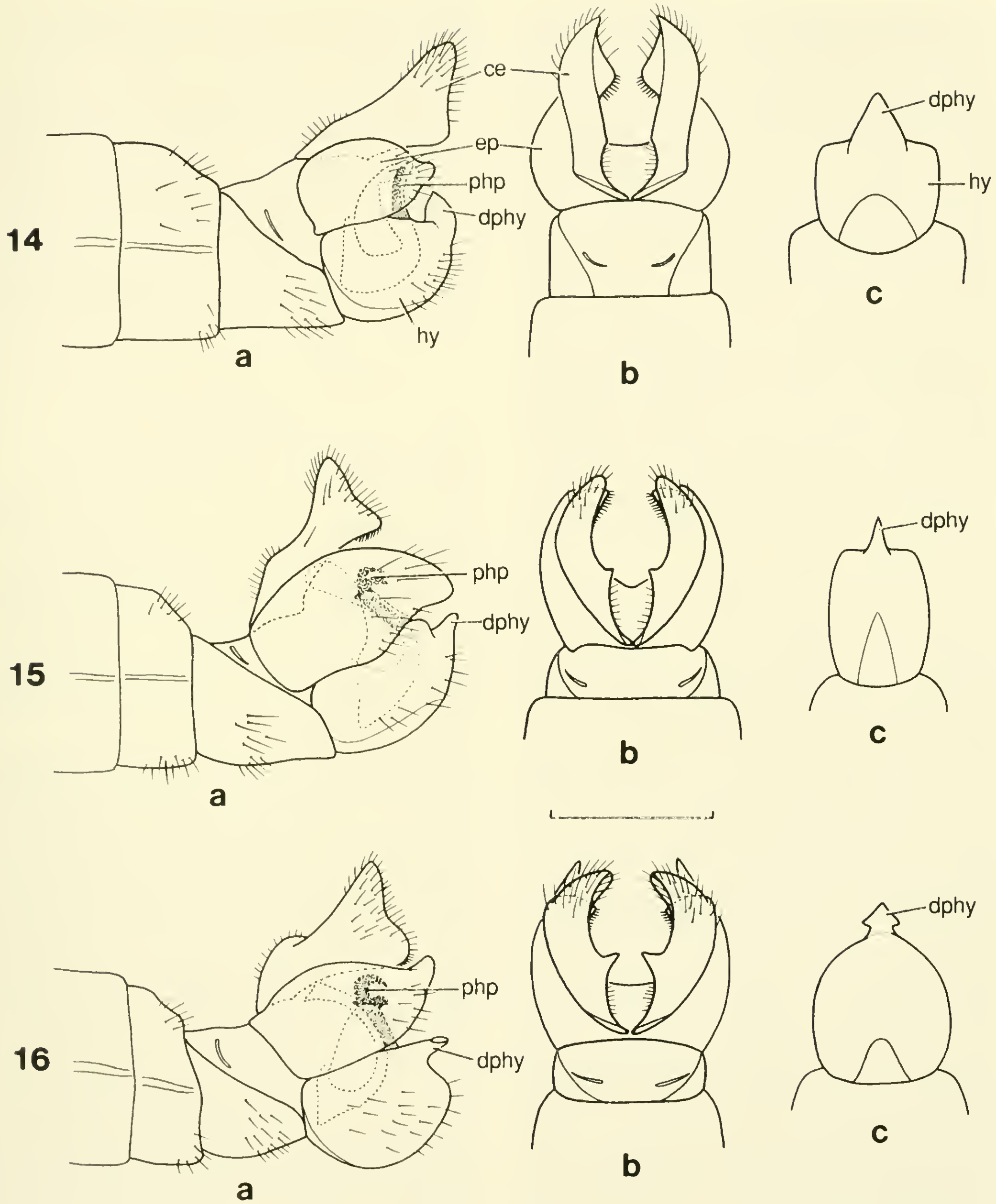


13

Figs. 11–13. 11a (lateral) and b (dorsal), *Neoplasta paramegorchis* n. sp., male terminalia. 12, *Neoplasta scapularis* wing. 13, *Neoplasta hebes* wing. bm-dm = cell; R2+3 = vein. Hypandrium removed in dorsal view. Scale bars = 0.25 mm (Fig. 11) and 1.0 mm (Figs. 12, 13).

parison, the weakly developed phallic processes of males of *N. parahebes* are smoothly truncate apically, lacking hook-like development, and difficult to discern.

Description.—MALE. Body length including terminalia ca. 2.3–2.4 mm. Propleuron black. Basoventral swelling of mid femur weakly developed, bearing row of 7–



Figs. 14–16. 14a (lateral), b (dorsal) and c (ventral), *Neoplasta parahebes* n. sp., male terminalia. 15a (lateral), b (dorsal) and c (ventral), *Neoplasta hebes* male terminalia. 16a (lateral), b (dorsal) and c (ventral), *Neoplasta hansoni* n. sp., male terminalia. ce = cercus; dphy = distal projection of hypandrium; ep = epandrial lobe; hyp = hypandrium; php = phallic process. Hypandrium removed in dorsal view. Scale bar = 0.25 mm.

9 (usually 8) weak, yellow bristles (see Fig. 7). Vein R_{2+3} usually strongly curved anteriorly, joining C about 0.25 distance between R_1 and R_4 (see Fig. 13). Terminalia (Fig. 16) with long axis in a horizontal plane; hypandrium with distal projection more or less shovel shaped in posterior view, extending posteriorly in lateral view; epandrial lobe with apex turned posterodorsally; cercus triangular distally in lateral view, tightly associated with epandrial lobe; phallic process ending in 2 hook-like structures projecting posteriorly. FEMALE. Similar to male in coloration and venation, but larger, ca. 2.6–2.8 mm; indistinguishable from females of other species in the *N. hebes* group.

Type material.—HOLOTYPE male, labelled: "UTAH Utah Co/Prov/11–18 Sep 1985/Malaise trap" (USNM). The specimen is in excellent condition and most of the diagnostic features of terminalia visible without maceration. ALLOTYPE, same data as holotype (USNM). PARATYPES. California: 11 males, 2 females, Nevada Co., Jul (UCR); 1 male, Stanislaus Co., Turlock Lk. Rec. Area, Sep (UKL); 1 male, Tehama Co., S. Frk. Battle R., May (UNH); 1 male, Calaveras Co., San Andreas, Jun (WSU). Idaho: 1 male, Franklin Co., Thomas Spr., Jun (USU); 1 male, Snake R., Divide Crk., May (USNM). Nebraska: 1 male, Redington, May (USNM). Utah: 15 males, 12 females, Cache Co., Jun–Jul; 3 males, 3 females, Kane Co., 6 mi N. Kanab, Jun; 2 males, Utah Co., Mapleton, Jul; 18 males, 9 females, Utah Co., Provo, Jun–Sep (USU; PERC); 2 males, Cache Co., Jul (CAS). Washington: 2 males, Columbia Co., 20 mi E. Dayton, May (WSU); 1 male, Wawawai, Jun (USNM).

Distribution.—Males of this species are known from northcentral California and southeastern Washington east to extreme western Nebraska (Fig. 20).

Etymology.—This species is named in honor of W. J. Hanson, who collected the type series and who also has contributed excellent material representing other *Neoplasta* and other genera of Hemerodromiinae.

Remarks.—The shape of the apicodorsal projection of the hypandrium appears to vary somewhat with the structure being more expanded laterally on specimens from California and western Nebraska in comparison to specimens from southeastern Washington, Idaho and Utah. No other consistent differences were found among males from throughout the range.

Neoplasta hebes Melander
(Figs. 13, 15)

Neoplasta hebes Melander, 1947: 261.

Diagnosis.—Males of *N. hebes* are differentiated from those of other members of the *N. hebes* group by the down-turned apex of the epandrial lobe and the pointed distal projection of the hypandrium that extends posterodorsally. Also, the cerci appear to be more loosely associated with the epandrial lobes in dried specimens.

Description.—Body length including terminalia of male ca. 2.0–2.3 mm, of female ca. 2.4–2.6 mm. Propleuron black. Mid femur of male with weakly developed basoventral swelling bearing row of 5–8 (usually 6) weak, yellow bristles (see Fig. 7); female lacking swelling and vestiture of male. Vein R_{2+3} usually strongly curved anteriorly, joining C about 0.25 distance between R_1 and R_4 (Fig. 13). Male terminalia (Fig. 15) with long axis in a horizontal plane; hypandrium with pointed distal projection extending posterodorsally in lateral view; cercus triangular distally in lateral view, loosely associated with epandrial lobe; apex of epandrial lobe turned ventrolaterally; phallic process ending in 2 hook-like structures projecting posteriorly, visible upon maceration. Female similar to male in coloration and venation, but slightly larger; indistinguishable from females of other species in the *N. hebes* group.

Type material examined.—HOLOTYPE male, labelled "Berkeley/Aug '15, Cal./A.

L. Melander" (USNM). The specimen is in excellent condition and most of the diagnostic features of terminalia visible without maceration; the elaborated type locality is California, Alameda County, near the city of Berkeley. PARATYPES. California: 1 male, 1 female, Contra Costa Co., San Pablo, Nov; 1 male, Santa Cruz Co., Felton, May (CU); 1 male, 3 females, Santa Clara Co., Live Oak Prk., Jul; 11 males, 3 females, San Bernardino Co., Scotland, Sep. (USNM).

Other material examined.—Arizona: 1 male, 2 females, Cochise Co., 5 mi W. Portal, May (UCR). California: 6 males, 2 females, Contra Costa Co., Mt. Diablo St. Prk., Jun–Aug; 2 males, 1 female, Contra Costa Co., Briones Reg. Prk., May; 1 male, Los Angeles Co., Angeles Nat. For., Islip Cyn., Jun; 18 males, 1 female, Los Angeles Co., San Gabriel R. (north fork), 2 mi S. Goldbrook Sta., Apr–Jun; 9 males, 12 females, Marin Co., Mt. Tamalpais, Jul; 1 male, 1 female, Mendocino Co., Leggett, May; 1 male, Napa Co., 2 mi NNE Angwin, Nov; 1 male, Siskiyou Co., Klamath Nat. For., Jul (CAS); 1 male, San Bernardino Co., Big Morengo Cyn., Mar; 1 male, 2 females, San Bernardino Co., San Bernardino Mts., Thurman Flat, May (UCR). Oregon: 1 male, Marion Co., Enchanted Forest, 11 km S. Salem, Aug; 1 male, 2 females, Marion Co., Silver Falls St. Prk., Jun (CAS); 1 male, Multnomah Co., Troutdale, Aug (USNM). Washington: 1 male, Pierce Co., Glover Crk., Aug (USU).

Distribution.—Males of this species are known from western Washington and Oregon, California, and extreme southeastern Arizona (Fig. 20).

Neoplasta parahebes MacDonald & Turner, New Species
(Fig. 14)

Diagnosis.—Males are differentiated from those of *N. hebes* and *N. hansoni* by the shape of the cercus, shape and orientation of the distal projection of the hypandrium, and the weakly developed phallic processes. Each cercus is expanded apicodorsally into a lobe that is about half the total length of the cercus, with a weakly developed apicoventral projection. The distal projection of the hypandrium is distinctive in being bluntly pointed and extending anterodorsally, and the phallic processes differ in being weakly developed and lacking hook-like structures.

Description.—MALE. Body length including terminalia ca. 2.0–2.2 mm. Propleuron black. Mid femur with weakly developed basoventral swelling bearing row of 6–8 (usually 6) weak, yellow bristles (see Fig. 7). Vein R_{2+3} usually strongly curved anteriorly, joining C about 0.25 distance between R_1 and R_4 (see Fig. 13). Terminalia (Fig. 14) oriented in a horizontal plane; hypandrium with distal projection bluntly pointed at apex, extending anterodorsally; cercus elongated apicodorsally, resulting in dorsal lobe being ca. ½ length of cercus, with weakly developed apicoventral projection; apex of epandrial lobe oriented posteriorly; phallic processes of hypandrium straight and smoothly truncate apically, difficult to discern even when macerated. FEMALE. Similar to male in coloration and venation, but slightly larger, ca. 2.4–2.6 mm; indistinguishable from females of other species in the *N. hebes* group.

Type material.—HOLOTYPE male, labelled: "WASHINGTON: Brooks/Mem. SP, 12 mi. NE/Goldendale, Klickitat/Co., 2700–3000 ft./27-VI-1975/W. J. Turner" (USNM). The specimen is in excellent condition and most of the diagnostic features of terminalia visible without maceration. The elaborated type locality is Washington, Klickitat County, Brooks Memorial State Park, about 70 kilometers south of the city of Yakima. ALLOTYPE, same data as holotype (USNM). PARATYPES. CANADA. British Columbia: 1 male, Robson, May (CNC). UNITED STATES. California: 1 male, 8 females, Humboldt Co., Six Rivers Nat. For., Jul; 7 males, Marin Co., Apr–

May; 6 males, 2 females, Mendocino Co., E. of Covelo, Jun; 1 male, Monterey Co., Los Padres Nat. For., San Antonio R., May; 4 males, 1 female, Plumas Co., Lassen Nat. For., n. frk. Feather R., May (CAS); 1 male, Oak Glen, Jul; 1 male, Mt. Home, Jul (USNM); 2 males, San Bernardino Co., Kilpecker Cr., June (UCR). Idaho: 2 males, Latah Co., Moscow Mt., Jun (USNM); 1 male, 47 females, Kootenai Co., 10 mi N. Harrison, July (WSU). Oregon: 1 male, Jackson Co., Hepsie Mt. Rd., Jun (USU); 1 male, Baker Co., 36 mi SE Union, Jun (WSU). Washington: 14 males, 8 females, Asotin Co., Field Springs St. Prk., Jun–Jul; 3 males, 4 females, Columbia Co., 20 mi S. Dayton, May; 3 males, 16 females, Klickitat Co., Brooks Mem. St. Prk., Jun; 1 male, Yakima Co., 8 mi SW Tieton, Jun (WSU); 1 male, Vashon, May (USNM).

Distribution.—Males of this species are known from southcentral British Columbia, northcentral Idaho and Washington, south into extreme southern California (Fig. 20).

Etymology.—The specific epithet is an arbitrary combination of letters incorporating "para," Greek for beside or near, and "hebes," alluding to the close structural similarity between the new species and *N. hebes.*

Remarks.—*Neoplasta parahebes* and *N. hebes* are sympatric and may represent relatively recent divergences, with hybridization occasionally occurring. This conclusion is based on the existence of two males, from two widely separated areas of sympatry, that possessed cerci of intermediate structure.

THE *N. SCAPULARIS* SPECIES GROUP

Adults of this group are larger (body length of male including terminalia 2.8–3.4 mm) than those of the *N. hebes* group and vein R_{2+3} gradually curves anteriorly and joins C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Males are characterized by the long axis of terminalia being oriented in a more or less vertical plane (Figs. 2–5, 8–11), each cercus being smoothly lobed and bearing an anterior process, the hypandrium lacking development of phallic processes, abdominal tergum 8 typically being collar-like (Figs. 3–5, 8–11), and the basoventral swelling on the mid femur ranging from weakly to strongly developed (see Figs. 6, 7). The group includes western and southwestern species, including some that extend into the Neotropical Region, but also includes two taxa in the eastern United States, one of which may be a species complex occurring throughout North America.

Neoplasta bifida MacDonald & Turner, NEW SPECIES
(Fig. 4)

Diagnosis.—Males are characterized by the deeply cleft anterior process of the cercus, which consists of two blade-like projections.

Description.—Body length including terminalia ca. 3.0 mm. Propleuron black. Mid femur with prominent basoventral swelling, bearing 4 closely spaced, yellow bristles (see Fig. 6); mid tibia bearing distal row of black setulae. Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Terminalia (Fig. 4) oriented in a vertical plane; epandrial lobe strongly convex, projecting apicodorsally and partially overlapping cercus; cercus broadly oval in a dorsal plane in lateral view, bearing bifid anterior process consisting of 2 blade-like projections of unequal length. FEMALE. Similar to male in size, coloration and venation; indistinguishable from females of other species of the *N. scapularis* group that have a black propleuron.

Type material.—HOLOTYPE male labelled: "ARIZ: Pima Co., Catalina/Mtns., Marshall Gulch/near Summerhaven, 28 May/1986, J. Jenkins coll" (USNM). The specimen is in excellent condition, with macerated terminalia in a glycerin microvial attached to pin; the type locality is about

30 kilometers northeast of the city of Tucson. PARATYPES. MEXICO: Durango: 1 male, 10 mi W. El Salto, Jun (CNC). UNITED STATES: Arizona: 7 males, 16 females, same data as holotype (WSU); 1 male, Cochise Co., Chiricahua Mts., May (WSU); 13 males, 8 females, Cochise Co., 5 mi W. Portal, Oct–Dec (AMNH); 1 male, 1 female, Cochise Co., Chiricahua Mts., Sep (USU).

Distribution.—Males of this species are known only from extreme southeastern Arizona and from near Durango, Mexico (Fig. 19).

Etymology.—The specific epithet is from the Latin word "bifidus," meaning split into two parts, in reference to the deeply cleft anterior process of each cercus.

Neoplasta concava MacDonald & Turner, New Species
(Fig. 10)

Diagnosis.—Males are distinguished by a more or less smoothly rectangular cercus, which is oriented in an anterodorsal plane in lateral view, and the prominent basoventral swelling of the mid femur. Maceration is necessary to reveal the diagnostic cavity on the median margin of the cercus, but the shape of the cercus differs from similar species on which it is more or less triangular in lateral view.

Description.—MALE. Body length including terminalia ca. 3.2 mm. Propleuron typically brown, occasionally nearly black. Mid femur with prominent basoventral swelling, bearing row of 6–8 closely spaced, yellow bristles (see Fig. 6); mid tibia indented apically, with distal ¼ bearing black setulae. Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Terminalia (Fig. 10) oriented in a vertical plane; cercus more or less rectangular in an anterodorsal plane in lateral view, ca. 1.5–2.0× larger than epandrial lobe; cercus deeply excavated along median margin; anterior process of cercus broadly lobed distally. FEMALE. Similar to male in size, color, and venation; indistinguishable from other species of the *N. scapularis* group that have either a brown or black propleuron.

Type material.—HOLOTYPE male, labelled: "Utah: Wayne Co./Capital Reef N. Prk./Pleasant Crk./V.31–VI.2-1992/J. F. MacDonald" (USNM). The specimen is in excellent condition and most of the diagnostic features of terminalia visible without maceration; the type locality is Capitol Reef National Park in southcentral Utah. ALLOTYPE, same data as holotype (USNM). PARATYPES. Arizona: 1 male, Alpine, Jun (USNM); 5 males, 4 females, Cochise Co., Chiricahua Mts., May (WSU); 1 male, Cochise Co., 5 mi SW Portal, May–Jun (USNM); 4 males, 25 females, Cochise Co., Huachuca Mts., Mar–Apr (CNC); 1 male, Patagonia; 2 males, White Mts., Jul (USNM). Colorado: 2 males, 3 females, Park Co., 11 Mile Cyn., 8 mi SW Florissant, Jun (MAC; PERC); 1 male, Chaffee Co., Buena Vista, Jun (CNC). New Mexico: 2 males, 4 females, Grant Co., Iron Crk. Cmpgr., Jun–Jul (USU); 1 male, Los Alamos Co., Jemez Sprs., Jul (UKL). Utah: 3 males, 4 females, Cache Nat. For., Wasatch Mts., Jul (USNM); 1 male, 2 females, Capital Reef Nat. Prk., Garfield Co., Sulphur Crk., Aug (USU); 8 males, 1 female, Capitol Reef Nat. Prk., Wayne Co., May–Jun (USNM); 1 male, Millard Co., Fool Crk. Pass, Jun (USU); 2 males, Utah Co., Mapleton, Aug (USU); 4 males, 3 females, Washington Co., Leeds Cyn., Jun and Sep (CAS, USU); 1 male, 1 female, Washington Co., Zion Nat. Prk., Jun (USU).

Distribution.—Males of this species are known from the central Rocky Mountains south into extreme southern Arizona and New Mexico (Fig. 18).

Etymology.—The specific epithet is from the Latin word "concavus," in reference to the relatively deep excavation along the inner margin of each cercus, which is visible only upon maceration.

Fig. 17. Distribution of *Neoplasta scapularis*.

Fig. 18. Distribution of *Neoplasta concava, N. megorchis, N. paramegorchis* and *N. scapuliformis*.

Remarks.—*Neoplasta concava* may on occasion hybridize with *N. scapularis,* as evidenced by one male collected near Patagonia, Arizona that possessed terminalia intermediate between the two species.

Neoplasta deyrupi MacDonald & Turner, New Species
(Fig. 5)

Diagnosis.—Adults closely resemble those of *N. scapularis* in general structure and coloration. Males of *N. deyrupi,* however, are easily distinguished by the elongate, recurved anterior process on each cercus, which typically is visible on unmacerated specimens.

Description.—MALE. Body length including terminalia ca. 3.5 mm. Propleuron brown to dark brown. Mid femur with diffuse basoventral swelling, bearing row of 8–9 yellow bristles (see Fig. 7), the distal 2 more widely spaced and slightly off-set posterolaterally; mid tibia ventrally bearing black setulae over distal ¼. Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Terminalia (Fig. 5) oriented in a vertical plane; cercus broadly triangular in anterodorsal plane, slightly larger than epandrial lobe; anterior process of cercus elongate and slender, curving posteriorly upward and inward. FEMALE. Similar to male in size, coloration, and venation; indistinguishable from females of other species of the *N. scapularis* group that have a brown propleuron.

Type material.—HOLOTYPE male, labelled: "USA: Indiana/Tippecanoe Co./5 km W. Lafayette/May 10, 1992/J. F. MacDonald" (CNC, holotype no. 21339). The specimen is in excellent condition and the diagnostic features of the terminalia visible without maceration. ALLOTYPE, same data as holotype (CNC). PARATYPES. Indiana: 16 males, 10 females, same data as holotype, May–Jul (MAC, PERC). Georgia: 1 male, Rabun Co., Pine Mt., May; 1 male, White Co., Unicoi St. Prk., Jun (CNC); 1 male, Rabun Co., Black Rock Mt., May (CU). North Carolina: 1 male, Black Mt., May (AMNH). Virginia: 1 male, Loudoun Co., Harpers Ferry, May (CNC). South Carolina: 1 male, Spartanburg, Jun (USNM).

Distribution.—Males of this species are known from Indiana, and the central and southern Appalachian Mountains (Fig. 19).

Etymology.—This species is named after Mark Deyrup, who made collecting in Indiana enjoyable and contributed part of the material in the type series from West Lafayette.

Remarks.—Based on specimens collected in Malaise traps placed along and across small streams in hardwood forest in Indiana, *N. deyrupi* exhibits an adult flight period that appears to be limited to May and early June. This early season activity may be a consequence of larval development in small streams that tend to cease flowing by mid-summer. Additional collecting likely will reveal more widespread distribution over eastern North America now that this species is distinguished from *N. scapularis.*

Neoplasta megorchis Melander, New Status
(Figs. 6, 8)

Neoplasta scapularis variety *megorchis* Melander, 1947: 263.

Diagnosis.—Males are recognized by the long setae on the outer surface of the large, broadly triangular cercus; they also are characterized by the strongly developed basoventral swelling on the mid femur, including an off-set distal bristle, and a brownish propleuron. Males of *N. concava,* which are similar in general appearance to those of *N. megorchis,* differ in possessing relatively short setae on a more or less rectangular cercus.

Description.—MALE. Body length including terminalia ca. 3.2 mm. Propleuron brown. Mid femur with prominent basoventral swelling, bearing closely spaced row of 4–5 (usually 4) yellow bristles, with an additional distal bristle off-set posterolaterally (Fig. 6). Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Terminalia (Fig. 8) oriented in a vertical plane; cercus broadly triangular in anterodorsal plane in lateral view, ca. 2× larger than epandrial lobe; setae on outer surface longer than anterior process; anterior process of cercus broadly lobed apically, narrowed basally, bearing patch of black setulae on inner surface. FEMALE. Similar to male in size, coloration, and venation; indistinguishable from females of other species of the *N. scapularis* group that have a yellowish brown to dark brown propleuron.

Type material examined.—HOLOTYPE male labelled, "Ilwaco, Washington/May 25, 1917/A. L. Melander" (USNM). The specimen is in fair condition, lacking the head and all but the coxa of the right front leg; the macerated terminalia (JFM, July 1988) are in a glycerin microvial attached to the pin. The elaborated type locality is Washington, Pacific County, Illwaco, about 20 kilometers northwest of Astoria, Oregon. PARATYPES: California: 1 male, Humboldt Co., Blue Lk., Jun; 1 male, Santa Cruz Co., Santa Cruz Mts., Jul (USNM). Oregon: 2 males, Curry Co., Humbug St. Prk., Aug; 1 male, Washington Co., Forest Grove, Jun; (USNM). Washington: 1 male, Island Co., Orcas Island, Aug (USNM).

Other specimens examined.—California: 1 male, Monterey Co., Big Sur, Sep (USNM). Oregon: 1 male, 1 female, Wallowa Co., Minam R., Jul (CAS). Washington: 5 males, Asotin Co., Asotin Crk., Jun–Aug (WSU).

Distribution.—Males of this species are known from Washington, Oregon and the coastal mountains of northern and central California (Fig. 18).

Neoplasta octoterga MacDonald & Turner, New Species
(Fig. 2)

Diagnosis.—Males are characterized by the unusual development of the eighth abdominal tergum, which is elongated and sclerotized. As a result, the terminalia are distinctly separated from the seventh abdominal segment, a condition that is apparent even on unmacerated, dried specimens.

Description.—MALE. Body length including terminalia ca. 2.8 mm. Propleuron yellow or black. Mid femur with diffuse basoventral swelling (see Fig. 7); vestiture variable, either 8–9 yellow bristles or 2–5 stronger, yellow bristles. Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Abdominal segment 8 (Fig. 2) elongate, tubular, with tergal plate deeply excised basally in dorsal view. Terminalia (Fig. 2) oriented in a vertical plane; cercus broadly oval and elongated in a dorsal plane, posterior margin lobed; anterior process of cercus weakly to moderately developed. FEMALE. unknown.

Type material.—HOLOTYPE male, labelled, "U. S. A.: OREGON: Hood/River Co. Starvation/Creek State Park, at/falls. 26 June 1978/D. D. Wilder collector" (CAS). The specimen is in good condition and most of the diagnostic features of terminalia visible without maceration; the type locality is about 20 kilometers west of the town of Hood River. PARATYPES. CANADA. British Columbia: 1 male, Trans. Canada Hwy. #1, Chase Crk. Falls, Aug, (CAS). UNITED STATES. California: 3 males, Modoc Co., Cedar Pass Cmpgr., Aug; 1 male, Mono Co., 8 mi N. Bridgeport, Jul (CAS). Idaho: 1 male, Nez Perce Co., Soldier's Mdw. Reservoir, 45 km SE Lewiston, Jul (CAS). Oregon: 1 male, same data as holotype; 2 males, Josephine Co., 3 km S. Cave Junction, Jun (CAS). Utah: 2 males, Cache Co., Blacksmith Frk., Jul; 1 male, Washington Co., Leeds Cyn., Sep (USU).

Distribution.—Males of this species are known from the westcentral United States north into southcentral British Columbia (Fig. 19).

Etymology.—The specific epithet is formed from the Latin words "octo," for

Fig. 19. Distribution of *Neoplasta bifida, N. deyrupi, N. chrysopleura,* and *N. octoterga.*

Fig. 20. Distribution of *Neoplasta hebes, N. hansoni,* and *N. parahebes.*

eight, and "terga," for back, in reference to the distinctive eighth abdominal tergum.

Remarks.—Males of this species appear to vary in propleural coloration and the degree of development of the anterior process of the cercus. A male from Utah, with terminalia identical to the holotype, differed in possessing a black propleuron. In comparison to other males of *N. octoterga,* the anterior process of each cercus on one from northeastern California and another from northern Utah is relatively well developed.

Neoplasta paramegorchis MacDonald & Turner, New Species
(Fig. 11)

Diagnosis.—Males are characterized by a unique combination of features, some of which individually can be found in males of other species. Each cercus is triangular in lateral view and about 1.5–2.0 times larger than the corresponding epandrial lobe, the setae on the outer surface of each cercus are shorter than the anterior process, the anterior process of each cercus is broadly truncate apically, the propleuron is yellow (occasionally yellowish brown), and the basoventral swelling on the mid femur is diffuse.

Description.—MALE. Body length including terminalia ca. 3.2 mm. Propleuron yellow, occasionally yellowish brown. Mid femur with diffuse basoventral swelling (see Fig. 7), bearing row of 6–8 (usually 6) yellow bristles. Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Terminalia (Fig. 11) oriented in a vertical plane; cercus broadly triangular in an anterodorsal plane in lateral view, ca. 1.5–2.0× larger than epandrial lobe; anterior process of cercus broad and smoothly truncate apically, bearing large patch of black setulae on inner surface. FEMALE. Similar to male in size, coloration, and venation; indistinguishable from female of other species of the *N. scapularis* group that have a yellow propleuron.

Type material.—HOLOTYPE male, labelled: "Utah Cache Co/Logan Cyn, Turner/C. G. 16–30 Aug 85/W. J. Hanson" (CNC, holotype no. 21340). The specimen is in excellent condition and most of the diagnostic features of terminalia visible without maceration; the type locality is Logan Canyon northeast of the city of Logan. ALLOTYPE, same data as holotype (CNC). PARATYPES. CANADA. Alberta: 3 males, Jumping Pd. Crk., 20 mi W. Calgary, Jun–Aug; 1 male, 15 mi E. Morley, Aug; 1 male, Mt. View, Jun (CNC); 1 male, Wild Hay R. at Highway 40, Jul (CAS). UNITED STATES. Arizona: 7 males, 1 female, Cochise Co., nr. Portal, Jun (USNM); 10 males, 3 females, Coconino Co., Havashu Falls, Mar (UCR). California: 1 male, Mono Co., Leavitt Mdw., Aug (CAS). Colorado: 1 male, 1 female, Gunnison Co., 17.7 km SE Cimarron (CAS); 1 male, Eagle Co., State Bridge, nr. Bond, Jun (CNC); 1 male, Summit Co., Frisco, Jun (USNM). Idaho: 2 males, 3 females, Bear Lk. Co., nr. Montpelier, Aug (CAS); 2 males, 1 female, Caribou Co., Kendall Crk., Jun–Jul; 1 male, Franklin Co., Aug (USU). Montana: 2 males, Jefferson Isle., Jul; 1 male, Vernon, Aug (USNM, WSU). New Mexico: 14 males, 15 females, Grant Co., Pinos Altos, Jun; 1 male, Jemez Sprs., Jul; 1 male, Oak Cr., nr. Flagstaff, May; 1 male, Reserve, Jun (CAS, USNM). South Dakota: 3 males, Lawrence Co., Spearfish Crk., 1 female, Beaver Crk., Jun (USNM). Utah: 7 males, 5 females, Capitol Reef Nat. Prk., Wayne Co., May–Jun (USNM); 1 male, Cache Co., Beaver Mt., Aug; 11 males, 12 females, Cache Co., Blacksmith Frk., Jun–Jul; 3 males, Cache Co., Franklin Basin, Jul; 1 male, Cache Co. W. Hodges Cyn., Aug; 123 males, 119 females, Cache Co., Logan Cyn., Jun–Aug; 1 male, 13 females, Cache Co., Logan, Jun–Sep; 26 males, 13 females, Utah Co., Provo, Jun–Sep; 4 males, Washington Co., Leeds Cyn., Jun; 2 males, Washington Co., Lower Deep Crk., Aug; 1 male, Upper Deep Crk., Aug; 1 male, Washington Co., Wiley Crk., Sep (USU); 2 males, Cache Co., Blacksmith

Frk., Jul (CAS). Wyoming: 1 male, Little Wind R., Sep (AMNH); 1 male, 3 females, Dubois, Sep (FSCA, USNM); 1 female, Bull Lk., Sep; 1 female, Dimwiddie Crk., Sep; 1 male, 2 females, Divide Crk., Sep; 2 females, Torrey's Lk., Sep; 1 male, Yellowstone, Jul (USNM).

Distribution.—The vast majority of specimens have been collected in the Rocky Mountains from Alberta south to extreme southern New Mexico and Arizona, but males also are known from eastern California and western South Dakota (Fig. 18).

Etymology.—The specific epithet is an arbitrary combination of letters incorporating "para," Greek for beside or near, and "megorchis," alluding to the structural similarity between the new species and *N. megorchis.*

Remarks.—Minor variation in the structure of terminalia exists in some males from Arizona and New Mexico, on which the cercus is less extended in a dorsal plane and the anterior process of the cercus is broader in lateral view. Such males, however, appear to match the species in other respects, including a yellow or yellowish brown propleuron and a diffuse basoventral process on the mid femur that bears six to eight setae.

***Neoplasta scapularis* (Loew)**

(Figs. 7, 9, 12)

Hemerodromia scapularis Loew, 1862: 209.

Diagnosis.—Males are characterized by a unique combination of features, some of which individually can be found in males of other species. Each cercus is broadly triangular in lateral view and subequal in size to the corresponding epandrial lobe, the setae on the outer surface of each cercus are shorter than the anterior process, and the anterior process of each cercus is straight.

Description.—MALE. Body length including terminalia ca. 3.2–3.4 mm. Propleuron ranging from yellow to light brown to nearly black. Mid femur with basoventral swelling ranging from diffuse and bearing row of 8–9 yellow bristles (Fig. 7) to prominent and bearing closely-set row of 4–5 stronger, yellow bristles, on some with an additional distal bristle off-set posterolaterally (see Fig. 6). Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (Fig. 12). Terminalia (Fig. 9) oriented in a vertical plane; cercus broadly triangular in an anterodorsal plane in lateral view, slightly larger than epandrial lobe; anterior process of cercus straight. FEMALE. Similar to male in size, coloration, and venation; indistinguishable from females of other species of the *N. scapularis* group.

Type material examined.—LECTOTYPE male, here designated from MCZ type series #1643, consisting of two males and three females, all in excellent condition. The two males possess the same data; upper label "Md" and lower label "Loew coll."; no other data present on labels. The male with a yellowish brown propleuron is designated LECTOTYPE and the second male with a brownish propleuron PARALECTOTYPE. Terminalia of neither male were dissected and macerated since the distinguishing features could be discerned. Three PARALECTOTYPE females: one with yellow propleuron with upper label "Me" and lower label "Loew coll."; two with brownish propleuron with upper label "Penn." and lower label "Loew coll." The lectotype and all paralectotypes are deposited in MCZ.

Other material examined.—584 males, 570 females (see remarks section and Fig. 17). CANADA: Northwest Territories, Alberta, British Columbia, Ontario, Quebec, New Brunswick, Northwest Territories, and Nova Scotia. UNITED STATES: Alaska, Arizona, Arkansas, California, Colorado, Idaho, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Tennessee, Utah, Virginia, Washington, and Wisconsin.

Distribution.—Males are known throughout the lower United States and southern Canada (Fig. 17).

Remarks.—The taxonomic status of *N. scapularis* requires more study. This taxon may represent a species complex, but we were unable to identify discrete phena because intermediates connecting recognizable forms were encountered throughout its transcontinental distribution. For example, eastern specimens with a black propleuron usually possess a prominent basoventral swelling on the mid femur and an off-set distal bristle, but others with a black propleuron and identical terminalia have a diffuse basoventral swelling on the mid femur. And, while all west coast specimens possess a yellow propleuron, some have a mid femur identical to that of eastern specimens that possess a black propleuron and a prominent basoventral swelling with an off-set distal bristle. Unfortunately, few specimens exist from the central United States and Canada, but males from the Rocky Mountains are intermediate in propleural coloration, development of the mid femur and structure of the anterior process of the cercus, seemingly connecting their eastern and western counterparts.

More detailed discussion of character variation is warranted to support our taxonomic decision. Four forms of mid femur structure exist in males possessing nearly identical terminalia: 1) mid femur strongly arched basally, with prominent basoventral swelling bearing row of 4–5, closely-spaced bristles with an additional distal bristle off-set posterolaterally; 2) mid femur very strongly arched basally, with prominent swelling bearing row of 4–5, closely-spaced bristles, but lacking an off-set distal bristle; 3) mid femur slightly arched basally, with diffuse basoventral swelling bearing row of 8–9, weaker bristles, with two distal bristles slightly stronger and slightly off-set posterolaterally; and 4) mid femur strongly arched basally, with prominent basoventral swelling bearing row of 6–7, closely-spaced bristles with an additional distal bristle slightly off-set posterolaterally. The first condition tends to be common on eastern specimens with a black propleuron and on specimens from Sequoia and Yosemite National Parks in California with a yellow propleuron. The second condition occurs on eastern specimens possessing a yellow propleuron. The third condition exists on specimens across the continent, including eastern specimens with propleural coloration ranging from yellow to nearly black. The fourth condition exists on specimens from the Rocky Mountains possessing a propleuron ranging in color from light brown to nearly black.

Overall, the propleuron was found to be yellow on 487 of 584 males (83%) and 499 of 570 females (88%) sampled over the geographical range of *N. scapularis.* Variation in propleural coloration was found to be greatest in specimens along the Appalachian Mountains and eastern seaboard, where the propleuron ranged from light brown to black on 61 of 155 males (39%) and 47 of 141 females (33%). The propleuron on 22 males from central Colorado and New Mexico ranged from yellowish brown in the north to brown in the south. A yellow propleuron occurred on all 407 males and 429 females from California north to Alaska.

Maceration of males revealed that specimens concurrently collected in Great Smoky Mountains National Park, the central Atlantic seaboard, New England, Ontario and Quebec possess nearly identical terminalia, but exhibit the range of propleural coloration from yellow to brown to black. Males with a yellow propleuron and a diffuse basoventral swelling on the mid femur differ slightly in the shape of the anterior process of the cercus, with eastern specimens and northern Rocky Mountain specimens possessing a narrower and more pointed anterior process than their west coast counterparts. Males from the west coast possess an anterior process of the cercus that is slightly expanded and more truncate apically than their eastern counterparts.

Based on the variation just described, we treat *N. scapularis* as a widely distributed species that varies in propleural coloration, the structure of the mid femur, and the shape of the anterior process of the cercus. We found no evidence to support Melander's (1947) variety "*alleghani*" established on the basis of a black propleuron, and no evidence to support Melander's (1947) variety "*radialis*" based on a slight difference in wing venation.

Neoplasta scapularis is one of the most widely distributed hemerodromine species (Fig. 15) and the most frequently encountered *Neoplasta,* except in the central Rocky Mountains where *N. paramegorchis* and *N. hansoni* are more commonly collected. *Neoplasta scapularis* was shown to be associated with a variety of lotic habitats in Quebec, including large rivers and small streams (Harper 1980, Landry and Harper 1985). In the present study, specimens commonly were taken in our Malaise traps set up along or across streams in Indiana, Georgia, Great Smoky Mountains National Park, and the central Sierra Nevada mountains of California.

***Neoplasta scapuliformis* MacDonald & Turner, New Species**

(Fig. 3)

Diagnosis.—The only known male of *N. scapuliformis* closely resembles males of *N. scapularis* that have a yellow propleuron. The terminalia are distinctive, however, with each cercus being broadly oval in a posterodorsal plane and bearing a weakly differentiated anterior process. This is in contrast to the well developed anterior process found on the cercus of males of all other species in the *N. scapularis* group, except *N. octoterga* (the males of which possess a distinctive eighth abdominal tergum).

Description.—MALE. Body length including terminalia ca. 3.0 mm. Propleuron yellow. Mid femur with diffuse basoventral swelling (see Fig. 7), bearing row of 6 yellow bristles. Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Terminalia (Fig. 3) oriented in a vertical plane; cercus broadly oval dorsally in lateral view, subequal in size to epandrial lobe; anterior process of cercus weakly differentiated from body of cercus. FEMALE. Similar to male in size, coloration, and venation; indistinguishable from females of other species of the *N. scapularis* group that have a yellow propleuron.

Type material.—HOLOTYPE male, top label: "ARIZONA Oak/Crk Cn Sedona/29 June 1953," bottom label "W W Wirth/ Collector" (USNM). The specimen is in good condition, but the macerated terminalia, which are in a glycerin microvial attached to pin, are over-cleared and nearly unapparent in the microvial. The type locality is about 30 kilometers south of the city of Flagstaff. ALLOTYPE, same data as holotype (USNM).

Distribution.—The only known male is from northcentral Arizona (Fig. 18).

Etymology.—The specific epithet is an arbitrary combination of letters incorporating "formis," Latin for shape or figure, and "scapularis," alluding to the structural similarity between the new species and *N. scapularis.*

THE *N. CHRYSOPLEURA* SPECIES GROUP

This group includes one species in America north of Mexico, *N. chrysopleura* described below, but appears to include additional representatives in the Neotropical Region. This conclusion is based on preliminary examination of specimens of other species of *Neoplasta* from South America.

***Neoplasta chrysopleura* MacDonald & Turner, New Species**

(Fig. 1)

Diagnosis.—Adult males and females are distinguished by the coloration of the thoracic pleura. In addition, males of *N. chrysopleura* have distinctive terminalia, described below, and different vestiture on the legs. For example, the fore femur bears a complete row of large, bluntly pointed setulae ventrally in contrast to the single large setula within a row of much smaller setulae that exists on males of other species treated here.

Description.—MALE. Body length including terminalia ca. 3.5 mm. Propleuron, mesopleuron, metapleuron and ventral portion of laterotergite golden yellow; remainder of thorax black; legs yellow. Vein R_{2+3} gradually curving anteriorly, joining C from 0.3–0.5 distance between R_1 and R_4 (see Fig. 12). Fore femur ventrally bearing median row of 9–10 large, black setulae over basal ⅔, with intermixed smaller black setulae forming 2 diverging rows over distal ⅓. Mid femur strongly arched basally, with 4 golden bristles lining basoventral swelling on outer surface and 3 weaker bristles on inner surface. Mid tibia with distal patch of black setulae lining indentation for reception of basoventral swelling of mid femur, including 6 stronger setulae forming an outer row. Terminalia (Fig. 1) oriented in a horizontal plane; cercus pointed posteriorly in lateral view and strongly notched over distal ½ in dorsal view; epandrial lobe nearly rectangular in lateral view, with distal fringe of long setae; hypandrium more or less rectangular in lateral view, with patch of prominent setae mid ventrally and large distal process projecting dorsally. FEMALE. Similar to male in size, coloration, and venation; lacking prominent vestiture of male mid leg.

Type material.—HOLOTYPE male, top label "USA: AL. Co./10 km E. Evergreen/ 23. IV. 1989/J.M. Cumming," bottom label "ex. along woodland/sandbottom stream" (CNC, holotype no. 21338). The specimen is in excellent condition and most of the diagnostic features of terminalia visible without maceration. ALLOTYPE, same data as holotype (CNC). PARATYPES. Alabama: 2 females, same data as holotype (CNC). South Carolina: 2 males (both partially damaged; one male with macerated terminalia in glycerin microvial attached to pin), Anderson, 21. VII. 1957 (CNC).

Distribution.—This species is known only from the southeastern United States (Fig. 19).

Etymology.—The specific epithet is formed from the Greek "chryso," for gold, and "pleura," for side, in reference to the color of the thoracic pleura, all of which are golden yellow.

Remarks.—The type series, collected by J. M. Cumming (Biological Resources Division, Agriculture Canada, Ottawa), was taken while sweeping vegetation along the banks of a sand bottom stream that ran through a hardwood forest.

CONCLUDING REMARKS

Adults of species of *Neoplasta* reportedly prey upon black fly larvae (Peterson 1960) and caddisfly pupae (Knutson and Flint 1971), but no other prey records exist. Larvae and pupae have not been described, but they are thought to be aquatic (Steyskal and Knutson 1981), and data associated with the collection of adults support this contention. Adults of *Neoplasta scapularis* have been captured in emergence traps placed over streams in Quebec and were most abundant in association with areas of greatest current (Harper 1980, Landry and Harper 1985). During the present study, adults of *N. concava, N. deyrupi, N. paramegorchis* and *N. scapularis* were collected in Malaise traps set up either along or across small streams. Adults of *N. concava* and *N. paramegorchis* also were aspirated from leaves of trees along streams in southcentral Utah and southern Colorado; those of *N. scapularis* were collected in a similar manner in Indiana and Great Smoky Mountains National Park. These adults appear to be restricted to shaded foliage in such habitats, most commonly the undersides of leaves, and they typically are active only during mid- to late afternoon.

Awareness of possible sites of larval development and knowledge of specific habitats in which adult activity occurs will be of value in ecological and biological research pertaining to this genus. Description of larvae could be of importance to phylogenetic studies of the Hemerodromiinae, especially since adults of *Neoplasta* differ from those of other genera in such features as fore leg structure and wing venation. The use of techniques presented by Cumming and Cooper (1992) involving decapitation of female adults to force oviposition and subsequent rearing of larvae in nutrient agar may be a means of obtaining larvae of *Neoplasta* for study, in the event their particular development site is not discovered and they cannot be collected.

The species of *Neoplasta* treated here appear to have diverged relatively recently, as suggested by their uniform morphology and often subtle differences in male terminalia. Also, we have noted what appears to be hybridization, in the form of recognizable intermediates between two different pairs of closely related species (see remarks under *Neoplasta concava* and *N. parahebes*). Answers to questions pertaining to the mechanisms of reproductive isolation among closely related species may be approachable now that we can pinpoint adult activity to a particular time and place, for example, mid-afternoon on the undersides of leaves overhanging small streams. Similarly, the taxonomic status of "*N. scapularis*" may be resolved if living specimens can be observed and collected so that the color and structural forms of adults can be studied in relation to geographical distribution, reproductive behavior, and molecular characters.

ACKNOWLEDGMENTS

We thank the following individuals for the loan of material: P. H. Arnaud, Jr. (CAS); R. W. Brooks (UKL); D. S. Chandler (UNH); P. J. Clausen (UMSP); S. Frommer (UCR); W. J. Hanson (USU); L. Knutson (USNM); J. K. Liebherr (CU); R. T. Schuh (AMNH); H. J. Teskey and J. M. Cumming (CNC); and H. V. Weems (FSCA).

Sincere appreciation is extended to the dipterists in the Biological Resources Division, Agriculture Canada, Ottawa, who greatly facilitated the research during visits by the first author, and especially to J. M. Cumming and B. Sinclair who assisted in the interpretation of male terminalia and also collected valuable series of adults. We also thank W. J. Hanson who collected large series of species of *Neoplasta,* including two type series. Arwin Provonsha, Department of Entomology, Purdue University, prepared the illustrations. This paper is Purdue Agricultural Experiment Station journal No. 13506.

LITERATURE CITED

Collin, J. E. 1933. Diptera of Patagonia and South Chile. Part IV, Empididae. British Museum (Natural History), London. 334 pp.

Coquillett, D. W. 1895. Revision of the North American Empididae.—A family of two-winged insects. Proceedings of the United States National Museum 18: 387–440.

———. 1903. The genera of the dipterous family Empididae, with notes and new species. Proceedings of the Entomological Society of Washington 5: 245–272.

Cumming, J. 1992. Lactic acid as an agent for macerating Diptera specimens. Fly Times 8: 7.

Cumming, J. M. and B. E. Cooper. 1993. Techniques for obtaining adult-associated immature stages of predacious tachydromine flies (Diptera: Empidoidea), with implications for rearing and biocontrol. Entomological News 104: 93–101.

Cumming, J. M. and B. J. Sinclair. 1990. Fusion and confusion: Interpretation of male genitalic homologies in the Empidoidea (Diptera). Abstract of the second International Congress of Dipterology, Bratislava, third supplement, p. 334.

Harper, P. P. 1980. Phenology and distribution of aquatic dance flies (Diptera: Empididae) in a Laurentian watershed. American Midland Naturalist 104: 110–117.

Knutson, L. V. and O. J. Flint, Jr. 1971. Pupae of Empididae in pupal cocoons of Rhyacophilidae and Glossosomatidae (Diptera, Trichoptera). Proceedings of the Entomological Society of Washington 73: 314–320.

Landry, B. and P. P. Harper. 1985. The aquatic dance fly fauna of a subarctic river system in Quebec, with the description of a new species of Hemerodromia (Diptera: Empididae). Canadian Entomologist 117: 1379–1386.

Loew, H. 1862. Diptera Americae septentrionalis indigena. Centuria secunda. Berlin. Entomologische Zeitschrift 6: 185–232.

MacDonald, J. F. 1993. Review of the genus *Chelipoda* Macquart of America north of Mexico (Diptera: Empididae, Hemerodromiinae). Proceedings of the Entomological Society of Washington 95: 327–350.

McAlpine, J. F. 1981. Morphology and terminology—Adults, 2, pp. 9–63. *In* McAlpine, J. F. et al., (eds.), Manual of Nearctic Diptera. Vol. 1. Monograph No. 27. 674 pp. Research Branch, Agriculture Canada.

Melander, A. L. 1902. A monograph of the North American Empididae. Part I. Transactions of the American Entomological Society 28: 195–367.

———. 1928. Diptera, Family Empididae. Fascicle 185, pp. 1–434. *In* Wytsman, P., ed., Genera Insectorum. Louis Desmet-Verteneuil, Bruxelles.

———. 1947. Synopsis of the Hemerodromiinae (Diptera: Empididae). Journal of the New York Entomological Society 55: 237–273.

Peterson, B. V. 1960. Notes on some natural enemies of Utah black flies (Diptera: Simuliidae). Canadian Entomologist 92: 266–274.

Smith, K. G. V. 1962. Studies on the Brazilian Empididae (Diptera). Transactions of the Royal Entomological Society of London 114: 195–266.

———. 1967. Family Empididae, 39, pp. 39–44. *In* A Catalogue of the Diptera of the Americas South of the United States. Departmento de Zoologia, Secretaria da Agricultura, Sao Paulo, Brazil.

Steyskal, G. C. and L. V. Knutson. 1981. Empididae, 47, pp. 607–624. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera. Vol. 1. Monograph No. 27. 674 pp. Research Branch, Agriculture Canada.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 377–382

BIOLOGY OF *HYADINA ALBOVENOSA* (DIPTERA: EPHYDRIDAE), A CONSUMER OF CYANOBACTERIA

B. A. Foote

Department of Biological Sciences, Kent State University, Kent, Ohio 44242.

Abstract.—Information is presented on the life cycle and larval feeding habits of *Hyadina albovenosa* Coquillett, a common and widely distributed shorefly species of the subfamily Hyadininae and tribe Hyadinini. Larvae were found in nature only on soil-inhabiting colonies of *Anabaena*, a genus of Cyanobacteria (blue-green algae). Laboratory feeding tests indicated that the larvae can develop on a wide mixture of Cyanobacteria and even on such true algae as the diatom *Navicula pelliculosa* and the euglenophyte *Euglena gracilis*. Under laboratory conditions, the life cycle was completed in 18–19 days if *A. variabilis* served as the larval food. Eight generations a year can be produced in northeastern Ohio.

The larval food preference of *H. albovenosa* is contrasted and compared with those of other species of Hyadininae that utilize soil-inhabiting Cyanobacteria.

Key Words: Insecta, Diptera, Ephydridae, biology, *Hyadina albovenosa*

The superfamily Ephydroidea, consisting of 5 families (Curtonotidae, Camillidae, Drosophilidae, Diastatidae, Ephydridae), contains some 4000 species and has a worldwide distribution (McAlpine 1989). Undoubtedly the larger and better known families biologically are the Drosophilidae and Ephydridae whose larvae commonly have microphagous habits. Many species of Drosophilidae occur in forested habitats where they consume heterotrophic microorganisms, particularly yeasts (Ferrar 1987), whereas many species of Ephydridae occur in open, wetland habitats where their larvae feed on a wide variety of algae (Foote 1977, 1979).

Two of the more interesting assemblages of phycophagous Ephydridae are in the tribes Hyadinini (*Axysta, Hyadina, Lytogaster, Microlytogaster, Pelina, Pseudohyadina*) and Philygriini (*Nostima, Philygria*) of the subfamily Hyadininae (Mathis and Zatwarnicki 1990). Larvae of species of these two tribes seemingly are specialized for the consumption of Cyanobacteria (blue-green algae) (Foote 1977). The larval feeding habits of *Lytogaster excavata* (Sturtevant and Wheeler), *Nostima approximata* Sturtevant and Wheeler, and *Pelina truncatula* Loew have been elucidated in earlier papers (Foote 1981a, b, 1983).

This paper discusses the larval feeding habits of *Hyadina albovenosa* Coquillett and presents data on its utilization of different microbial species. Trophic resource partitioning among certain species of Hyadininae is also discussed.

Materials and Methods

All field work was carried out in northeastern Ohio in Portage County. The laboratory rearings and larval feeding tests were maintained in an environmental chamber programmed to give a photoperiod of 15L: 9D and a temperature of 22°C (+1°C). Most of the algae used in the feeding tests were obtained from the University of Texas Culture Collection of Algae (Starr 1978). Species lacking UTEX numbers in the list below were obtained from the Phycology Laboratory of Kent State University. Each algal species was cultured on nutrient agar in sterile Petri plates until a distinct algal lawn had appeared on the surface of the agar. Feeding tests were performed following the procedures given in Zack and Foote (1978). The algal monocultures used in the feeding tests are given below.

- Cyanobacteria
  - *Anabaena flos-aquae* (1444)
  - *Anabaena variabilis* (B-377)
  - *Cylindrospermum* sp. (LB-942)
  - *Gloeocapsa alpicola* (B-589)
  - *Lyngbya spiralis* (B-1831)
  - *Nostoc commune* (584)
  - *Oscillatoria tenuis* (B-428)
  - *Spirulina* sp.
  - *Symploca muscorum* (B-617)
  - *Synechococcus leopoliensis* (625)
- Euglenophyceae
  - *Euglena gracilis* var. *bacillus* (L-884)
- Chlorophyceae
  - *Chlamydomonas eugametos* (9)
  - *Chlorella vulgaris* (29)
  - *Cosmarium botrytis* (175)
  - *Scenedesmus quadricauda* (76)
- Chrysophyceae
  - *Botrydiopsis alpina* (295)
  - *Botrydium becherianum* (158)
- Bacillariophyceae
  - *Navicula pelliculosa* (668)

LIFE HISTORY

According to Clausen (1983, 1984), the genus *Hyadina* in North America consists of 8 species. *Hyadina albovenosa* ranges from eastern Canada to Georgia and west to Arizona and on south to Mexico and El Salvador (Clausen 1983, fig. 31).

Deonier (1965) reported adults to be occasional inhabitants of the marsh-reed habitat. I found adults occasionally in sedge marshes, particularly in stands of *Carex stricta* Lam., but encountered them much more frequently in moist to wet mowed lawns. One particularly productive habitat consisted of an extensive grass lawn bordering a drainage ditch located near the Kent State University Field House. Other Ephydridae occurring at this site were *Hydrellia formosa* Loew, *Paracoenia fumosalis* (Fallén), *Scatella picea* (Walker), *S. stagnalis* (Fallén), *Leptopsilopa atrimana* (Loew), *Lytogaster excavata* (Sturtevant and Wheeler), *Philygria debilis* Loew, and *Nostima picta* (Fallén). The cyanobacterial genera *Anabaena, Cylindrospermum, Nostoc,* and *Oscillatoria* were abundant on the moist soil among the grass blades.

One female was reared from a third-instar larva feeding on a field-collected sample of *Anabaena* at the lawn site. The larva was collected on June 10, and the adult emerged on June 26.

Adults were particularly common at the lawn site during late spring and early summer, with the first seasonal record being May 4. Populations declined steadily as summer progressed, and the last seasonal record was obtained on August 15. A few adults were taken throughout June and July in weekly 20-sweep samples of nearly pure stands of *C. stricta* and reed canary grass, *Phalaris arundinacea* L., growing in a small marsh east of Kent.

Field-collected adults lived 10–35 days in laboratory cultures of *Anabaena variabilis,* but reared adults rarely survived more than 10 days on the same food substrate. Adults were relatively inactive but spent considerable periods of time feeding on the cultured lawn of *Anabaena*. Mating was observed within 3 days in a reared pair that had developed on *A. variabilis*. No overt courtship displays were noted, and it appeared that males attempted to mount any suitably sized individual, even those belonging to different ephydrid species. Copulation lasted 3–6 hours, and males continued to "ride" females after mating was completed in a manner similar to that described for *Nostima approximata* (Foote 1983). The single recorded pre-oviposition period, from emergence of the female to her first egg laying, lasted three days.

Females readily deposited eggs on cultured monocultures of a variety of blue-green algae, including species of *Anabaena, Calothrix, Cylindrospermum, Nostoc, Oscillatoria,* and *Spirulina.* However, females seemingly preferred *Anabaena* in mixed algal cultures. No or very few egg were deposited in cultures of other taxa of algae (greens, euglenophytes, diatoms, etc.), even if those non-cyanobacteria cultures were the only ones available to the females. A total of 453 eggs were deposited over an 18-day span by a field-collected female confined to a culture of *A. variabilis.* She began laying on May 30, the day after her capture, and continued to deposit 1–64 eggs daily until she died on June 15. Eggs were usually widely scattered over the surface of the algae. Each egg was covered with a thin layer of fecal material deposited by the female. Interestingly, the micropylar end of the egg never became overrun by algal filaments, suggesting that an antibiotic was present. In contrast, the remainder of the egg quickly became covered by a layer of algal trichomes. The incubation period of 10 eggs averaged 2 days (1.5–3.0 days).

Newly hatched larvae quickly began feeding on the algal lawn by pulling trichomes of *A. variabilis* into its oral cavity. This was accomplished through a raking action of the comb-like structures located on the facial mask on either side of and in front of the oral opening. Larvae fed gregariously on the algal lawn and displayed no obvious animosity to each other. They moved slowly over the algal surface and did not bury themselves into the substrate. As larvae moved across the algal lawn, they left behind an elongate track cleared of algae. Older larvae fed in a similar manner, and broken algal trichomes could be seen on the agar plate. The mouthparts moved relatively slowly and did not impart the flickering motion so typical of ephydrid larvae that are filter feeders of algal cells. Larval development (hatching to formation of puparium) was completed in an average of 5 days (n = 10). One day was spent in the first instar; 2, in the second, and 2, in the third instar.

A few hours prior to pupating, larvae ceased feeding, emptied the gut contents, and moved to a somewhat drier site on the agar substrate. Puparia commonly were clustered, with 2–5 puparia in each cluster. Both anterior and posterior spiracles usually projected above the algal lawn, whereas the central portion of the puparium frequently became covered with algae and detritus. The pupal period ranged from 8–9 days, averaging 8.5 days (n = 10).

Hyadina albovenosa is a multivoltine species in northeastern Ohio, requiring only 18–19 days to complete its life cycle (egg to egg) when reared on *A. variabilis.* This suggests that at least 8 generations a year could be produced in northeastern Ohio during a warm season extending from mid-May to mid-October.

Larvae completed development on 11 of the 19 tested algae, although the survivorship rate on different algae varied from 3 to 93 percent (Table 1). Nine of the 11 species of Cyanobacteria allowed for a complete life cycle. Only cultures of *G. alpicola* and *S. leopoliensis* were completely unsatisfactory. The most unexpected result was the relatively high survivorship (73%) of larvae reared on cultures of *Nostoc commune,* a taxon that was not used by *Lytogaster excavata, Nostima approximata,* or *Pelina truncatula* (Foote 1981a, b, 1983). Somewhat surprisingly, larvae also completed development on monocultures of the diatom *Navicula pelliculosa* and the euglenophyte *Euglena gracilis.* However, no record of the use of these two algae in nature was obtained.

There were strong differences in the larval and pupal periods of larvae developing on different species of algae (Table 2). The shortest combined developmental period (larval + pupal) occurred on *A. flos-aquae*

Table 1. Results of larval feeding tests for *H. albovenosa* using different algal monocultures.

Taxon	n	% Reaching Instar 2L	3L	P	A
Cyanobacteria					
Anabaena flos-aquae	30	100	97	87	40
Anabaena variabilis	30	100	100	100	93
Calothrix sp.	30	100	100	80	47
Cylindrospermum sp.	50	98	98	90	54
Gloeocapsa alpicola	20	0	—	—	—
Lyngbya spiralis	40	63	23	13	3
Nostoc communis	30	100	100	93	73
Oscillatoria tenuis	30	97	97	70	60
Spirulina sp.	30	100	93	83	73
Symploca muscorum	30	57	57	30	27
Synechococcus leopoliensis	30	100	50	33	0
Chlorophyceae					
Chlamydomonas eugametos	30	43	23	3	0
Chlorella vulgaris	20	25	0	—	—
Cosmarium botrytis	10	0	—	—	—
Scenedesmus quadricauda	10	10	0	—	—
Euglenophyceae					
Euglena gracilis	30	53	27	10	3
Bacillariophyceae					
Navicula pelliculosa	50	54	36	30	16
Chrysophyceae					
Botrydiopsis alpina	50	46	30	2	0
Botrydium becherianum	10	10	0	—	—

(12.3 days); the longest, on *E. gracilis* (23.0 days). A long developmental period of 21.9 days was also obtained on the cyanobacterium *Spirulina* sp.

The results of the choice tests utilizing 4 sets of algal combinations (Table 3) showed that the larvae most commonly chose *A. variabilis*. Very few larvae chose *L. spiralis* and none selected *N. commune*. The order of preference was *A. variabilis* ≫ *Calothrix* sp. > *A. flos-aquae* = *O. tenuis* = *Cylindrospermum* sp. > *L. spiralis*.

Discussion

Laboratory feeding results indicate that trophic resource partitioning occurs among

Table 2. Developmental period in days (larval plus pupal) of *H. albovenosa* feeding on eleven species of Cyanobacteria and algae.

Taxon	Developmental Period n	$\bar{x}$	s
Cyanobacteria			
A. flos-aquae	12	12.3	0.89
A. variabilis	28	14.1	1.24
Calothrix sp.	14	17.1	2.23
Cylindrospermum sp.	27	13.2	0.75
L. spiralis	1	17.0	1.73
N. commune	22	18.3	2.87
O. tenuis	18	13.6	1.09
Spirulina sp.	11	21.9	3.14
Symploca muscorum	8	17.4	1.19
Euglenophyceae			
E. gracilis	1	23.0	—
Bacillarophyceae			
N. pelliculosa	8	17.3	2.93

Table 3. Food preferences of newly hatched larvae of *H. albovenosa*. Each replicate consisted of five newly hatched larvae placed in the center of a ring of four algal plugs. Location of larvae after 24 h is given.

Alga	Replicate Number 1	2	3	4	5	$\bar{x}$
Test A						
A. flos-aquae	0	0	1	1	1	0.6
A. variabilis	3	5	4	2	4	3.2
Calothrix sp.	2	0	0	1	0	0.6
N. commune	0	0	0	0	0	0.0
Test B						
A. variabilis	3	5	4	2	2	3.2
Calothrix sp.	0	0	0	3	1	0.8
Cylindrospermum sp.	2	0	1	0	2	1.0
N. commune	0	0	0	0	0	0.0
Test C						
A. flos-aquae	2	0	0	0	0	0.4
A. variabilis	3	5	4	5	4	4.2
L. spiralis	0	0	0	0	0	0.0
O. tenuis	0	0	1	0	1	0.4
Test D						
A. variabilis	1	2	4	2	1	2.0
Calothrix sp.	1	3	1	0	2	1.4
L. spiralis	1	0	0	1	0	0.4
O. tenuis	1	0	0	2	2	1.0

Table 4. Percent of four species of Hyadininae attaining adult stage on six species of Cyanobacteria in laboratory feeding tests.

Species of Cyanobacteria	Species of Hyadiniinae			
	Hyadina albovenosa	*Lytogaster excavata*	*Pelina truncatula*	*Nostima approximata*
A. flos-aquae	40	0	20	0
A. variabilis	93	70	100	20
C. sp.	54	40	100	0
L. spiralis	3	0	40	0
N. commune	73	0	0	0
O. tenuis	60	0	30	72

at least some of the four ephydrid species that utilize soil-inhabiting Cyanobacteria in northeastern Ohio (Table 4). *Nostima approximata* had a high survival rate on *O. tenuis,* a low rate on *A. variabilis*, and zero survival on six other species of blue-green algae. This species probably is a specialist on *Oscillatoria.* Unpublished data on *Philygria debilis* Loew, another member of the tribe Philygriini, indicate that it also is a specialist on *Oscillatoria. Hyadina albovenosa* was the only species that could develop on *Nostoc* and showed high survival rates on *Cylindrospermum* and *Oscillatoria* in the laboratory. Perhaps it should be considered as a generalist feeder of Cyanobacteria, although it was found only on *Anabaena* in nature. Little trophic segregation apparently occurs between *L. excavata* and *P. truncatula,* as both species had high survival rates on *A. variabilis* and *Cylindrospermum* sp. However, larvae of *P. truncatula* were able to complete development on *Lyngbya,* whereas those of *L. excavata* all died on this genus. None of the four species were able to utilize the unicellular genera *Gloeocapsa* and *Synechococcus.* In contrast, all four species produced adults from larvae feeding on the filamentous genera *Anabaena, Cylindrospermum,* and *Oscillatoria.*

Results obtained in laboratory feeding tests may not reflect actual use of Cyanobacteria in nature. Field collections of larvae actually feeding on different species of blue-green algae (Table 5) suggest that *H. albovenosa* is a consumer of *Anabaena, L. excavata* and *P. truncatula* prefer *Cylindrospermum,* and *N. approximata* and *P. debilis* utilize *Oscillatoria.* A single rearing of another species of Hyadinini, *Microlytogaster extera* (Cresson), suggests that larvae of that species utilize *Lyngyba* (Foote 1977).

Table 5. Utilization of soil-inhabiting Cyanobacteria by six species of Hyadininae in nature.

Hyadininae	Genus of Cyanobacteria			
	Anabaena	*Cylindropsermum*	*Lyngbya*	*Oscillatoria*
Hyadinini				
H. albovenosa	X			
L. excavata		X		
P. truncatula		X		
M. extera			X	
Philygriini				
N. approximata				X
P. debilis				X

LITERATURE CITED

Clausen, P. J. 1983. The genus *Hyadina* and a new genus of nearctic Ephydridae (Diptera). Transactions of the American Entomological Society 109: 201–228.

———. 1984. A new nearctic species of *Hyadina* (Diptera: Ephydridae). Entomological News 95: 83–86.

Deonier, D. L. 1965. Ecological observations on Iowa shore flies (Diptera: Ephydridae). Proceedings of the Iowa Academy of Sciences 71: 496–510.

Ferrar, P. 1987. A guide to the breeding habits and immature stages of Diptera Cyclorrapha, part 1: Text. E. J. Brill/Scandinavian Science Press, Leiden. 478 pp.

Foote, B. A. 1977. Utilization of blue-green algae by larvae of shore flies. Environmental Entomology 6: 812–814.

———. 1979. Utilization of algae by larvae of shore flies (Diptera: Ephydridae), pp. 61–71. *In* Deonier, D. L., ed., First Symposium on the Systematics and Ecology of Ephydridae (Diptera). North American Benthological Society.

———. 1981a. Biology and immature stages of *Lytogaster excavata,* a grazer of blue-green algae (Diptera: Ephydridae). Proceedings of the Entomological Society of Washington 83: 304–315.

———. 1981b. Biology and immature stages of *Pelina truncatula,* a consumer of blue-green algae (Diptera: Ephydridae). Proceedings of the Entomological Society of Washington 83: 607–619.

———. 1983. Biology and immature stages of *Nostima approximata* (Diptera: Ephydridae), a grazer of the blue-green algal genus *Oscillatoria.* Proceedings of the Entomological Society of Washington 85: 472–484.

Mathis, W. N. and T. Zatwarnicki. 1990. Taxonomic notes on Ephydridae (Diptera). Proceedings of the Biological Society of Washington 103: 891–906.

McAlpine, J. F. 1989. 116. Phylogeny and classification of the Muscomorpha, pp. 1397–1518. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera, Vol. 3. Research Branch Agriculture Canada Monograph 32.

Starr, R. C. 1978. The culture collection of algae at the University of Texas at Austin. Journal of Phycology 14(suppl.): 47–100.

Zack, R. S., Jr. and B. A. Foote. 1978. Utilization of algal monocultures by larvae of *Scatella stagnalis.* Environmental Entomology 7: 509–511.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 383–403

FOSSIL PERISCELIDIDAE (DIPTERA)

David A. Grimaldi and Wayne N. Mathis

(DAG) Department of Entomology, American Museum of Natural History, New York, New York 10024-5192; (WNM) Department of Entomology, NHB 169, Smithsonian Institution, Washington, D.C. 20560.

Abstract.—All known fossil species of periscelidid flies occur in amber and are treated. *Periscelis annectans* Sturtevant, from upper Oligocene amber of Chiapas, Mexico, is redescribed and illustrated; it belongs to the subgenus *Myodris* Lioy. Six new amber species are described, all from the lower Miocene–upper Oligocene amber of the Dominican Republic. Three species are: *Periscelis* (*Myodris*): *amberifera, brodzinskyi,* and *fascianota.* Other species are: *Planinasus electra, Stenomicra anacrostichalis* and *S. sabroskyi.* Keys to some genera and subgenera are presented. Despite their rarity in nature, high diversity of periscelidids in Dominican amber is certainly attributable to an association with decaying trees. Presence of modern subgenera in the Oligo-Miocene suggests an origin of periscelidids perhaps in the Paleocene.

Key Words: Diptera, Periscelididae, *Periscelis, Planinasus, Stenomicra,* fossil, amber

Flies of the family Periscelididae are obscure muscomorphans with about 50 described species worldwide. Specimens are rare in collections notably because their habits are often quite specific to tree trunks and logs that are sometimes in a decaying state (Teskey 1976). *Planinasus* Cresson, for example, is frequently found on rotting logs in or near streams in the neotropics, and *Periscelis* Loew and *Stenomicra* Coquillett usually occur at sap fluxes of living trees (many neotropical *Stenomicra* are also found in rolled leaves of *Heliconia* L., living on beetle frass).

Given their predilection for tree trunks and logs, it is not too surprising that an occasional specimen was preserved in amber. Five pieces of amber with six specimens of periscelidids represent the total number of these flies seen in about 20,000 pieces of Dominican amber screened by the senior author. Specimens, thus, are quite rare even as fossils in amber.

Amber is a generic term for fossilized, highly polymerized, resinous sap that can be exuded from a large variety of coniferous and deciduous trees (Langenheim 1969). Although of varying age, pieces date from the Carboniferous (280–345 million years ago), and those from the Cretaceous (65–140 million years ago) are the oldest pieces with insect inclusions. Because of the fine preservation and three-dimensional detail preserved in amber, it is an exceptional mode of fossilization for small, delicate insects like acalyptrate flies (e.g. Baroni-Urbani and Graeser 1987, Henwood 1992).

The large deposits of Baltic amber (also called succinite) have the longest history of research on their fossiliferous inclusions (Bachofen-Echt 1949). These deposits vary in age from Eocene to middle Miocene (Larsson 1978). Hennig (1965, 1967) revised the diverse fauna of acalyptrates in Baltic amber, but no periscelidids are known from that material.

Sturtevant (1963) described the first fossil periscelidid, *Periscelis annectans,* from the upper Oligocene–lower Miocene amber (ca. 25 million years old) of Chiapas in southern Mexico. The locations and stratigraphy of that amber deposit are well established (Hurd et al. 1962, Langenheim et al. 1967). Amber very similar to that from southern Mexico is also found in the Dominican Republic (Langenheim [1990] prefers to call the Mexican and Dominican amber "copal," a term also generally applied to amber from New Zealand). Like the material from Chiapas, Dominican amber also has fine clarity (and even better preservation of inclusions), and both are derived from canopy-sized trees of the tropical legume genus *Hymenaea* L. (Langenheim 1969, Cunningham et al. 1983, Hueber and Langenheim 1986). Dominican amber from the Cordillera Central also appears to be contemporaneous with the Mexican amber. The stratigraphy, however, is very incomplete, being based solely on benthic Foraminifera from the Palo Alto mine (Baroni-Urbani and Saunders 1982) among the 15 or so deposits in this region (Martinez and Schlee 1984). Dating based on lithology has also been done (Brouwer and Brouwer 1982). An Eocene age is repeatedly cited by a few investigators (Poinar and Cannatella 1987, Poinar and Singer 1990). That date is an extrapolation from a chemical study (Lambert et al. 1985) and needs to be confirmed with stratigraphy. In the Cordillera Oriental of the Dominican Republic, there are very recent deposits of fossilized resins that are perhaps only several thousand years old. That material is easily identified on the basis of its very light color, softness, fine surface cracks, and manner of preservation of enclosed insects.

We take this opportunity to redescribe and illustrate *Periscelis annectans* and the five other Dominican fossils. The phylogenetic position of the fossil species will hopefully be incorporated into cladistic analyses of modern species. However, comprehensive revisions of the modern species are first needed. Those now underway are as follows: *Planinasus* (Mathis and Baptista), New World *Periscelis* (Mathis and Papp), and New World *Stenomicra* (Sabrosky and Grimaldi). The magnitude of the problem for descriptive taxonomy of these flies is illustrated by *Stenomicra*: 20 species worldwide are described, but about 100 new ones exist for the neotropics alone (Sabrosky, pers. comm.). It will be several years before these revisions are complete. That fact plus the distinctive nature of the fossil species compels us to provide descriptions and new names for the Dominican amber species.

Methods.—The authenticity of the amber specimens was determined by visual inspection (e.g. color, clarity, details of preservation), as well as by several simple, standard tests. Although the exact provenance of the Dominican amber specimens is unknown, it can be conservatively estimated to be lower Miocene–upper Oligocene in age as they match specimens of known provenance. Cutting, grinding, and polishing of specimens followed the procedures given in Grimaldi (1993). The Dominican amber specimens are deposited in the Entomology Department, American Museum of Natural History. The piece of Chiapas amber is deposited in the Department of Paleontology, University of California, Berkeley, California.

Morphological terminology follows McAlpine (1981). In the descriptions, the term ipsilateral is used, as in standard medical terminology, to refer to structures on the same side in bilaterally symmetrical animals.

Family Periscelididae Oldenberg

Periscelidinae Oldenberg, 1914: 41.

Periscelidae.—Hendel, 1916: 297 [first use giving family status].

Periscelididae.—Stackelberg, 1933: 4 [first use with correct orthography].

Diagnosis.—*Head:* Frons with 1–2 fronto-orbital setae; postocellar setae present and divergent or absent. Pedicel cap-like, with a dorsal cleft, bearing 1 or more dorsoapical setae; flagellomere 1 frequently sharply deflexed, arising from ventral surface of pedicel; arista pectinate (sometimes bipectinate). Face uniformly sclerotized and arched, setose laterally.

Thorax: Dorsocentral setae usually 2 (0 + 2), sometimes 1 (0 + 1), none presutural; posterior intra-alar seta reduced; scutellum with 1–2 pairs of marginal setae; scutellar disc bare; 2 notopleural setae; anepisternal seta usually lacking (present in *Planinasus*). Wing: subcosta rudimentary, not reaching costal margin nor fused apically with R_1; no costal breaks (a weakness in the costa just apicad of the humeral crossvein in *Planinasus*); costa extended to R_{4+5} or M; cell dm with a fold running entire length; cell *cup* present, although vein CuA_2 either well developed or extremely reduced. Mid tibia bearing prominent, apicoventral seta.

Discussion.—We accept McAlpine's concept of Periscelididae (1978, 1983, Mathis 1992), including a few genera that were assigned to Aulacigastridae (*Cyamops* Melander, *Planinasus* Cresson, and *Stenomicra* (Coquillett). McAlpine characterized Periscelididae primarily by the cap-like pedicel, which has a dorsal cleft. This character occurs in all Periscelididae but also in Neurochaetidae (McAlpine 1978, Woodley 1982) and perhaps other genera. Perhaps these genera should likewise be included in Periscelididae, with the cap-like pedicel as a synapomorphy.

KEY TO SUBFAMILIES OF PERISCELIDIDAE

1. Fronto-orbital seta 1; ocellar setae present. Costa short, extended to vein R_{4+5}; CuA_2 weak or lacking, cell *cup* absent; postpronotum bearing a well-developed seta .... Periscelidinae
– Fronto-orbital setae 2; ocellar setae absent. Costa long, extended to vein M; CuA_2 usually well developed, usually with a distinct cell *cup* (weak or lacking in *Stenomicra*); postpronotum lacking a well-developed seta .... Stenomicrinae

Subfamily Periscelidinae Oldenberg

Periscelidinae Oldenberg, 1914: 41.

Diagnosis.—*Head:* Eye microsetulose (bearing interfacetal microsetulae); occiput with a silvery white, microtomentose area immediately adjacent to posterior margin of compound eye; frons with only 1 reclinate fronto-orbital seta; postocellar setae present, divergent; ocellar setae present, well developed; face uniformly sclerotized and transversely arched (shield-like in *Scutops*); face setose laterally, strongly receded ventrally, extended laterally below gena; gena extended anterodorsally, bearing a row of setae, with anterior seta inserted well above oral margin; mouth opening large.

Thorax: Postpronotal seta well developed. Wing with costa extended to R_{4+5}; cell *cup* either lacking or present but very weakly developed and with vein CuA_2 extremely reduced.

Abdomen: 7th spiracle ("stigma") not free in female postabdomen. See Griffiths (1972) for discussion of male terminalia.

Discussion.—The immature stages, and to an extent the adults, are associated with sap from bleeding deciduous trees (oak, elm, and cottonwood). Teskey (1976) described and figured a larva of *Periscelis* sp.

The genera comprising Periscelidinae are those that Hennig (1969) included in his more restricted concept of the family, viz: *Periscelis* Loew, *Marbenia* Malloch, *Neoscutops* Malloch, *Scutops* Coquillett, and possibly *Diopsosoma* Malloch (we doubtfully include the latter). Certainly the first four genera comprise a well-established monophyletic assemblage, with corroborative synapomorphies as follows: 1. Mouth opening large. 2. Occiput with a silvery white, microtomentose area immediately adjacent to the posterior margin of the compound eye. 3. One fronto-orbital seta, reclinate. In the subfamily Stenomicrinae there are two fronto-orbital setae, a reclinate and proclinate seta. 4. Costal vein short, extended only to vein R_{4+5}. The generalized condition, found in related genera and families, is for the costal vein to extend to vein M. 5. Vein CuA_2 reduced or absent. Typically this vein is present, resulting in a well-defined cell *cup.* Its reduction or absence here is an autapomorphy. 6. Several characters of the male terminalia (see Griffiths 1972).

Only the genus *Periscelis* of this subfamily has any known fossils, and all are known from amber only. Sturtevant (1963) described the first fossil species, *P. annectans,* from amber taken in the state of Chiapas, Mexico. Here we include an additional three species, all from Dominican amber.

Genus *Periscelis* Loew

Periscelis Loew, 1858: 113. Type species: *Periscelis annulipes* Loew, by subsequent designation (Sturtevant 1923: 1).—Duda, 1934: 5 [revision palearctic species].—Sabrosky, 1965a:710 [nearctic catalog].—Pires do Prado, 1975: 1 [neotropical catalog].—Papp, 1984a: 233–234 [palearctic catalog]; 1988: 273–284 [discussion, figures].

Sphyroperiscelis Sturtevant, 1923: 1. Type species: *Sphyroperiscelis wheeleri* Sturtevant, by original designation.—Sturtevant, 1954: 551 [synonymy].

Description.—*Head:* Face distinctly angulate or with a protrudent, transverse carina in lateral view; dorsal ½ of face narrow, not distinctly and broadly flattened or shield-like, ventral half of face lacking transverse furrows. Eye normal, not borne on a conspicuous stalk; pedicel cap-like, not porrect.

Thorax: Scutellum broadly rounded apically, lacking patch of long setae apically. Chaetotaxy as follows: posterior dorsocentral setae 2; presutural seta lacking; prescutellar acrostichal setae variable, depending on species group; 1 supra-alar seta. Wing mostly hyaline; apical section of vein M straight or very shallowly arched; vein R_1 bare above; vein R_{2+3} more or less evenly arched throughout length except just before apex.

Abdomen: Male genitalia, see diagnosis of subgenera.

Discussion.—All fossil species of *Periscelis* belong to the subgenus *Myodris* Lioy, which is distinguished from the other subgenera by characters indicated in the following key.

KEY TO SUBGENERA OF *PERISCELIS*

1. Prescutellar acrostichal setulae moderately well developed, distinct from other acrostichal setulae; crossvein dm-cu straight and well developed throughout length; male genitalia lacking digitiform process at base of epandrium between surstylus and cercus .... *Myodris* Lioy

– Prescutellar acrostichal setulae undifferentiated; crossvein dm-cu weakened to completely attenuate anteriorly, usually angulate or curved toward base, sometimes nearly straight; male genitalia with a ventrally oriented, narrow process at the ventral margin of the epandrium between the surstylus and cerci 2

2. Mesonotum mostly bare of microtomentum, shiny and with bicolored pattern of dark brown and yellowish orange; cercus of ♂ bearing 5 stout, teeth-like setae along anteroventral surface; large species, length 2.7 mm or longer .... *Notioscelis* Mathis

– Mesonotum invested with microtomentum, appearing somewhat dull, mostly unicolorous; cercus of ♂ bearing several long setulae, especially posteriorly, but not teeth-like setae; small species, length 2.5 mm or smaller .... *Periscelis* Loew

Subgenus *Myodris* Lioy

Myodris Lioy, 1864: 1103 [as a genus]. Type species: *Notiphila annulata* Fallén, by original designation.—Mathis, 1992: 1993: 15 [key, as a subgenus of *Periscelis*].

Meronychina Enderlein, 1914: 327 [as a genus]. Type species: *Notiphila annulata* Fallén, by monotypy.—Enderlein, 1917: 72 [as *Meronychia,* sic].—Sturtevant, 1954: 556 [synonymy with *Periscelis*].

Microperiscelis Oldenberg, 1914: 37, 42 [as a genus]. Type species: *Notiphila annulata* Fallén, by subsequent designation (Sturtevant, 1923:1).—Sturtevant, 1923: 1 [synonymy with *Periscelis*].

Phorticoides Malloch, 1915: 86 [as a genus]. Type species: *Phorticoides flinti* Malloch, by original designation.—Sturtevant, 1954: 556 [synonymy with *Periscelis*].

Diagnosis.—*Thorax:* Mesonotal vestiture variable, essentially bare or densely microtomentose, with the scutum mostly gray but with a brown, median stripe on posterior ½–⅔; prescutellar acrostichal setae well developed. Wing completely hyaline to maculate; crossvein dm-cu complete and equally well developed along its length.

Abdomen: Male genitalia as follows: epandrium and surstylus connected to internal structures of genitalia by membranes only; cercus well sclerotized, longer than wide, becoming narrower ventrally, bearing several long setae and 2, stout, tooth-like setae at apex; surstyli usually asymmetrical to some degree, narrow and acutely pointed apically, bearing sparse, short setulae; lacking a process between bases of surstylus and cercus; gonite distinct and comparatively long, as long or longer than the surstylus.

Discussion.—Seven species now comprise this subgenus, including three that are extant (*P. annulata* (Fallén), *P. flinti* (Malloch), and *P. kabuli* Papp) and the four fossil species that are keyed and described in this paper.

KEY TO FOSSIL SPECIES OF THE SUBGENUS *MYODRIS*

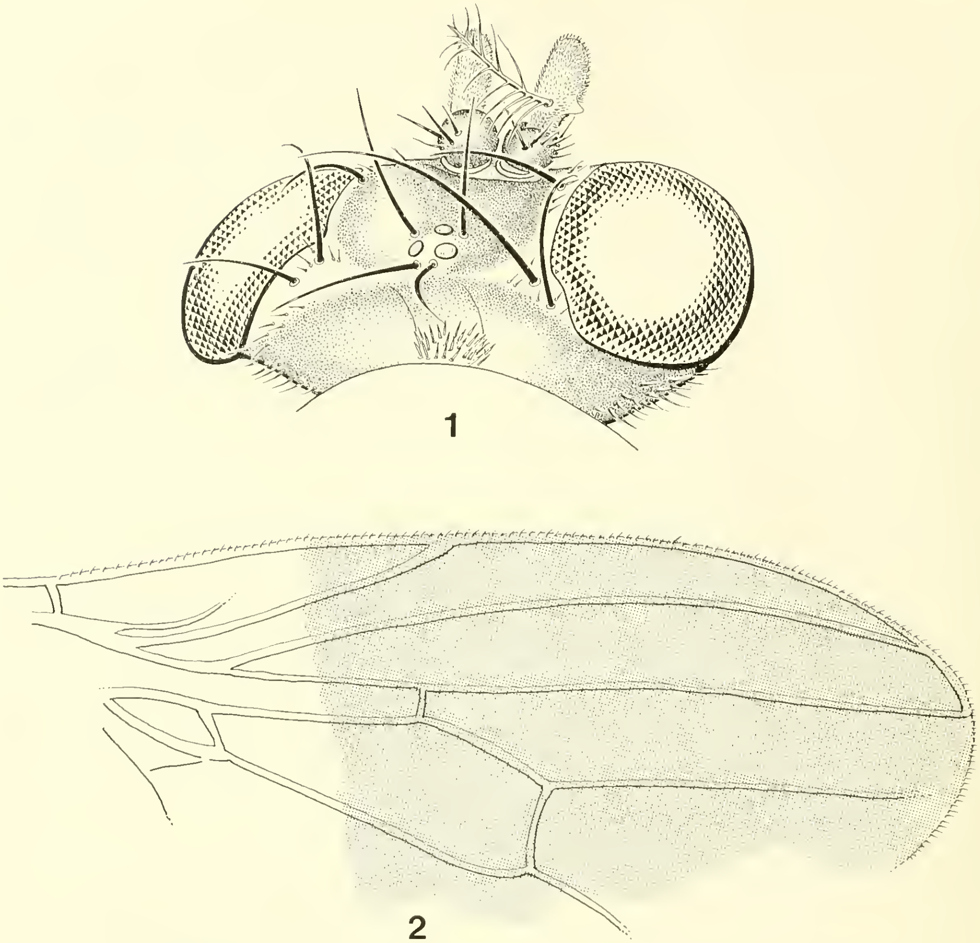
1. Thorax appearing densely microtomentose, mostly pale gray with some brown spots; fore femur with 3 prominent setae along apical ⅓ of posteroventral surface; tibiae uniformly colored .... *P. brodzinskyi,* new species
– Thorax appearing uniformly dark brown and lacking dense microtomentum; fore femur with 5–6 prominent setae along apical ⅓ of posteroventral surface; tibiae with alternating dark and pale bands 2
2. Frons including ocellar triangle uniformly pale brown; face lacking dark spot in middle .... *P. amberifera,* new species
– At least ocellar triangle dark brown, contrasted with paler remainder of frons; face with dark bigeminate spot in middle 3
3. Acrostichal setulae numerous, in about 6 irregular rows. Apical scutellar setae strongly cruciate before midlength of setae. Pleuron with a midpleural dark band, extended from anepisternum to katatergite; katepisternum darker than remainder of pleuron .... *P. facianota,* new species
– Acrostichal setulae fewer, in about 4 rows. Apical scutellar setae cruciate at apical ⅕. Pleuron uniformly dark colored and lacking a midpleural band .... *P. annectans* Sturtevant

Periscelis (*Myodris*) *amberifera* Grimaldi and Mathis, NEW SPECIES

Figs. 1, 2

Description.—*Head* (Fig. 1): Frons, including ocellar triangle, brownish yellow to yellow; fronto-orbital seta inserted near eye margins; inner and outer vertical setae inserted close together, distance between about 3 times setal width at base; inner vertical seta very long, length nearly twice outer vertical; ocellar setae inserted just laterad of ocellar triangle, long, extended past lunule; postocellar setae about equal in length to ocellars, divergent. Antenna: pedicel dark brown, scape and flagellomere 1 concolorous, pale, mostly yellow; pedicel bearing 2 large, black, lateral setae and 1 large medial seta; arista with 7 dorsal and 3 ventral branches; no supernumerary lateral trunk (as in species of *Planinasus*). Face obscured. Genal setulae dense, long.

Thorax: Mesonotum, pleuron, and postnotum uniformly dark brown. Acrostichal setulae irregularly arranged, not in rows; katepisternum bearing 1 large and 1 smaller setae; distance between ipsilateral dorsocentral setae about ½ length of either seta; distance between dorsocentral rows wide, about equal to length of a seta; a pair of prescutellar acrostichal setae between posterior dorsocentrals, length and thickness ⅓ that of posterior dorsocentral seta, distance from posterior dorsocentral about equal to length of smaller seta; scutellum with 2 pairs of setae; apical pair twice length of anterior pair. Halter pale. Wing (Fig. 2) with uniform light infuscation on apical ⅔; vein R_1 long, extended to nearly midway along costal vein; vein R_{2+3} arched; veins R_{4+5} and M_1 parallel; vein M_1 ended just short of wing margin; cell dm large, wider than distance between veins R_{4+5} and M_1. Legs: fore femur



Figs. 1, 2. *Periscelis amberifera*. 1, head, posterodorsal view; 2, wing.

dark brown, with row of 8–9 setae along posterior surface, lengths slightly greater than femoral width; apical ⅕ of all femora pale; tibiae with 2 dark bands, ⅖ and ⅘ along length of tibia; tarsomeres pale, except pretarsus, which is dark; basitarsomere about equal in length to all other tarsomeres.

Abdomen: Dorsoventrally somewhat flattened, sides tapered apically. Tergites pale brown.

Measurements.—Head width and thorax length not measurable; body length 2.63 mm, wing length 1.76 mm.

Type material.—Holotype ♀ (AMNH DR-8-207A): the specific provenance is unknown within the Dominican Republic; the inclusion is in a large piece of amber (4.0 × 3.3 cm) that is dark yellow and has several small inclusions, including a male ant and a mymarid wasp.

Etymology.—The species epithet, *amberifera*, refers to the holotype being an inclusion borne in amber.

Remarks.—This species is very similar to *P. facianota* but is distinguished from the latter by the coloration of the frons, including the ocellar triangle, which is generally pale brownish yellow to yellow.

Periscelis (*Myodris*) *facianota*
Grimaldi and Mathis, New Species

Figs. 3–5

Description.—*Head* (Figs. 3, 4): Frons mostly pale, brownish yellow, except for dark brown ocellar triangle and broad area immediately adjacent. All setae black. Fronto-orbital setae inserted about midway along length of frons, very close to eye margin, length about same as outer vertical seta; inner vertical seta slightly longer than outer seta, with slightly curved tips; distance between inner and outer vertical setae about 4–5 times diameter of setal bases (best seen in dorsal view); ocellar setae inserted slightly outside triangle, lateral to sides joining anterior and posterior ocelli; postocellar seta with acute bend at base, strongly divergent, lying immediately behind posterior ocelli. Posterodorsal margin of frons forming acute angle with posterior surface of head, this edge quite sharp; posterior surface of head dark brown, slightly concave. Antenna: pedicel velvety black, strikingly contrasted with remainder of yellow antenna and frons, bearing 3 stout dorsolateral setae and 1 ventrolateral seta (some dorsolaterals with apex slightly curved), 1 large dorsal seta and several smaller proximal ones dorsolateral to it; flagellomere 1 yellow; arista with 6 dorsal, 3 ventral branches, plus small terminal fork and about 8 minute medial branches [apices of arista inadvertently sheared off during a later preparation]. Face slightly carinate, with bigeminate black spots in middle of face between narrowest area separating eye margins. Gena bearing 3 setae above frontal-genal suture, pointed ventrolaterally; row of 6 setae below suture. Clypeus and palp black; clypeus with pointed frontal surface.

Thorax (Fig. 3): Mesonotum uniformly dark brown. Pleuron mostly pale, with a midpleural dark band, extended from anepisternum to katatergite; at least katepisternum apparently dark, but much of pleuron is obscured. Acrostichal setulae arranged in about 6 irregular rows between anterior dorsocentrals; posterior dorsocentral setae about twice the length and thickness of the anterior dorsocentral setae, slightly curved, convergent; lateral thoracic setae all quite thick, curved, and stiff; 1 stout postpronotal seta; postalar seta curved posterodorsad and adpressed to notum; 2 large katepisternal setae. Anterior scutellar setae convergent, lying close along sides of scutellum; apical scutellars twice the length of anterior scutellar setae, crossed for about ⅔ their length, slightly upright. Wing (Fig. 5): slightly infuscate but without markings; veins R_{2+3}, R_{4+5}, and M parallel; vein CuA_1 incomplete. Halter pale. Legs: femora slightly brown; fore femur with row of about 10 stout setae on ventral surface; tibiae with 2 dark bands, forming yellow apical, middle, and proximal bands; tarsomeres 1 and 2 pale brown, remainder paler.

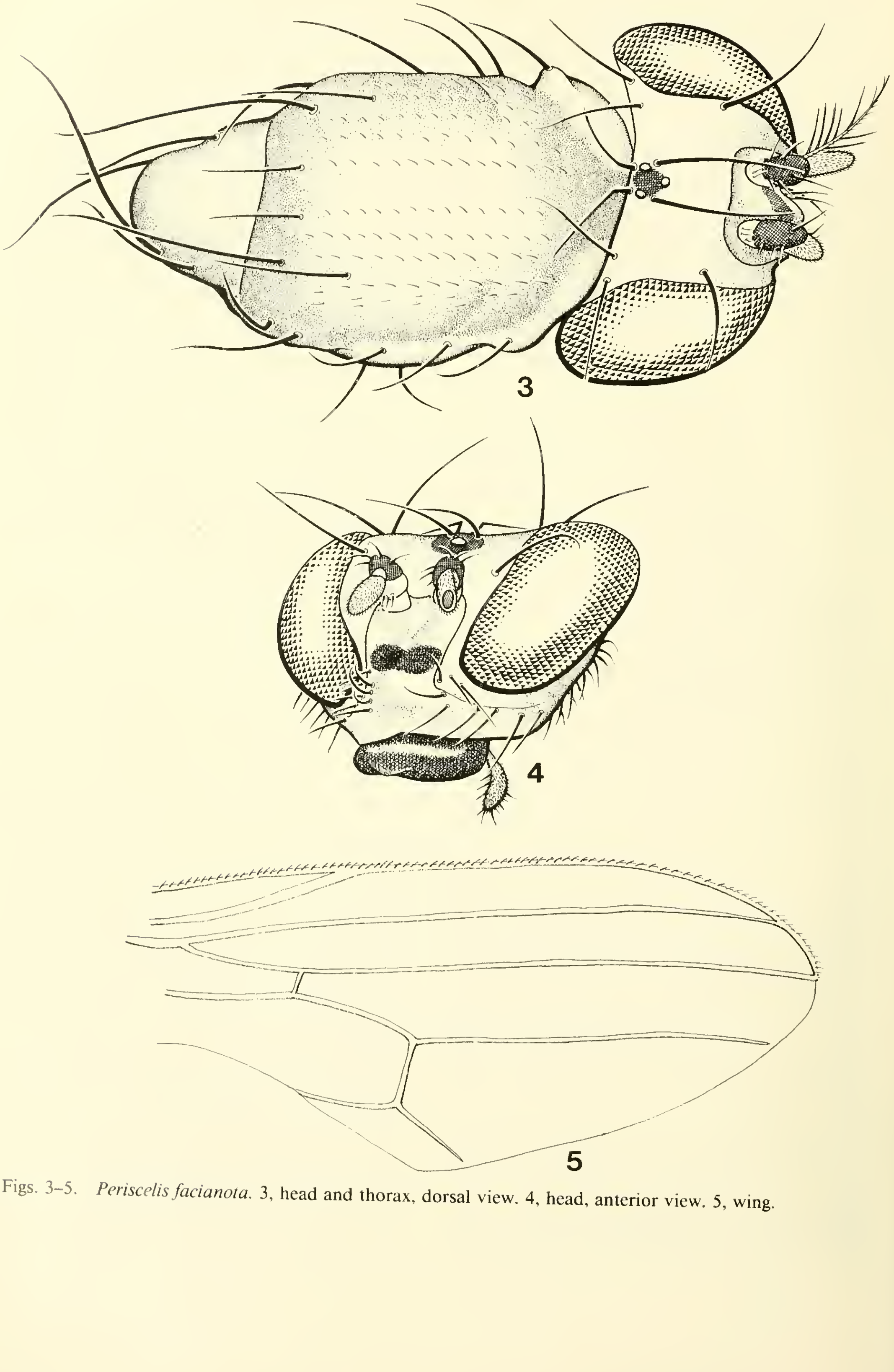
Abdomen: Tergites dark brown.

Measurements.—Head width 1.02 mm; thorax length 1.26 mm; body length 2.913 mm; distance between apices R_1–R_{2+3} 1.04 mm; distance between apices R_{2+3}–R_{4+5} 0.12 mm; length along basal segment of vein M/apical segment 0.29/0.91 mm.

Type material.—Holotype ♀ (AMNH 11856): the specific provenance is unknown within the Dominican Republic; the inclusion is in a small piece of amber (0.7 × 1.3 cm; 1.1 × 1.3 cm before cutting) that is medium yellow and has two layers of fine bubbles and no other insect inclusions.

Etymology.—The specific epithet, *facianota,* is of Latin derivation and alludes to the brown, bigeminate spot on the face.

Remarks.—Although similar to *P. amberifera* and *P. annectans,* this species is distinguished as follows: (1) the dark brown ocellar triangle that is distinctly contrasted with the mostly yellow remainder of the frons, (2) the six irregular rows of acrostichal setulae, and (3) apical scutellar setae that are strongly cruciate near their bases.



Figs. 3–5. *Periscelis facianota.* 3, head and thorax, dorsal view. 4, head, anterior view. 5, wing.

Periscelis (*Myodris*) *brodzinskyi* Grimaldi and Mathis, New Species
Fig. 6

Description.—This specimen is obscured by an ant that is on top of the specimen. The ant's mandibles are apparently biting into the fly's scutellum. The fly is intact, but the wings are not fully visible. The left wing is folded on top of the abdomen, and the right wing is partially hidden.

Head: Frons mostly pale yellow, fronto-orbital plates slightly darker. Fronto-orbital seta inserted about midway along length of frons. Inner and outer vertical setae obscured; ocellar setae inserted within ocellar triangle, reclinate, length obscured. Antenna: scape and pedicel yellowish, scape slightly darker and bearing larger seta on medial surface, 1 on anterolateral surface, 3 smaller ones on ventrolateral margin; arista plumose, with 5 dorsal and 3 ventral branches (and very small terminal fork). Face obscured, but setae can be seen in lateral view: row of 4–5 oriented mediad; with 3 setae ventrolateral to these, oriented laterad. Lateral oral margin with 5–6 setae. Gena with several small setulae, but no larger seta. Eye pale.

Thorax: Notum partially obscured by ant, but apparently pale, yellowish gray with some light brown areas. Postpronotum bearing a smaller seta anteriorly in addition to larger seta; posterior notopleural seta slightly smaller; anterior dorsocentral seta short, length about ½ that of posterior seta; 1 large katepisternal seta (oriented dorsad) and several smaller ones; a pair of long apical scutellar setae present, tips nearly touching, length slightly greater than posterior dorsocentrals; anterior scutellar setae obscured. Legs: fore and mid femora pale brown, other segments and hind legs paler; tibiae uniformly colored, lacking bands; fore femur with row of 3 larger setae on apical half of ventral surface; tarsomere 1 about equal in length to tarsomeres 2 + 3 + 4; mid tibia with large apical spine on medial surface, length nearly twice width of tibia. Left wing adpressed to abdomen; right wing mostly visible; humeral vein present; subcostal vein short, length less than ½ length of cell sc and not sharply upturned toward costal vein; vein R_1 long, nearly ½ length of wing; vein R_{4+5} straight, equidistant between R_{2+3} and M_1; veins R_{2+3} and M_1 slightly sinuous, with apices slightly divergent; pale subapical band of infuscation present; veins CuA_1 and M_1 convergent at crossvein m-cu; basal cells of wings obscured.

Abdomen: Most of abdomen and genitalia obscured.

Measurements.—Head not measurable; body length 3.65 mm; thorax length 1.37 mm; wing length 2.20 mm; distance between apices R_1–R_{2+3} 1.10 mm; distance between apices R_{2+3}–R_{4+5} 0.124 mm; length along basal portion of vein M/apical portion 0.34/0.93 mm.

Type material.—Holotype (sex ?; AMNH DR-8-207B): the specific provenance is unknown within the Dominican Republic; the inclusion is a large piece of amber (4.0 × 3.3 cm) that is dark yellow and has several small inclusions, including a male ant and a mymarid wasp.

Etymology.—It is a pleasure to name this genitive patronym after Mr. Jacob Brodzinsky, whose enthusiasm for fossils in amber and entrepreneurial skills made the amber pieces we studied from the Dominican Republic available to our study.

Remarks.—This species differs markedly from the preceding two species and is easily distinguished by the: (1) densely microtomentose mesonotum that is mostly pale gray with some brown spots (the mesonotum in the preceding species is entirely black, with at most sparse microtomentum); (2) fore femur bearing 3 prominent setae along apical half of posteroventral surface (there are 5–6 setae in the other species); (3) tibiae uniformly colored (the tibiae in the other fossil species are distinctly banded.

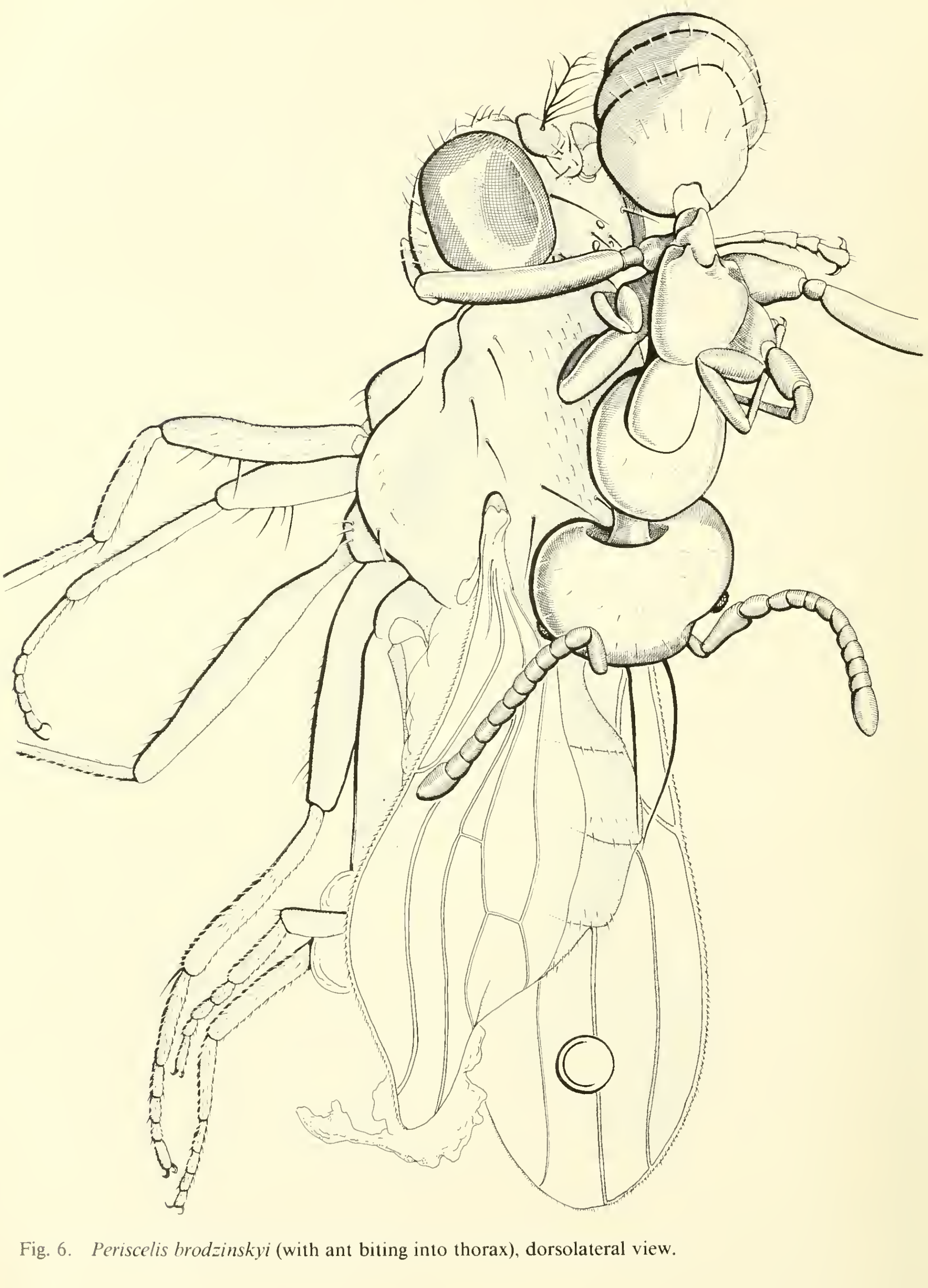


Fig. 6. *Periscelis brodzinskyi* (with ant biting into thorax), dorsolateral view.

Periscelis (*Myodris*) *annectans* Sturtevant
Figs. 7–9

Periscelis annectans Sturtevant, 1963: 122.

Description (taken in part from Sturtevant 1963).—*Head* (Figs. 7, 8): Frons with ocellar triangle dark brown, contrasted with paler lateral and anterior margins. Antenna with flagellomere 1 arising from ventral apical surface of pedicel; antennal bases rather close together, closer to each other than either is to margin of eye; arista with 7 dorsal and 3 ventral branches. Face yellow, with a transverse ridge.

Thorax (Figs. 7, 9): Mesonotum and pleuron generally and uniformly dark brown, with microtomentum sparse or lacking. Chaetotaxy as follows: anterior acrostichal setulae sparse and minute; prescutellar acrostichal setae moderately well developed, inserted just posterior to level of posterior dorsocentral setae; 2 postsutural dorsocentral setae and apparently a few minute setulae extended anteriad from larger setae; 1 postpronotal seta; 2 notopleural setae; 1 supra-alar seta; 1 postalar seta; 2 lateral scutellar setae, basal seta about ⅔ length of apical seta; scutellar disc bare. Anepisternum bare. Wing apparently hyaline (difficult to discern); crossvein dm-cu apparently straight. Legs: Tibiae yellow but interrupted by sub-basal and subapical dark bands.

Abdomen: Concolorous with mesonotum.

Measurements.—Head width 0.91 mm; thorax length 0.96 mm; body length 2.52 mm; wing length 1.79 mm.

Type material.—The amber piece containing the holotype ♀ (?, apex of abdomen partially obscured) was found in Mexico. Chiapas: Las Cruces landslide (23 km SE Simojovel, 6.8 km SE Rancho Santo Domingo). The holotype is deposited at UCAL (Paleo. 12639)]. The piece of amber has become dark colored, reddish brown (slightly ruby from some angles) due to exposure to air and the process of oxidation. The dark coloration, which is apparently irreversible, makes examination of the inclusion difficult.

Remarks.—Our placement of this species in the subgenus *Myodris* is tentative, being based primarily on the presence of prescutellar acrostichal setae. The characters of the wing, the shape of crossvein dm-cu in particular, could not be accurately determined as the wing of the specimen is too obscure to be studied.

Subfamily Stenomicrinae Papp

Stenomicridae Papp, 1984b: 61.

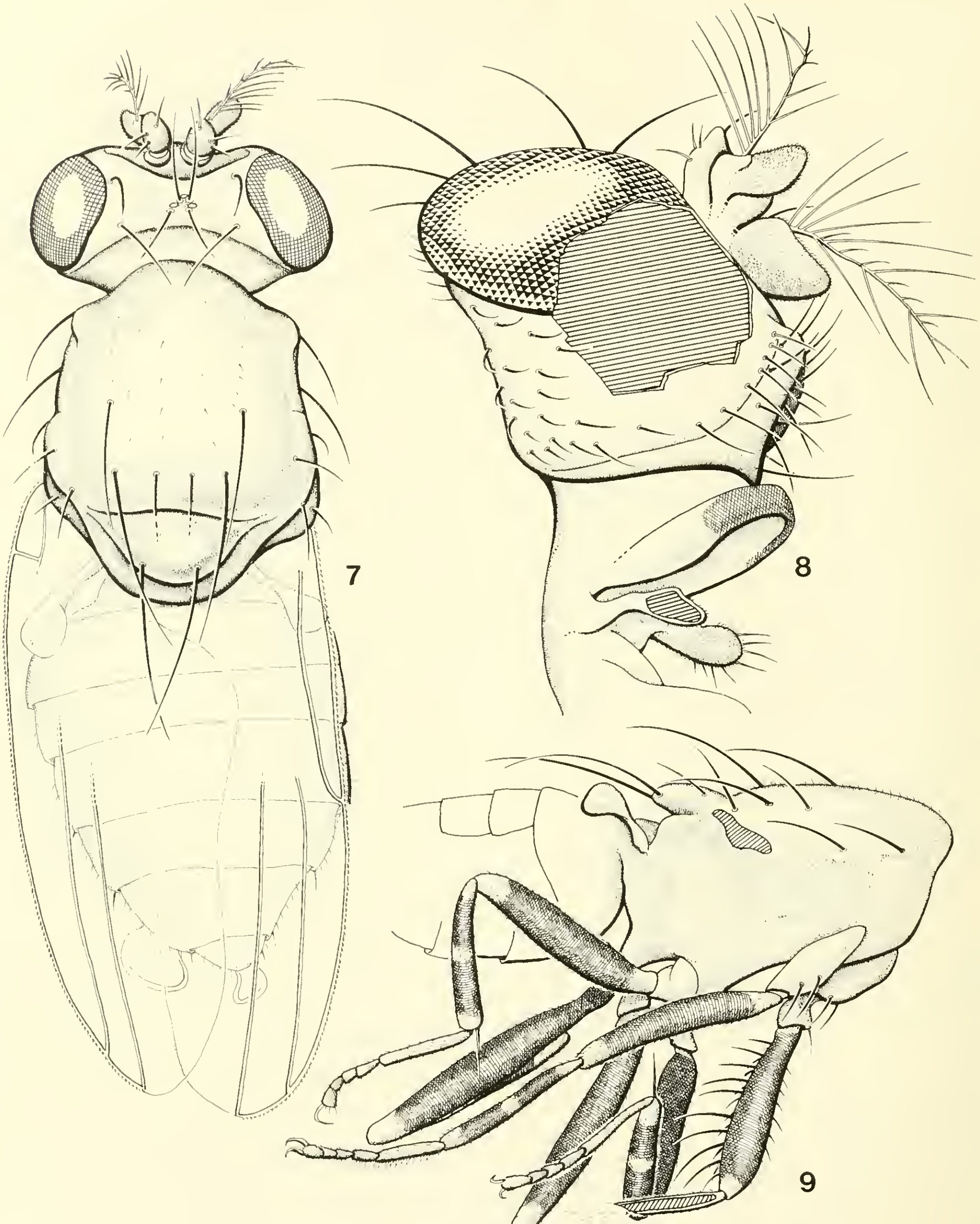
Diagnosis.—*Head:* Frons with 2 fronto-orbital setae, 1 reclinate, 1 proclinate; at least 1 vertical seta (apparently the outer) present; postocellar setae usually lacking (present in *Stenomicra,* where they are slightly divergent); ocellar setae lacking. Pedicel bearing 1 or more dorsoapical setae.

Thorax: Postpronotum frequently polished, lacking a well-developed seta. Wing: costa extended to vein M; cell *cup* usually present, CuA_2 usually well developed (very weakly developed or lacking in *Stenomicra*). Middle tibia with ventroapical spine-like seta.

Discussion.—The subfamily Stenomicrinae was first proposed as a monogeneric family with *Stenomicra* as its type genus (Papp 1984b). As we accept McAlpine's (1978, 1983) proposal that *Stenomicra* is closely related to *Planinasus* and *Cyamops* and that this assemblage of genera and those of the subfamily Periscelidinae are likewise closely related, we prefer recognition of an expanded concept of Periscelididae, with Periscelidinae and Stenomicrinae as included subfamilies.

KEY TO FOSSIL GENERA OF THE SUBFAMILY STENOMICRINAE

1. Frons with 1 pair of intrafrontal setae; eyes lacking interfacetal microsetulae; inner vertical seta present, orientation inclinate. Katepister-



Figs. 7–9. *Periscelis annectans* Sturtevant. 7, body, dorsal view. 8, head, latero-oblique view. 9, thorax, lateral view.

num with 2 subequal setae; 1 supra-alar seta well developed. Crossvein bm-cu absent, making cells bm and dm confluent; vein CuA$_2$ well developed; cell *cup* present. Hind femur bearing anterodorsal, preapical seta .... *Planinasus* Cresson

– Frons lacking intrafrontal setae; eyes microsetulose, sometimes sparsely; inner vertical seta present but with proclinate orientation. Katepisternum bearing 1 prominent seta; lacking a supra-alar seta. Crossvein bm-cu absent, making cells bm and dm confluent; vein CuA$_2$ weak or lacking; cell *cup* lacking. Hind femur lacking anterodorsal, preapical seta .... *Stenomicra* Coquillett

Genus *Planinasus* Cresson

Planinasus Cresson, 1914: 245 [in the family Ephydridae]. Type species: *Planinasus ambiguus* Cresson, by original designation; 1918: 65 [discussion, genus probably not in Ephydridae].—Malloch, 1934: 52 [generic key in the family Periscelidae].—Curran, 1934: 327 [generic key in the family Drosophilidae].—Hennig, 1969: 614–616 [revision in the family Aulacigastridae].—McAlpine, 1983; 56 [discussion, assigned to the family Periscelididae].

Schizochaeta Malloch, 1934: 52 [type species: *Schizochaeta shannoni* (Malloch, by original designation].—Hennig, 1969: 614 [synonymy].

Diagnosis.—*Head:* Frons with 1 pair of intrafrontal setae; both inner and outer vertical setae well developed; postocellar seta absent. Interantennal space at least equal to antennal length, much greater in some species; flagellomere 1 arising from anterior surface of pedicel; arista bipectinate. Face uniformly sclerotized and usually arched, bearing a prominent, dorsoclinate, sometimes convergent to cruciate pair of setae near or on transverse facial carina, usually with several other facial setae, these usually ventroclinate and sometimes arranged in a transverse row. Eye bare of interfacetal microsetulae. Gena very short, height less than width of pedicel, lacking a genal seta.

Thorax: Dorsocentral setae 2, both postsutural (*P. ambiguus* with a 3rd small, anterior, dorsocentral seta, less than ⅓ length of either posterior 2); 1 supra-alar seta; 1 postalar seta; lateral scutellar setae 1 pair, apical, scutellar disc bare; postpronotum bare, shiny; anepisternal seta(e) present; 2 katepisternal setae, anterior seta slightly weaker. Wing: no costal breaks (a weakness in the costa just apicad of the humeral crossvein); costal vein extended to vein M; subcosta rudimentary, neither reaching costal margin nor fused apically with vein R$_1$; vein R$_{2+3}$ minutely but densely trichiose on ventral surface; crossvein bm-cu present, with distinct discal cell and cell *bm*; cell *cup* present, vein CuA$_2$ well developed. Legs: fore femur with 1–2 posteroventral setae at apical ⅓; mid tibia with apicoventral spine; hind femur with anterodorsal preapical seta; all tibiae with subapical dorsal seta.

Abdomen: 7th spiracle ("stigma") not free in female postabdomen. See Griffiths (1972) for discussion of male terminalia.

Distribution.—Known only from the New World tropics.

Discussion.—This genus is now being revised (Mathis and Baptista, pers. comm.), and the information on the new species described here is written within the context of their study. Within the subfamily Stenomicrinae, *Planinasus* is similar to *Cyamops*, and the two lineages may be sister groups. Evidence for this relationship is the following synapomorphies: 1. Mid tibia with an apical, anteroventral spine. 2. Arista bipectinate (McAlpine 1983: 56). 3. Face bearing a dorsoclinate pair of setae, these usually inserted above the other facial setae.

Planinasus is distinguished from other genera of Periscelididae and its monophyly is established by the following apomorphic characters: 1. Frons bearing a pair of intrafrontal setae with an upright to slightly reclinate orientation. Within Stenomicrinae, intrafrontal setae, as described, are unique to *Planinasus*. 2. Fore femur with

2–3 posteroventral setae on apical half. 3. Scutellum bearing a single pair of apical marginal setae. 4. Reclinate fronto-orbital seta inserted behind proclinate fronto-orbital seta. 5. Each tibia with a dorsoapical seta. 6. Hind femur with a subapical dorsal seta.

Planinasus electrus Grimaldi and Mathis, New Species

Figs. 10–13

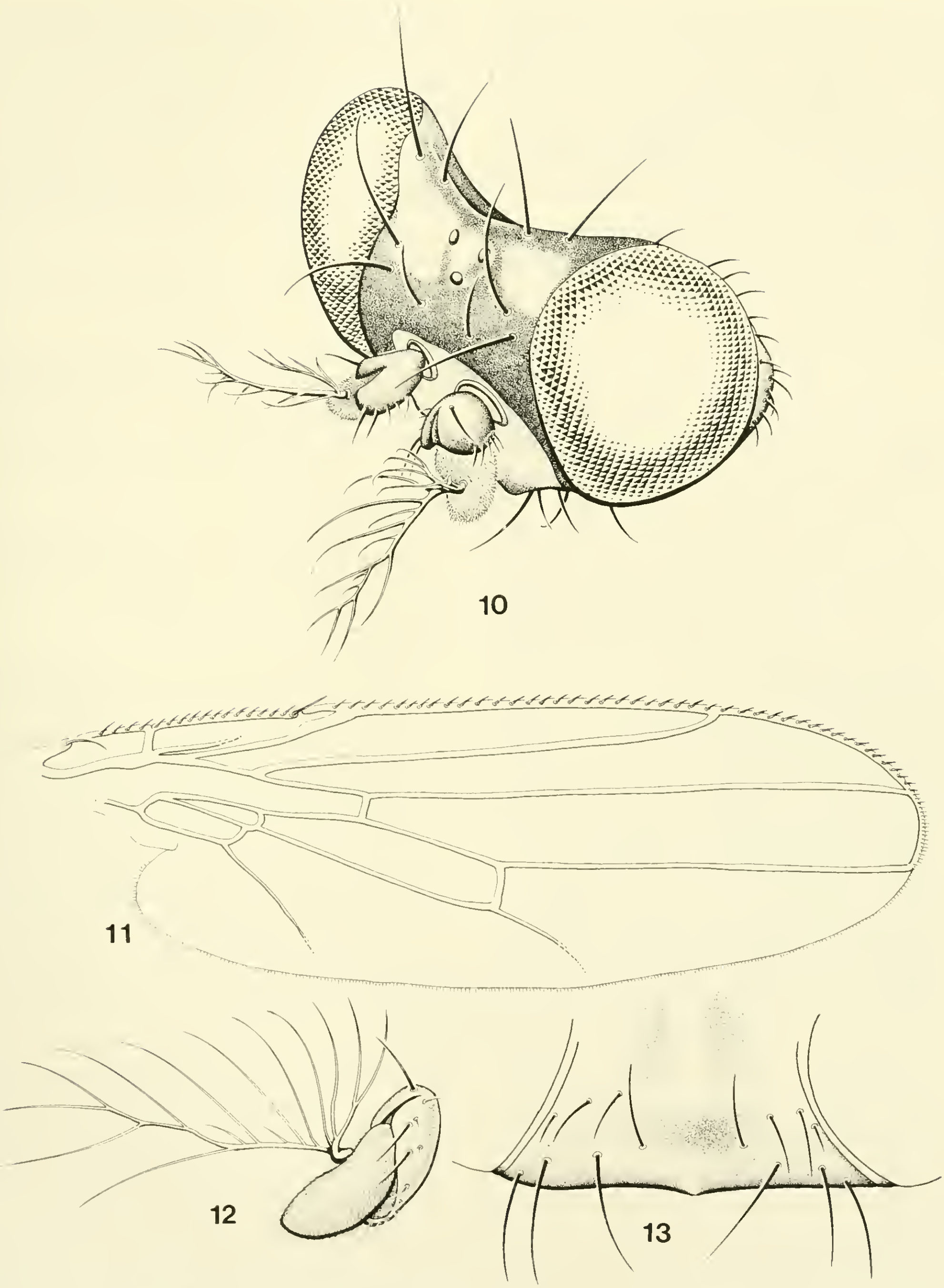
Description.—*Head* (Fig. 10): Frons dark brown, glabrous; intrafrontal seta short, about ½ length of outer vertical seta, reclinate, separated by slightly more than distance between outside margins of posterior ocelli; postocellar seta lacking; proclinate and reclinate fronto-orbital setae approximately equal in length, reclinate seta inserted slightly medial to proclinate seta, separated from latter by about 3 times its diameter at base; inner and outer vertical setae about equal in length. Antenna (Fig. 12): bicolored, scape and pedicel brown, flagellomere 1 pale, mostly whitish yellow with pale brown area immediately around base of arista; scape very thin; antennal bases separated by about diameter of pedicel; pedicel with deep anterior cleft; ventral projection of pedicel short, not extended anteriorly much beyond dorsal margin; medial half of pedicel with 2 black, stout setae of equal length, both oriented anteriad, parallel; lateral half of pedicel with thin seta dorsally, near cleft, and 4–5 fine, smaller setulae in row on anterolateral margin; flagellomere 1 short, width about ⅔ length; arista with lateral trunk bearing 4 branches, all on one side; apical branch pair smallest; main ramus of arista with 4 large dorsal branches, plus terminal fork; 4 smaller medial branches; 2 ventral branches; both rami of arista with a common base, but no common ramus. Face bicolored, mostly pale, whitish yellow, but with oral margin and narrow medial extension brown; facial setae (Fig. 13) in 2 irregular rows; setae along ventral row larger, medial pair dorsoclinate followed by 3 ventroclinate to slightly inclinate setae in row along sloping line at transition between pale and brown coloration; 2 other facial setae inserted dorsad of longer row, between large dorsoclinate setae and anteroventral margin of eye (seta inserted closer to eye almost twice length of seta inserted between it and dorsoclinate setae). Proboscis pale; palp thin, pale.

Thorax: Mesonotum and pleuron dark brown; anterior dorsocentral seta about midway between anterior margin of notum and notal-scutellar suture; posterior dorsocentral seta inserted closer to scutellum than to anterior dorsocentral seta; acrostichal setulae minute, barely discernable; katepisternum with 1 larger seta, 3–4 much smaller setae; anepisternum with row of about 4 fine setulae along posterior margin. Legs: coxae and femora brown; tibiae mostly brown, apical ¼–⅕ pale; length of basal tarsomere about equal to length of all 4 distal tarsomeres; tarsomeres 1–4 pale; all pretarsi brown; mid tibia bearing several small setae (lengths about ½ that of tibia width); 1 ventroapical, 1 preapical lateral, and pair of dorsoapical. Halter pale. Wing (Fig. 11): hyaline; vein R_1 thickened at merger with C; Sc very short, incomplete; subcostal break present, but not well defined; vein R_{2+3} extended to about apical ⅓ of R_{4+5}; veins R_{4+5} and M_1 parallel; apices of veins CuA_1 and A_1 tapered, not extended to wing margin; cells *cup, bm,* and *dm* complete.

Abdomen: Relatively flat dorsoventrally; tapered apically. Tergites and epi- and hypoproct uniformly brown.

Measurements.—Head width 0.78 mm; width of face at narrowest point 0.25 mm; thorax length 0.74 mm; body length 2.20 mm; wing length 1.71 mm; distance between apices of R_1–R_{2+3} 0.77 mm; distance between apices R_{2+3}–R_{4+5} 0.44 mm; length along basal portion of vein M/apical portion 0.35/0.91 mm.

Type material.—Holotype ♀ (AMNH DR-8-208): specific provenance unknown within the Dominican Republic; size of piece of



Figs. 10–13. *Planinasus electrus.* 10, head, dorsolateral view. 11, wing. 12, antenna. 13, oral margin of face, showing arrangement of setae.

amber 1.1 × 1.3 cm, nearly flat (originally oval but corner trimmed off to better view face of specimen), clear yellow, with a milky layer of numerous fine bubbles.

Etymology.—The specific epithet, *electrus,* is derived from the Greek word *elektron,* meaning "amber."

Remarks.—The coloration of the face and pattern of facial setae in this species are apparently unique and easily distinguish it from congeners.

Genus *Stenomicra Coquillett*

Stenomicra Coquillett, 1900: 262. Type species: *Stenomicra angustata* Coquillett, by original designation.—Hendel, 1931: 10–12 [redescription].—Sturtevant, 1954: 560 [revision].—Hennig, 1958: 633–635 [generic characters, relationships].—Sabrosky, 1965b: 209–218 [revision Asiatic species]; 1975: 663–676 [revision afrotropical species].

Podocera Czerny, 1929: 93. Type species: *Podocera ramifera* Czerny, by monotypy.—Hendel, 1931: 10–12 [synonymy].

Neoscaptomyza Séguy, 1938: 347. Type species *Neoscaptomyza bicolor* Séguy, by original designation.—Sabrosky, 1975: 664 [synonymy].

Diadelops Collin, 1944: 265. Type species: *Diadelops delicatus* Collin, by monotypy.—Sturtevant, 1954: 560 [synonymy].

Diagnosis.—Small, slender flies, length 1.5–1.75 mm.

Head: Head in profile peculiarly angulate below, snout-like, projected forward at vibrissal angle; frons lacking intrafrontal setae; 1 well-developed fronto-orbital seta, preceded by a shorter seta that may be weak, hair-like, or somewhat longer and stronger, at its maximum development almost as strong as the fronto-orbital seta; outer vertical seta long, slightly reclinate; inner vertical seta proclinate, inserted well apart from outer seta, sometimes weak or absent. Arista pectinate. Eye bearing sparse interfacetal microsetulae; eye in profile more or less diagonal and length greater than width, with some enlarged facets either above or below. Face narrowed at the vibrissal angle, the eyes obviously closer together at the vibrissal angle than at the vertex, their inner margins appearing more or less emarginate at level of antennae. Face sloped anteroventrally from base of antenna to vibrissal angle, usually with slight median carina, smooth in a few species, wide above and narrow below; vibrissal angles prominent, especially in profile, the lower end of facial plate often forming a sharp rim above vertical epistomal area which continues around the oral opening as a broad to narrow peristomal area; median plate of clypeus a long, narrow, inverted U. Haustellum and labella broad and short, tending to fill the oral opening. Palp reduced, papilliform, difficult to discern.

Thorax: Mesonotum almost bare of setulae, typically with only the median acrostichal setulae and a dorsocentral row laterad, the former incomplete posteriorly and sometimes absent, the latter terminated with 1–2 postsutural, dorsocentral setae; lacking supra-alar setae; scutellum conical, rounded distally, bearing 1 pair of apical setae; postscutellum strongly developed, convex, nearly or quite attaining apex of scutellum; 1 postpronotal seta, weak; 1 presutural seta; posterior notopleural seta on callosity and well removed dorsally from notopleural suture; anepisternum and anepimeron usually bare; 1 katepisternal seta. Wing long and relatively narrow, usually narrowed at base with alula absent or very narrow and lacking fringe of hairs; vein R_1 very short; vein R_{2+3} usually very long; veins R_{4+5} and M parallel to subparallel, often slightly convergent at apex of wing; CuA_1 weak, not extended to margin of wing or absent; cells bm and dm distinct, partially separated, or confluent; vein CuA_2 weak or lacking; cell *cup* lacking. Legs: fore femur with 1 or more strong, straight posteroventral setae on distal half; mid tibia apically with strong, straight, ventral spur-like seta; hind femur lacking anterodorsal, preapical seta.

Abdomen: Slender and elongate, usually 7 tergites visible in addition to genital segments; sternites becoming broader distally; 7th segment a complete ring.

KEY TO FOSSIL SPECIES OF *STENOMICRA*

1. Inner vertical seta lacking; crossvein r-m apparently lacking; body uniformly pale, mostly pale yellow ...... *S. anacrostichalis*, new species
– Inner vertical seta present, proclinate; crossvein r-m present; body generally darker .... *S. sabroskyi*, new species

Stenomicra sabroskyi Grimaldi and Mathis, NEW SPECIES

Figs. 14–16

Description.—All setae pale; body with considerable brown coloration.

Head (Figs. 14, 15): Frons with middle portion slightly darker than fronto-orbits; 2 fronto-orbital setae, inserted on anterior ⅓ of frons, anterior seta inclinate, about ½ length of posterior, reclinate seta; inner vertical seta proclinate; outer vertical seta very pale, slightly shorter than reclinate fronto-orbital seta, parallel and reclinate. Eyes with sparse, thin interfacetal setulae; shape of posterior margin with typical concave margin and wide gena. Frontal margins of eyes convex at level of antenna; margins closest just above level of vibrissae. Antenna: scape, pedicel, and flagellomere 1 yellow; pedicel slightly elongate, overlapping flagellomere 1 anteriorly; arista plumose, with 4 dorsal and 2 ventral branches, plus terminal fork. Face with slight carina, extended between apices of flagellomere 1 and vibrissae; 1 pair vibrissae present, slightly divergent, upturned, inserted very close together, bases separated about 3 times diameter of setae; row of about 4 setae posterior to vibrissae, along oral margin; seta at posteroventral corner of eye long, straight, thin, pointed ventrad. Clypeus narrow, yellow. Proboscis obscured by bubble.

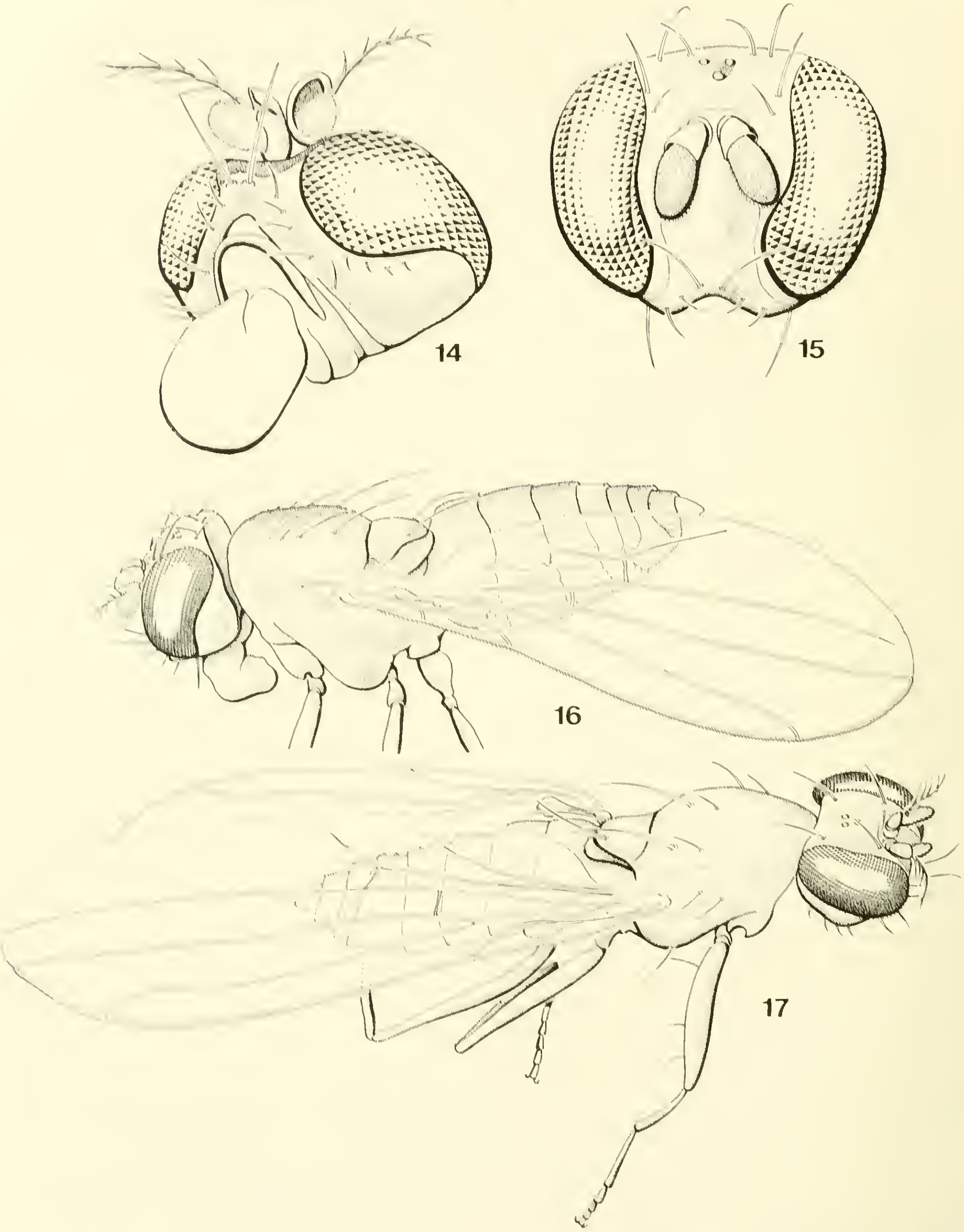
Thorax: Mesonotum pale brown; 2 medial rows apparent of about 4 acrostichal setulae each, rows end at anterior dorsocentral setae. 2 pairs dorsocentral setae present; distance between anterior and posterior dorsocentral setae slightly less than length of anterior seta; posterior dorsocentral set about twice length of anterior seta; 2–3 acrostichal setulae inserted anterior to and in line with ipsilateral dorsocentral setae, lengths about ½ that of anterior dorsocentral. Scutellum triangular, apically pointed, adpressed to postnotum; postnotum slightly longer than scutellum, brown; scutellum with an apical pair of setae; parallel, slightly upturned. Pleuron paler than notum. All legs yellow. Halter yellow. Wings hyaline; crossvein r-m present.

Abdomen: Tapered apicad; 7 tergites visible; tergites virtually bare, without large setae; all tergites brown except yellow tV; tVII apparently a syntergosternite, as in other *Stenomicra* (e.g. McAlpine 1987—note, Teskey (1987) refers to syntergosternite VII); hypoproct yellow, without larger setae.

Measurements.—Head length 0.20; thorax length 0.46 mm; body length 1.32 mm; wing length 1.13 mm; distance between apices R_1–R_{2+3} 0.66 mm; distance between apices R_{2+3}–R_{4+5} 0.27 mm; length along basal portion of vein M/apical portion 0.15/0.65 mm.

Type material.—Holotype ♀ (AMNH DR-6-15D): specific provenance unknown within the Dominican Republic; size of piece of amber 0.9 × 0.6 cm (cut from tear-drop shaped piece originally 2.1 × 1.5 cm), light yellow, with only a few fine bubbles and three minute male cecidomyiids (Diptera).

Etymology.—The species epithet, *sabroskyi,* is a genitive patronym to honor Dr. Curtis W. Sabrosky, who has contributed much to our knowledge of Periscelididae, the genus *Stenomicra* specifically.



Figs. 14–17. *Stenomicra* species. 14, head of *S. sabroskyi*, ventro-oblique view. 15, head of *S. sabroskyi*, anterior view. 16, body of *S. sabroskyi*, dorsolateral view. 17, body of *S. anacrostichalis*, dorsolateral view.

Remarks.—See "Remarks" section under the next species.

Stenomicra anacrostichalis Grimaldi and Mathis, NEW SPECIES

Fig. 17

Description.—All setae pale or golden colored, none black. Body entirely pale, yellowish.

Head: Ocellar triangle darker than remainder of frons; no postocellar setae apparent; fronto-orbital setae as a well-developed reclinate seta and a smaller (length slightly shorter than outer vertical seta), anterior, proclinate seta inserted slightly above lunule; only outer vertical seta present; parallel, directed slightly posteriad; length about equal to length of frons. Antenna: pedicel slightly darker than remainder of antenna, bearing 1 large dorsal seta, directed laterad; several smaller, ventral setae, also directed laterad; flagellomere 1 equal in length to pedicel; arista with 3 dorsal, 2 ventral branches, plus small terminal fork; bases of 1st and 2nd ventral branches closely opposed. Eyes large, faintly red, apparently bare but possibly with fine interfacetal setulae; posterior margin concave, making gena deep. Frontal inner margin of eyes slightly convex, but not strongly so around antennae, as in *S. sabroskyi*; eye margins almost parallel on front; facial margin of eyes very close to pedicel; closest margins of eyes on ventral part of face; face with 1 pair of upturned, slightly divergent setae inserted on small rounded facial area; 4 pairs inclinate facial setae ventro-lateral to upturned facial setae; the ventralmost pair longest (slightly longer, and thinner, than upturned vibrissae). Clypeus apparently deep, with pointed ventral margin.

Thorax: Mesonotum and pleuron uniformly yellow. Anterior dorsocentral seta about ½ width and thickness of posterior seta; distance between base of anterior dorsocentral and notal-scutellar suture slightly greater than length of anterior dorsocentral seta; posterior dorsocentral seta inserted about midway between anterior dorsocentrals and notal-scutellar suture; if acrostichal setulae present, very difficult to discern; postnotum projected slightly behind posterior margin of scutellum. Legs uniformly yellow; fore femur with 2 stiff, thin setae on ventral surface; near base and midline. Wing hyaline; halter pale.

Abdomen: Slightly flattened dorsoventrally; 7 tergites visible; without large setae; yellowish, lacking markings.

Measurements.—Head length 0.24; thorax length 0.52 mm; body length 1.42 mm; wing length (from actual base) 1.42 mm; distance between apices R_1–R_{2+3} 0.83 mm; distance between apices R_{2+3}–R_{4+5} 0.21 mm; length along basal portion of vein M/apical portion obscured.

Type material.—Holotype ♀ (AMNH 63): specific provenance unknown within the Dominican Republic; size of piece of amber 1.4 × 0.9 cm, dark yellow, center is frothy with dense bubbles. This piece of amber also contains a specimen of *Euceroplatus* sp. (Mycetophilidae).

Etymology.—The species epithet, *anacrostichalis*, refers to the apparent absence of acrostichal setulae in this species.

Remarks.—Easily distinguished from the other fossil species of *Stenomicra* in Dominican amber by: eyes are more laterally situated; frontal margins of the eyes less convex and much closer together; and acrostichal setulae absent.

ACKNOWLEDGMENTS

We are grateful to the following individuals who facilitated and aided in the production of this paper: Dr. David Lindberg, Museum of Paleontology, University of California at Berkeley, for allowing us to borrow and study the specimen of *Periscelis annectans*; Mr. Jacob Brodzinsky for assisting in the acquisition of amber with insect inclusions; and Drs. C. W. Sabrosky and N. E. Woodley for providing critical reviews of a draft of the manuscript. We also acknowledge and are grateful for support to DAG from the National Science Foundation (grant BSR-9020102) to conduct research on fossil Diptera in amber.

Literature Cited

Bachofen-Echt, A. 1942. Der Bernstein und seine Einschlusse. Springer-Verlag, Wien. 204 pp.

Baroni-Urbani, C. and J. B. Saunders. 1982. The fauna of the Dominican Republic amber: The present status of knowledge. Proceedings of the 9th Caribbean Geological Conference, Santo Domingo, August 1980, pp. 213–223.

Baroni-Urbani, C. and S. Graeser. 1987. SEM analyses of a pyritic ant in Baltic amber. Stuttgarter Beiträge zur Naturkunde 133. 16 pp.

Brouwer, S. B. and P. A. Brouwer. 1982. Geología de la región ambarifera oriental de la República Dominicana. Proceedings of the 9th Caribbean Geological Conference, Santo Domingo, August 1980, pp. 303–322.

Collin, J. E. 1944. The British species of Anthomyzidae (Diptera). The Entomologist's Monthly Magazine 80: 265–272.

Coquillett, D. W. 1900. Report on a collection of dipterous insects from Puerto Rico. Proceedings of the United States National Museum 22: 249–270.

Cresson, E. T., Jr. 1914. Descriptions of new genera and species of the dipterous family Ephydridae. I. Entomological News 25: 241–250.

———. 1918. Costa Rican Diptera collected by Philip P. Calvert, Ph.D., 1909–1910. Paper 3. A report on the Ephydridae. Transactions of the American Entomological Society 44: 39–68.

Cunningham, A., I. D. Gay, A. C. Oehlschlager, and J. H. Langenheim. 1983. C-13 NMR and IR analyses of structure, aging and botanic origin of Dominican and Mexican amber. Phytochemistry 22: 965–968.

Curran, C. H. 1934. The Families and Genera of North American Diptera. The Ballou Press, New York. 512 pp.

Czerny, L. 1929. *Podocera ramifera*, eine neue Gattung und Art der Periscelíden von Ceylon. Konowia 8: 93–94.

Duda, O. 1934. 58a. Periscelidae, pp. 1–13. *In* Lindner, E., ed., Die Fliegen der paläarktischen Region, 6. E. Schweizerbart'sche, Stuttgart.

Enderlein, G. 1914. 16. Ordn. Diptera, Fliegen, Zweiflügler, pp. 272–336. *In* Brohmer, P., ed., Fauna von Deutschland. Quelle and Meyer, Leipzig.

———. 1917. Dipterologische Studien XVI. Dipterologische Notizen. Zoologischer Anzeiger 49: 65–72.

Griffiths, G. C. D. 1972. The phylogenetic classification of Diptera Cyclorrhapha with special reference to the structure of the male postabdomen. *In* Schimitschek, E., ed., Series Entomologica, 8. Dr. W. Junk N.V., The Hague. 340 pp.

Grimaldi, D. 1993. The care and study of fossiliferous amber. Curator. 36: 31–49.

Hendel, F. 1916. Beiträge zur Systematik der Acalyptraten Musciden (Dipt.). Entomologische Mitteilungen 5: 294–299.

———. 1931. Kritische und synonymische Bemerkungen über Dipteren. Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien 81: 4–19.

Hennig, W. 1958. Die Familien der Diptera Schizophora und ihre phylogenetischen Verwandtschaftsbeziehungen. Beiträge zur Entomologie 8: 505–688.

———. 1965. Die Acalyptratae des Baltischens Bernsteins. Stuttgarter Beiträge zur Naturkunde 145. 215 pp.

———. 1967. Neue Acalyptratae aus dem Baltischen Bernstein. Stuttgarter Beiträge zur Naturkunde 175. 27 pp.

———. 1969. Neue Gattungen und Arten der Acalyptratae. Canadian Entomologist 101: 589–633.

Henwood, A. 1992. Exceptional preservation of dipteran flight muscle and the taphonomy of insects in amber. Palaios 7: 203–212.

Hueber, F. M. and J. Langenheim. 1986. Dominican amber tree had African ancestors. Geotimes 1968 (January): 8–10.

Hurd, P. D., Jr., R. F. Smith, and J. W. Durham. 1962. The fossiliferous amber of Chiapas, Mexico. Ciencia (México) 21: 107–118.

Langenheim, J. H. 1969. Amber: A botanical inquiry. Science 63: 1157–1169.

———. 1990. Plant resins. American Scientist 78: 16–24.

Langenheim, J. H., B. L. Hackner, and A. Bartlett. 1967. Mangrove pollen at the depositional site of Oligo-Miocene amber from Chiapas, Mexico. Harvard University Botanical Museum Leaflets 22: 284–324.

Lambert, J. B., J. S. Frye, and G. O. Poinar, Jr. 1985. Amber from the Dominican Republic: Analysis by nuclear magnetic resonance spectroscopy. Archaeometry 27: 43–51.

Larsson, S. G. 1978. Baltic Amber—A Paleobiological Study. Entomonograph 1. 192 pp.

Lioy, P. 1864. I. Ditteri distribuiti secondo un nuovo methodo di classificazione naturale. Atti dell' I.R. Istituto Veneto di scienze, lettere ed arti, ser. 3, 9: 1087–1126.

Loew, H. 1858. Ueber einige neue Fliegengattungen. Berliner Entomologische Zeitschrift 2: 101–122.

Malloch, J. R. 1915. An undescribed sapromyzid

(Diptera). Bulletin of the Brooklyn Entomological Society 10: 86–88.

———. 1934. A remarkable new genus of the family Periscelidae. Stylops 3: 52–53.

Martinez, R. and D. Schlee. 1984. Die Dominikanischen Bernstein-Lagerstätten der Nordkordillere, speziell auch aus der Werkstätten. Stuttgarter Beiträge zur Naturkunde 18(C): 79–84.

Mathis, Wayne N. 1993. A new species and subgenus of *Periscelis* Loew from Australia (Diptera: Periscelididae). Journal of the Australian Entomological Society. 32: 13–19.

McAlpine, David K. 1978. Description and biology of a new genus of flies related to *Anthoclusia* and representing a new family (Diptera, Schizophora, Neurochaetidae). Annals of the Natal Museum 23: 273–295.

———. 1983. A new subfamily of Aulacigastridae (Diptera: Schizophora), with a discussion of aulacigastrid classification. Australian Journal of Zoology 31: 55–78.

McAlpine, J. F. 1981. Morphology and terminology—Adults, pp. 9–63. *In* McAlpine, J. F. et al., eds. Manual of Nearctic Diptera, 1. Ottawa. [Volume 1 is Monograph 27 of Research Branch Agriculture Canada.]

———. 1987. Periscelididae, pp. 895–898. *In* McAlpine, J. F. et al., eds., Manual of Nearctic Diptera, 2. Research Branch Agriculture Canada. Monograph No. 28. Ottawa.

Oldenberg, L. 1914. Beitrag zur Kenntnis der europäischen Drosophiliden (Dipt.). Archiv für Naturgeschichte 80A(2): 1–42.

Papp, L. 1984a. Family Periscelididae, pp. 233–234. *In* Soós, A. and L. Papp, eds., Catalogue of Palaearctic Diptera, Vol. 9. Elsevier Science Publishers, Amsterdam.

———. 1984b. Family Stenomicridae, pp. 61–62. *In* Soós, A. and L. Papp, eds., Catalogue of Palaearctic Diptera, Vol. 10. Elsevier Science Publishers, Amsterdam.

———. 1988. *Periscelis kabuli* sp. n. and *P. Kaszabi* sp. n. with notes on larvae and pupae of the families Aulacigastridae and Periscelididae (Diptera). Acta Zoologica Hungarica 34(2–3): 273–284.

Pires do Prado, A. 1975. 67. Family Periscelididae, 3 pp. *In* Papavero, N., ed., A Catalogue of the Diptera of the Americas South of the United States, Fasc. 67. Departamento de Zoologia, Secretaria de Agricultura, São Paulo.

Poinar, G. O., Jr. and D. C. Cannatella. 1987. An upper Eocene frog from the Dominican Republic and its implications for Caribbean biogeography. Science 237: 1215–1216.

Poinar, G. O., Jr., and R. Singer. 1990. Upper Eocene gilled mushroom from the Dominican Republic. Science 248: 1099–1101.

Sabrosky, C. W. 1965a. Family Periscelididae, p. 710. *In* Stone, A. et al., eds., A Catalog of the Diptera of America North of Mexico. United States Department of Agriculture, Handbook 276, Washington, D.C. 1696 pp.

———. 1965b. Asiatic species of the genus *Stenomicra* (Diptera: Anthomyzidae). Bulletin of the British Museum (Natural History), Entomology 17: 209–218.

———. 1975. The genus *Stenomicra* in the Ethiopian Region (Diptera, Aulacigastridae). Annals of the Natal Museum 22: 663–676.

Séguy, E. 1938. Diptera. I. Nematocera et Brachycera. *In* Jeannel, R., ed., Mission Scientifique de l'Omo. Muséum National d'Histoire Naturelle 4(39) (Zoologie): 319–380.

Stackelberg, A. A. 1933. Les mouches de la partie Europeénne de l'URSS. *In* [Tableaux Analytiques de la Faune de l'URSS Publiées par l'Institut Zoologique de l'Academie des Sciences.] 7. 742 pp. Leningrad [in Russian].

Sturtevant, A. H. 1923. New species and notes on synonymy and distribution of Muscidae Acalypteratae (Diptera). Novitates of the American Museum of Natural History 76: 1–12.

———. 1954. Nearctic flies of the family Periscelidae (Diptera) and certain Anthomyzidae referred to the family. Proceedings of the United States National Museum 103(3332): 551–561.

———. 1963. A fossil periscelid (Diptera) from the amber of Chiapas, Mexico. Journal of Paleontology 37: 121–122.

Teskey, H. J. 1976. Diptera larvae associated with trees in North America. Memoirs of the Entomological Society of Canada 100. 53 pp.

———. 1987. Aulacigastridae. *In* J. F. McAlpine, ed., Manual of nearctic Diptera, 2: 891–894. Ottawa: Research Branch Agriculture Canada. Monograph No. 28.

Woodley, N. E. 1982. Two new species of *Neurochaeta* McAlpine (Diptera: Neurochaetidae), with notes on cladistic relationships within the genus. Memoirs of the Entomological Society of Washington 10: 211–218.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 404–411

LIFE HISTORY AND IMMATURE STAGES OF TWO SPECIES OF *MEGASELIA* (DIPTERA: PHORIDAE) PREDATORY ON GALL-INHABITING INSECTS

W. H. Robinson and B. V. Brown[1]

(WHR) Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061; (BVB) Maryland Center for Systematic Entomology, University of Maryland, College Park, Maryland 20742.

Abstract.—Larvae of *Megaselia chainensis* are predators of the cockscomb leaf gall aphid *Colopha ulmicola* on elm trees. Larvae of *M. submarginalis* are predators of larval *Contarinia negundifolia,* a leaf gall-inducing cecidomyiid fly on boxelder trees. Larvae of both *Megaselia* species consume several hosts during their development. Both are univoltine and synchronized with the life cycles of their hosts. Larvae of both species are described and illustrated.

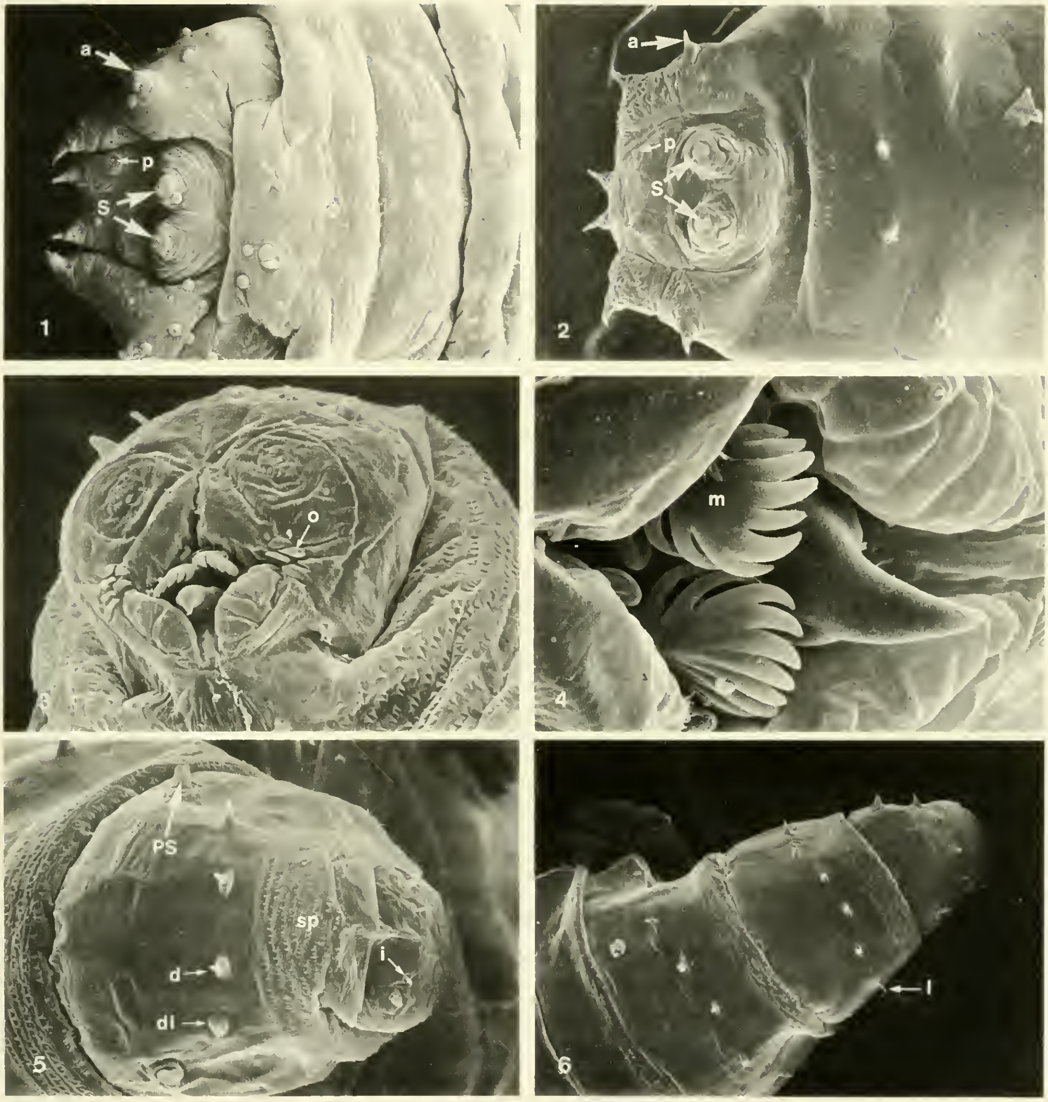
Key Words: Aphidae, Cecidomyiidae, gall, *Megaselia,* natural history, Phoridae, predator

The usual representation of phorid flies as indiscriminate scavengers is incorrect. We know of a large variety of life histories in this family, including those of species that are herbivores, predators, and parasitoids attacking a diverse array of prey and hosts (Schmitz 1938, Disney 1990). Recently, Ferrar (1987), Disney (1983) and Kistner (1982) have summarized information on predatory and parasitoid phorid species.

The purpose of this paper is to publish data on two further predatory species of *Megaselia* Rondani, one that attacks larvae of a species of cecidomyiid fly (Diptera: Cecidomyiidae) and one that attacks immatures and adults of an aphid species (Homoptera: Aphidae) (Robinson 1970). Other phorids are known to attack Diptera larvae, for instance larvae of *M. flavicoxa* Zetterstedt and *M. obscuripennis* (Wood) are parasitoids of sciarid larvae, larvae of *Peromitra incrassata* (Meigen) are endoparasites of larval *Bibio marci* (Linnaeus) (Diptera: Bibionidae) (Morris 1922, Gemesi and Disney 1991), larvae of *P. germanica* (Schmitz) are parasitoids of *Penthretia holosericea* Meigen (Diptera: Bibionidae) (Gemesi and Disney 1991), larvae of *M. mallochi* (Wood) are predators of sciarid pupae (Krespi et al. 1985, Deleporte 1986) and *M. paludosa* larvae are true parasites in tipulid larvae (Disney 1983). Our record of *M. submarginalis* (Malloch), however, seems to be the first example of a true predator of Diptera larvae, that is, one which kills many hosts. Other than *M. chainensis,* the only phorid species that has been recorded as attacking aphids is *Phora holosericea* Schmitz, whose larvae eat root aphids on various plants (Yarkulov 1972).

---

[1] Correspondance: Brian V. Brown, Department of Entomology, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, California 90007.



Figs. 1–6. Larvae of *Megaselia* species. 1, *M. submarginalis*, terminal segments, dorsal; Figs. 2–6. *M. chainensis*. 2, terminal segments, dorsal; 3, cephalic segment, ventral; 4, oral region; 5, cephalic segment and prothorax, dorsal; 6, thorax, dorsal. Abbreviations: a—anterior lateral papilla, d—dorsal papilla, dl—dorsolateral papilla, i—interantennal papilla, l—lateral papilla, m—mandible, o—oral papillae, p—posterior spiracular papilla, ps—prothoracic spiracle, s—terminal spiracle, sp—spinulae.

METHODS AND MATERIALS

Life history observations and photographs of larvae and prey of *M. chainensis* and *M. submarginalis* were provided by the senior author. Illustrations and descriptions of immature stages, and discussion of relationships were provided by the junior author.

Specimens were handled and examined as follows: larvae brought into the laboratory were reared in petri plates and provided with food and moist filter paper as a substrate. Larvae were collected into alcohol, sonicated in alcohol and ammonium hydroxide, critical-point-dried, sputter coated with gold-palladium, and examined with a Cambridge Stereoscan 100.

DESCRIPTION OF TAXA

Megaselia chainensis Disney 1985

Plastophora subconvexa Borgmeier 1963

Megaselia subconvexa, Disney 1978

(Figs. 2–13, 19–22)

Third-instar larva

Head.—Interantennal papilla present, level with antenna (Fig. 5, i). Several small papillae present lateral to oral opening (Fig. 3, o). Basal portion of dorsal and ventral cornua of cephalopharyngeal skeleton darkly sclerotized; ventral cornu elongate, enlarged, much longer than dorsal cornu, mostly unsclerotized (Fig. 13). Hypopharyngeal skeleton separated from cornua. Labium short. Mandible with numerous, medially-curved teeth (Figs, 4, m, 13, m; also Sinclair 1992, fig. 28). Parastomal bars thin. Pharyngeal ridges distinctly visible.

Thorax.—Each segment encircled by anterior rows of spinuli (Fig. 5, sp). Prothorax with dorsal (Fig. 5, d) and dorsolateral (Fig. 5, dl) papilla, anterior to spiracle (Fig. 5, ps). Spiracle apically bilobate. Mesothorax and metathorax with dorsal, dorsolateral and lateral (Fig. 6, l) papilla. Each segment with small, ventral creeping welt with small papillae (Fig. 7).

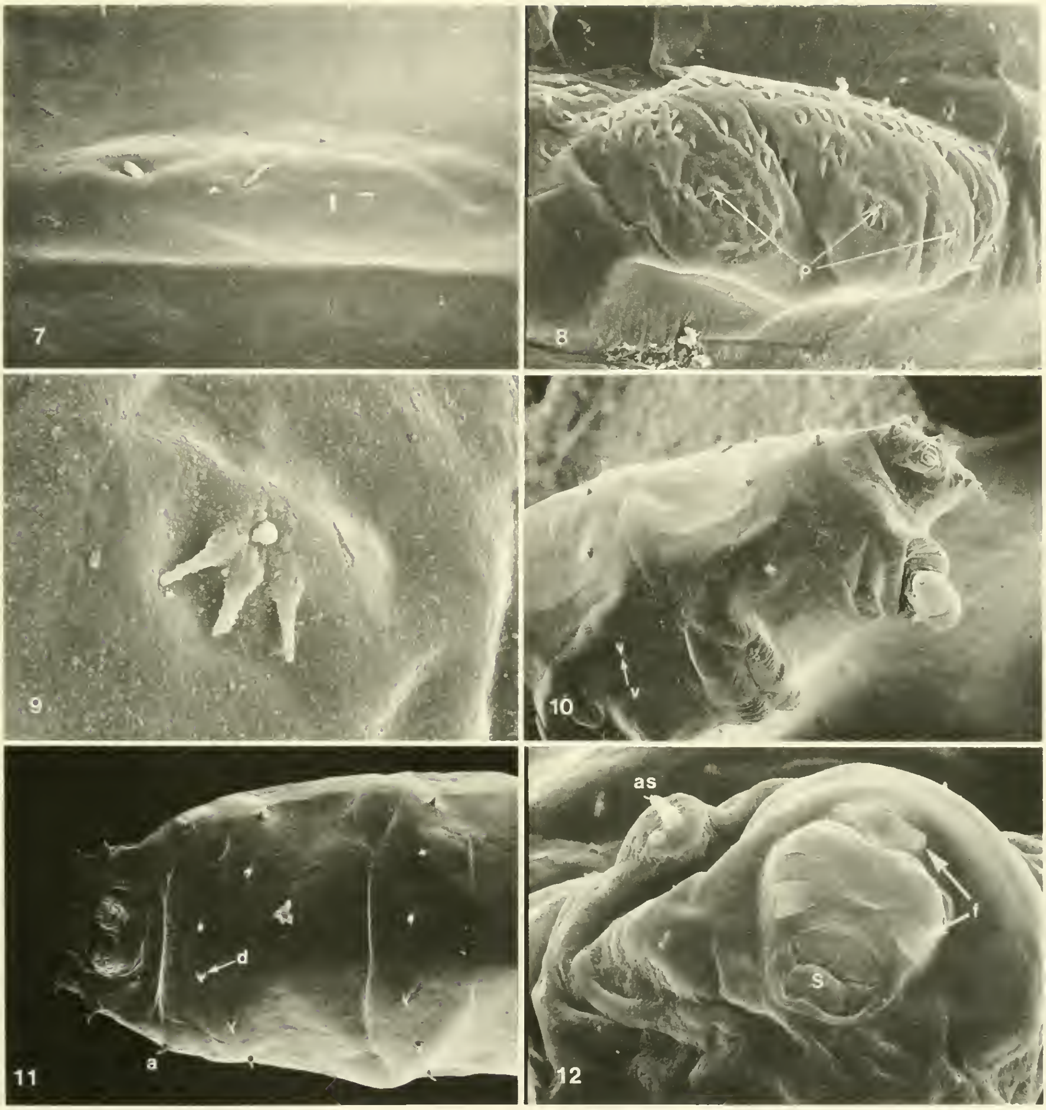
Abdomen.—Segments 1–6 with same six papillae found on mesothorax and metathorax, plus one ventral papilla (Fig. 10, v); all found along posterior one-third; segment 7 with all except dorsal, most medial (Fig. 11, d) anteriorly displaced; segment 8 with large, anterior papilla (Fig. 11, a), two large, lateral papillae and one small posterior papilla (Fig. 2); one papilla anterior (Fig. 12, as) and one posterior (Fig. 2, p) to spiracle. Flattened spiracular processes (Fig. 12, f) present beside posterior spiracle; four spiracular slits present. Ecdysial scar large, prominent (Fig. 12, s). Ventral creeping welt with three small papillae (Fig. 8, p), each surrounded by rosette of processes (Fig. 9).

Life history.—In the spring and early summer, aphids of the species *Colopha ulmicola* Fitch induce cockscomb galls on the leaves of American elm trees (*Ulmus americana* L.). These galls, each with several aphids, apparently are a natural oviposition site for *M. chainensis.* Field and laboratory observations indicate that the female phorid deposits 1–3 eggs within a gall (Fig. 21, e). No eggs were found outside galls. The female oviposits through the slit-like opening of the gall on the underside of the leaf (Fig. 19), and apparently does not discriminate between galls that contain aphids (Fig. 20, a), and those that are empty or damaged.

Soon after hatching, the first-instar larva begins feeding on the aphids within the gall. Its behavior is similar to that of the second- and third-instar larvae. The larva attacks an aphid by rasping at the integument with its mouth hooks. Once an opening is made in the integument, the larva eats the internal contents of the aphid. The second-instar larva remains in the gall and continues to feed on the enclosed aphids. If several larvae are in one gall, the number of aphids available for food diminishes, and some larvae leave the gall through the opening of the underside of the leaf. The third-instar larva continues to feed on aphids, including the spring migrant (alate) forms that are developing in the gall. The mature third-instar larva remains in the gall and pupariates.

The pupal respiratory horns appear after about 72 h, and after one month an adult is formed within the puparium (Fig. 22, p). The adult remains in this state until the following spring. There are one or perhaps two generations per year.

Geographic distribution.—Widespread in Canada and the northern United States of America (Borgmeier 1963, Robinson 1970).

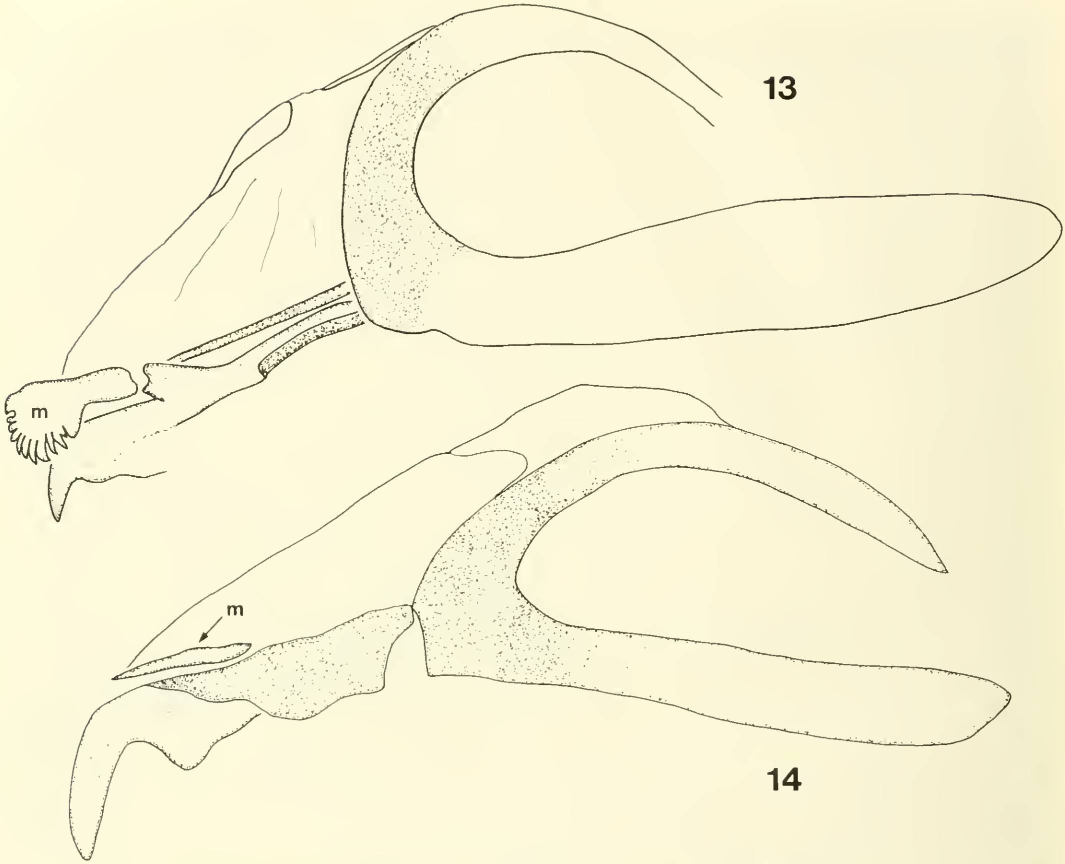


Figs. 7–12. Larva of *M. chainensis.* 7, mesothoracic creeping welt, ventral; 8, abdominal creeping welt, ventral; 9, papilla of abdominal creeping welt; 10, terminal segments, lateral; 11, terminal segments, dorsal; 12, spiracular region, dorsal. Abbreviations: a—anterior papilla of segment 8, as—anterior spiracular papillae, d—dorsal papilla, f—flattened spiracular process, p—papillae, s—ecdysial scar, v—ventral papilla.

Megaselia submarginalis **(Malloch)**
Aphiochaeta submarginalis
Malloch 1912
Megaselia (*Aphiochaeta*)
submarginalis, Brues 1950,
Borgmeier 1964
Plastophora submarginalis,
Borgmeier 1966
Megaselia submarginalis,
Disney 1978
(Figs. 1, 14–18)

Third-instar larva

The few available specimens of this species were killed and preserved in alcohol almost thirty years ago, and they have de-



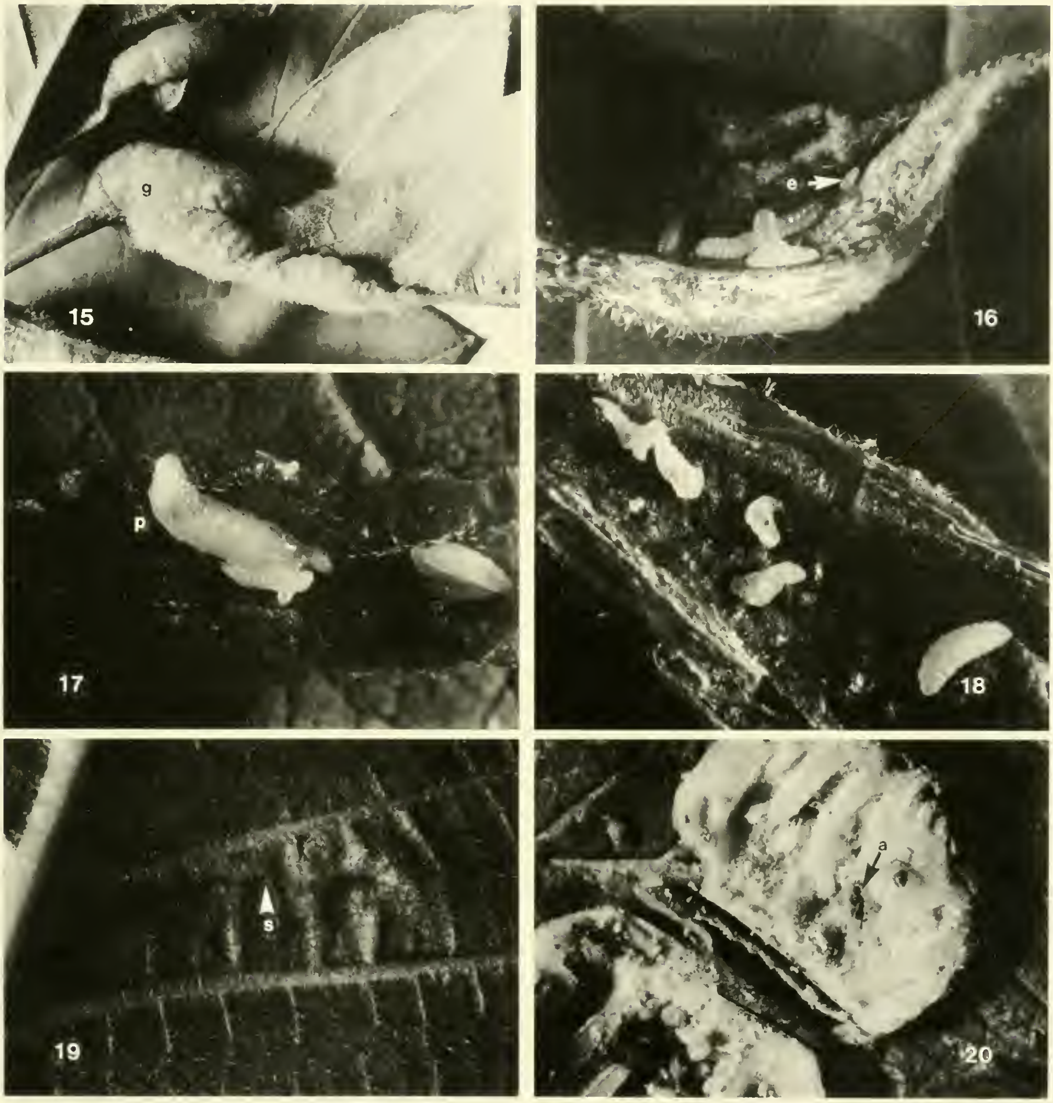
Figs. 13, 14. Cephalopharyngeal skeleton, lateral. 13, *M. chainensis*; 14, *M. submarginalis*. Abbreviation: m—mandible.

composed substantially, making it difficult to produce SEM illustrations of publishable quality. In general, papillae and body form are similar to those of *M. chainensis*. The following are some features of the larva of *M. submarginalis* that might be useful for distinguishing it from that of *M. chainensis*:

Cephalopharyngeal skeleton (Fig. 14). Bases, but not apices, of cornua darkly sclerotized. Labium elongate. Hypopharyngeal skeleton markedly separated from cornua. Mandible thin, elongate, not toothed (Fig. 14, m). Pharyngeal ridges faint.

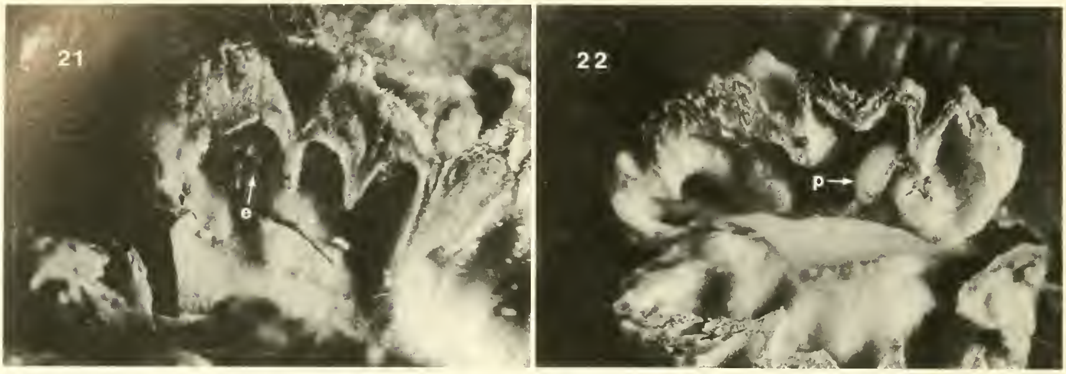
Abdominal segment 8 (Fig. 1). Most anterior lateral papilla (Fig. 1, a) small; posterior lateral papilla directed posteriorly; post-spiracular papilla (Fig. 1, p) smaller than that of *M. chainensis* (compare with Fig. 2, p).

Life history.—During early- to mid-May, larvae of the cecidomyiid fly, *Contarinia negundifolia* Felt, induce galls (Fig. 15, g) on the leaves of boxelder trees, *Acer negundo* L. (Wilson 1966). These galls, each with several cecidomyiid larvae (Fig. 16), apparently are a natural oviposition site for *M. submarginalis*. Field and laboratory observations indicate that the female deposits one egg within a gall (Fig. 16, e), after inserting the tip of her ovipositor into the upper opening of the gall, generally near the apex of the leaf. Eggs were not found outside the gall, and only one egg or larva was found in each infested gall.



Figs. 15–20. Life history and microhabitat of *Megaselia* species. Figs. 15–18. *M. submarginalis.* 15, boxelder leaf gall; 16, larvae of *Contarinia negundifolia* and egg of *M. submarginalis*; 17, larva of *M. submarginalis*; 18, four consumed and one living larva of *C. negundifolia*; Figs. 19, 20. *M. chainensis.* 19, ventral slit in elm cockscomb gall; 20, cockscomb gall opened to expose aphids. Abbreviations: a—aphid, e—egg, g—gall, p—phorid larva.

Soon after hatching, the first-instar phorid larva begins feeding on a cecidomyiid larva. The feeding behavior of the first-instar larva is similar to that of the second and third instar larvae. It curls around the cecidomyiid larva and begins rasping at the integument with its mouth hooks. Once an opening is made in the integument, the phorid larva consumes the internal contents of the cecidomyiid. The second-instar larva remains in the gall and continues to eat the enclosed cecidomyiid larvae. Three to six cecidomyiid larvae are consumed during this period, but the contents of each prey item



Figs. 21, 22. Life history of *M. chainensis.* 21, phorid egg in exposed cockscomb gall; 22, phorid puparium in exposed cockscomb gall. Abbreviations: e—egg, p—puparium.

are not always completely ingested. Several partially consumed cecidomyiid larvae can be found in most infested galls (Fig. 18). During the third stadium, the phorid larva continues to eat cecidomyiid larvae (Fig. 17, p), and apparently it completes development in a single gall. No phorid larvae were seen outside of galls until development was completed; thereafter they dropped to the ground where they pupariate.

After approximately 72 h the pupal respiratory horns appear. After one month, an adult is formed within the puparium, where it remains until the following spring. The life cycle of the phorid is correlated with that of its univoltine prey, as there is one generation per year.

Geographic distribution.—Widespread in Canada and the northern United States of America (Robinson 1970).

Taxonomic and Phylogenetic Notes

The species of *Megaselia* discussed in this paper were formerly classified in the genus *Plastophora* Brues, which Disney (1978, 1986) subsequently reduced to a synonym. Previously, species of *Plastophora* were characterized by females with a sclerotized ovipositor, but the degree of sclerotization varied widely among species, and these two species are among those with the least sclerotized ovipositors. They probably do not belong in a monophyletic group with many of the other species formerly classified as *Plastophora,* now classified in *Myriophora* Brown (Brown 1992). The genus *Megaselia* itself has been shown to be a paraphyletic group with respect to some other genera within the phorid subfamily Metopininae (Disney 1989), and will eventually have to be organized into monophyletic units.

Diversity of *Megaselia*

Approximately 1200 species of phorid flies were classified in the genus *Megaselia* at the time the catalogue of world Phoridae was published (Borgmeier 1968). Life histories of most species are completely unknown, but recent studies have shown that many are predators and parasitoids, restricted to one or a few hosts. This marked host specificity apparently allows the within-site diversity of *Megaselia* to be extremely high, often exceeding 50 species (Disney 1987, Brown 1989).

Acknowledgments

BVB was funded by Canadian Natural Sciences and Engineering Research Council Postgraduate and Postdoctoral Scholarships and an NSERC grant to G. E. Ball, University of Alberta.

LITERATURE CITED

Borgmeier, T. 1963. Revision of the North American phorid flies. Part I. The Phorinae, Aenigmatiinae and Metopininae, except *Megaselia*. Studia Entomologica 6: 1–256.

———. 1964. Revision of the North American phorid flies. Part II. The species of the genus *Megaselia*, subgenus *Aphiochaeta*. Studia Entomologica 7: 257–416.

———. 1966. Revision of the North American phorid flies. Part III. The species of the genus *Megaselia*, subgenus *Megaselia*. Studia Entomologica 8(1965): 1–160.

———. 1968. A catalogue of the Phoridae of the World (Diptera, Phoridae). Studia Entomologica 11: 1–367.

Brown, B. V. 1989. The phorid fauna of Guelph, Ontario (Diptera: Phoridae). Fly Times 2: 6–8.

———. 1992. Generic revision of Phoridae of the Nearctic Region and phylogenetic classification of Phoridae, Sciadoceridae and Ironomyiidae (Diptera: Phoridea). Memoirs of the Entomological Society of Canada 164: 1–144.

Brues, C. T. 1950. Family Phoridae, pp. 33–85. *In* Guide to the Insects of Connecticut. Part IV. Diptera, 4th Fascicle. Bulletin of the Connecticut Geological and Natural History Survey. 75. The State of Connecticut, Hartford.

Deleporte, S. 1986. Biologie et écologie du Diptère Sciaridae *Bradysia confinis* (Winn., Frey) d'une litière de feuillus (Bretagne intérieure). Revue d'Ecologie et de Biologie du Sol 23: 39–76.

Disney, R. H. L. 1978. A new species of afrotropical *Megaselia* (Diptera: Phoridae), with a re-evaluation of the genus *Plastophora*. Zeitschrift für Angewandte Zoologie 65: 313–319.

———. 1983. Scuttle flies—Diptera, Phoridae (except *Megaselia*). Handbooks for the Identification of British Insects 10: 1–81.

———. 1985. Replacement names for three species of *Megaselia* (Dipt., Phoridae) Entomologist's Monthly Magazine 121: 97.

———. 1986. A new genus and three new species of Phoridae (Diptera) parasitizing ants (Hymenoptera) in Sulawesi. Journal of Natural History 20: 777–787.

———. 1987. A preliminary survey of the scuttle flies of Hayley Wood, with descriptions of three new species. Proceedings and Transactions of the British Entomology and Natural History Society 20: 27–34.

———. 1989. A key to Australasian and Oriental *Woodiphora* (Diptera: Phoridae), affinities of the genus and description of new species. Journal of Natural History 23: 1137–1175.

———. 1990. Some myths and the reality of scuttle fly biology. Antenna 14: 64–67.

Ferrar, P. 1987. A guide to the breeding habits and immature stages of Diptera Cyclorrhapha. Entomograph. 8. Brill/ Scandinavian Science Press, Leiden. 907 pp.

Gemesi, O. and R. H. L. Disney. 1991. A further case of parasitisation of larval Bibionidae by a scuttle fly (Diptera: Phoridae). Entomologist's Gazette 42: 67–69.

Kistner, D. H. 1982. The social insect's bestiary, pp. 1–244. *In* Hermann, H. R., Social Insects. Academic Press, New York & London.

Krespi, L., S. Deleporte, and J.-P. Nenon. 1985. Etude de l'entomocenose predatrice et parasitaire de *Bradysia confinis* (Winn., Frey) (Diptere, Sciaridae). Bulletin de la Société scientifique de Bretagne 57: 11–23.

Malloch, J. R. 1912. The insects of the dipterous family Phoridae in the United States National Museum. Proceedings of the United States National Museum 43: 411–529.

Morris, H. M. 1922. On the larva and pupa of a parasitic phorid fly—*Hypocera incrassata* Mg. Parasitology 14: 70–74.

Robinson, W. H. 1970. A revision of the Nearctic species of groups I and II of *Megaselia* (Diptera: Phoridae). Ph.D. Thesis, Iowa State University. v + 192 pp.

Schmitz, H. 1938. Parasitisme bij Phoriden. Natuurhistorisch maandblad 27: 111–116.

Sinclair, B. J. 1992. A phylogenetic interpretation of the Brachycera (Diptera) based on the larval mandible and associated mouthpart structures. Systematic Entomology 17: 233–252.

Wilson, L. F. 1966. Life history, habits, and damage of the Boxelder Leaf Gall Midge, *Contarinia negundifolia* Felt (Diptera: Cecidomyiidae) in Michigan. Canadian Entomologist 98: 777–784.

Yarkulov, F. 1972. *Phora holosericea* (Diptera, Phoridae), a predator of root aphids. Zoologicheskii Zhurnal 51: 1415–1418.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 412–417

A CLADISTIC ANALYSIS OF *PROTODICTYA* MALLOCH (DIPTERA, SCIOMYZIDAE)

Luciane Marinoni and Claudio J. B. de Carvalho

(LM) Doctoral Course of Entomology in the Department of Zoology of the Universidade Federal do Paraná; (CJBC) Department of Zoology of the Universidade Federal do Paraná, Caixa Postal 19020, 81531-970, Curitiba, Paraná, Brazil.

Abstract.—A cladistic analysis of the Neotropical genus *Protodictya* Malloch, 1993 was done using HENNIG 86. The genus *Dictyodes* Malloch, 1933 was used as the outgroup. The monophyly of *Protodictya* is supported by the medio-apical process of the fifth sternite of the male. Resulting from this analysis *Protodictya* is divided into two main clades. The first monophyletic clade includes *P. chilensis* Malloch, 1933 and *P. guttularis* (Wiedemann 1830). The second clade consists of *P. lilloana* Steyskal, 1953, *P. apicalis* Steyskal, 1950, *P. iguassu* Steyskal, 1950, *P. nubilipennis* (Wulp 1897), *P. brasiliensis* (Schiner 1868), and *P. bidentata* (Marinoni and Knutson 1992).

Key Words: *Protodictya,* snail-killing flies, phylogeny, Neotropical

This study results from a revision of *Protodictya* Malloch (Marinoni and Knutson 1992), a Neotropical genus of snail-killing flies (Sciomyzidae) with eight species that collectively range from Mexico to southern Argentina. The objective of this paper is to present a phylogenetic analysis of the included species and a discussion of the evidence for a natural classification of the species *sensu* Wiley (1981).

Methods

The cladistic analysis was performed with the computer program Hennig86 (Farris 1988) using the option "implicit enumeration" (ie). The ordination and polarization of the characters were done in accordance with standard procedures for cladistic analysis (Wiley 1981). At the first analysis the characters were treated as unordered. A matrix of 21 characters and nine taxa were used in the analysis (Table 1). Autapomorphies for the species were not included in this matrix.

The genus *Dictyodes* Malloch (1933) was selected as the outgroup for the following reasons: 1. A cladistic analysis being developed by the first author of 44 genera of Sciomyzidae *sensu* Griffiths (1972) indicates that *Dictyodes* is the sister group of *Protodictya.* 2. Abercrombie (1970) stated that the eggs of *Protodictya* and *Dictyodes* are very similar. 3. Abercrombie (1970) also found that larvae of these two genera are both aquatic predators, suggesting a close relationship between them. 4. *Dictyodes* has morphological characters that are similar and consequently comparable to those of *Protodictya* (Marinoni and Knutson 1992, Abercrombie and Berg 1978). 5. These two genera have traditionally been assigned to the same taxonomic group (Steyskal and Knutson 1975, Knutson et al. 1976). 6. Both genera occur in the Neotropics (Knutson et al. 1976, Marinoni and Knutson 1992).

Table 1. Matrix of 21 characters and nine taxa with *Dictyodes* as outgroup.

Characters	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1
Species																					
P. chilensis	0	0	0	0	0	0	0	1	0	2	1	0	0	0	0	1	0	0	0	0	0
P. guttularis	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0
P. lilloana	2	0	0	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0
P. iguassu	1	1	1	1	1	2	1	1	1	0	1	1	1	1	1	0	1	1	2	2	2
P. apicalis	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1
P. nubilipennis	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1
P. brasiliensis	1	1	1	1	1	1	1	1	?	?	1	1	1	1	1	0	1	1	2	2	2
P. bidentata	1	1	1	1	1	0	1	1	?	?	1	1	1	1	1	0	1	1	1	1	1
D. dictyodes	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	2	0	1	?

The characters 9 and 10 for *P. bidentata* and *P. brasiliensis* were coded as missing because females for these species are unknown.

The character 21 was coded as missing for *Dictyodes* because of the absence of the hypandrial process in it.

CHARACTERS AND CHARACTERS STATES USED IN THE ANALYSIS

The characters discussed in the next section have the same numbering as in the character matrix.

Character 01. Length of second aristal segment: (0) twice as long as wide; (1) three or more times as long as wide; (2) less than twice as long as wide.

Character 02. Shape of face in profile: (0) strongly concave; (1) gently concave.

Character 03. Cell r2+3. (0) without pale spots; (1) with pale spots.

Character 04. Vestiture of the male syntergosternite: (0) with setae; (1) without setae.

Character 05. Size of the humeral seta: (0) smaller than the notopleural seta; (1) subequal in size to the notopleural seta.

Character 06. Size of the ocellar seta: (0) about half the length of the postocellar seta; (1) similar in length to the postocellar seta; (2) about one-third the length of the postocellar seta.

Character 07. Presutural seta: (0) absent or vestigial; (1) present and subequal in size to the notopleural seta.

Character 08. Medio-apical process of the fifth sternite of the male: (0) absent; (1) present.

Character 09. Shape of the spermathecae (Fig. 2): (0) spherical or nearly so; (1) with the top and bottom flat to concave; (?) non-comparable.

Character 10. Anterior spermathecae projection (Fig. 2): (0) vestigial; (1) absent; (2) well developed.

Character 11. Facial black spot: (0) absent; (1) present.

Character 12. Posterior seta of the head: (0) well developed; not so developed.

Character 13. Number of dorsocentral setae: (0) 4; (1) 2.

Character 14. Prominent eyes: (0) absent; (1) present.

Character 15. Subvibrissal setae: (0) absent; (1) present.

Character 16. Arista: (0) plumose; (1) not plumose.

Character 17. Lunula: (0) vestigial; (1) present but poorly developed; (2) well developed.

Character 18. Process between the eyes: (0) vestigial; (1) present but poorly developed; (2) well developed.

Character 19. Shape of anterior extremity of the paramere (Fig. 1): (0) rounded; (1) pointed; (2) not so pointed.

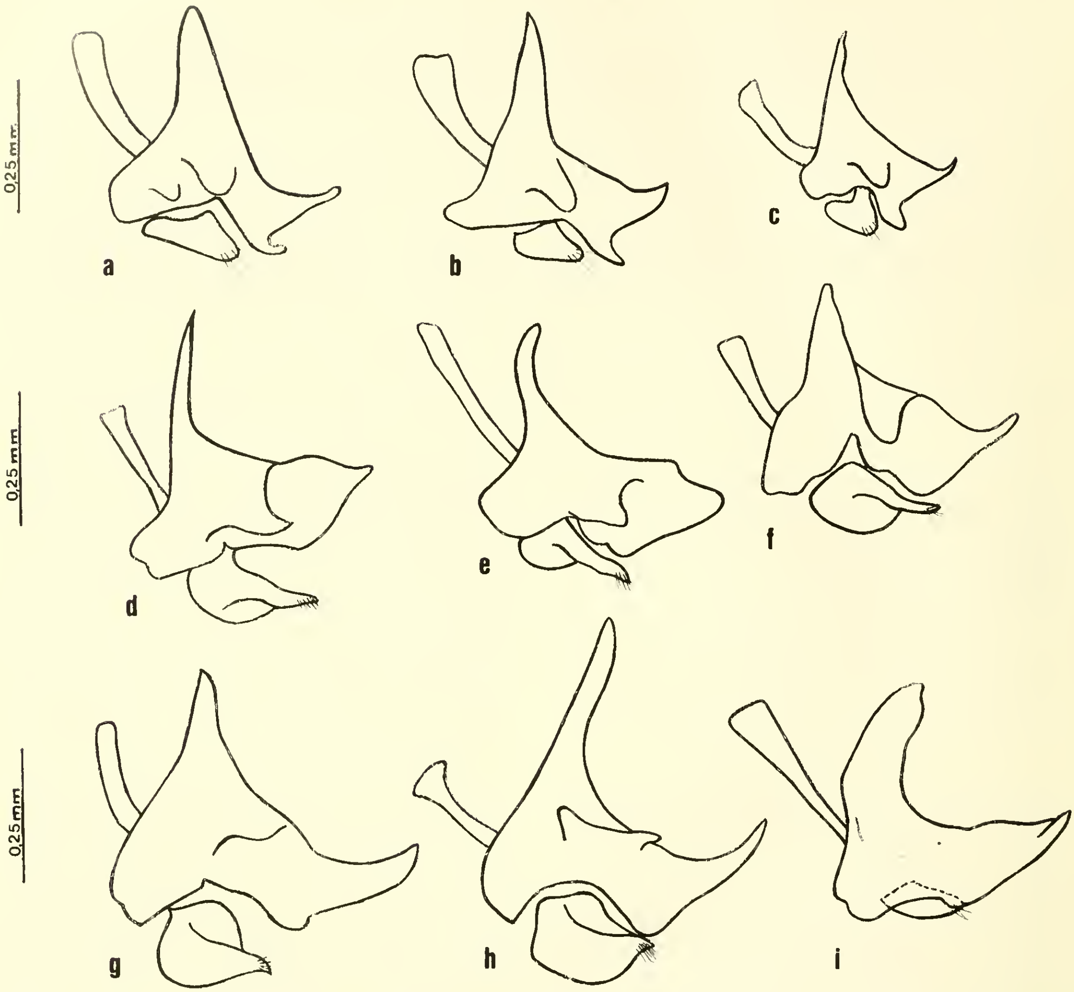


Fig. 1. Male terminalia shown laterally with aedeagus removed: a. *P. chilensis,* b. *P. guttularis,* c. *P. lilloana,* d. *P. apicalis,* e. *P. bidentata,* f. *P. nubilipennis,* g. *P. iguassu,* h. *P. brasiliensis,* i. *Dictyodes dictyodes.*

Character 20. Ventral surface of the gonopod (Fig. 1): (0) very sinuous; (1) sinuous, almost straight; (2) slightly sinuous.

Character 21. Hypandrial process (Fig. 1): (0) with the extremity pointed; (1) with the extremity rounded (finger-like); (2) almost straight, not finger-like.

RESULTS

The cladistic analysis resulted in a single, most-parsimonious cladogram with a length of 30 steps and a consistency index of 0.96. Two primary clades were formed at the base. The first clade consists of *P. chilensis* + *P. guttularis* and the second of *P. lilloana, P. apicalis, P. nubilipennis, P. iguassu, P. brasiliensis* and *P. bidentata.* The relationships among the species of the second clade were not well resolved, largely because females of *P. brasiliensis* and *P. bidentata* are unknown, and some character states for these species were coded as missing.

Steyskal (1950) defined two species groups using an intuitive method of analysis. *Protodictya chilensis, P. lilloana* and *P. guttu-*

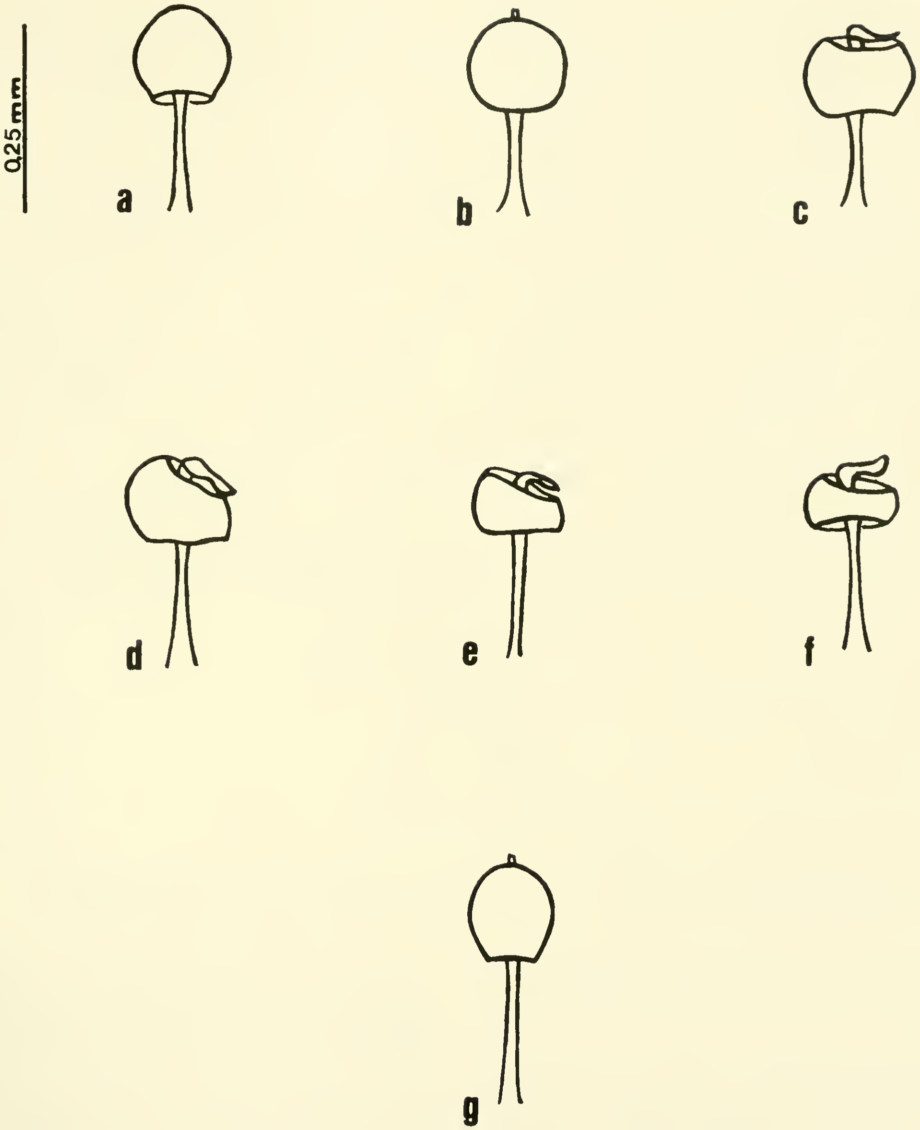


Fig. 2. Spermathecae of: a. *P. chilensis,* b. *P. guttularis,* c. *P. lilloana,* d. *P. apicalis,* e. *P. nubilipennis,* f. *P. iguassu,* g. *Dictyodes dictyodes.*

laris were placed in one group and *P. apicalis, P. iguassu, P. brasiliensis* and *P. nubilipennis* in another one. His groups are concordant in part with the monophyletic groups defined above.

Abercrombie (1970) presented the natural histories of the life stages of some Neotropical Sciomyzidae, including those of *P. chilensis, P. guttularis, P. lilloana* and *P. apicalis.* This author compared his results on *P. apicalis* with those of *P. hondurana* (= *P. nubilipennis*) presented by Neff and Berg (1961) and concluded that the larvae of both genera have similar behaviors. This evidence supports the presence of *P. apicalis* and *P. nubilipennis* in the same group of species. The larvae of both genera tolerate putrescent conditions and willingly feed on

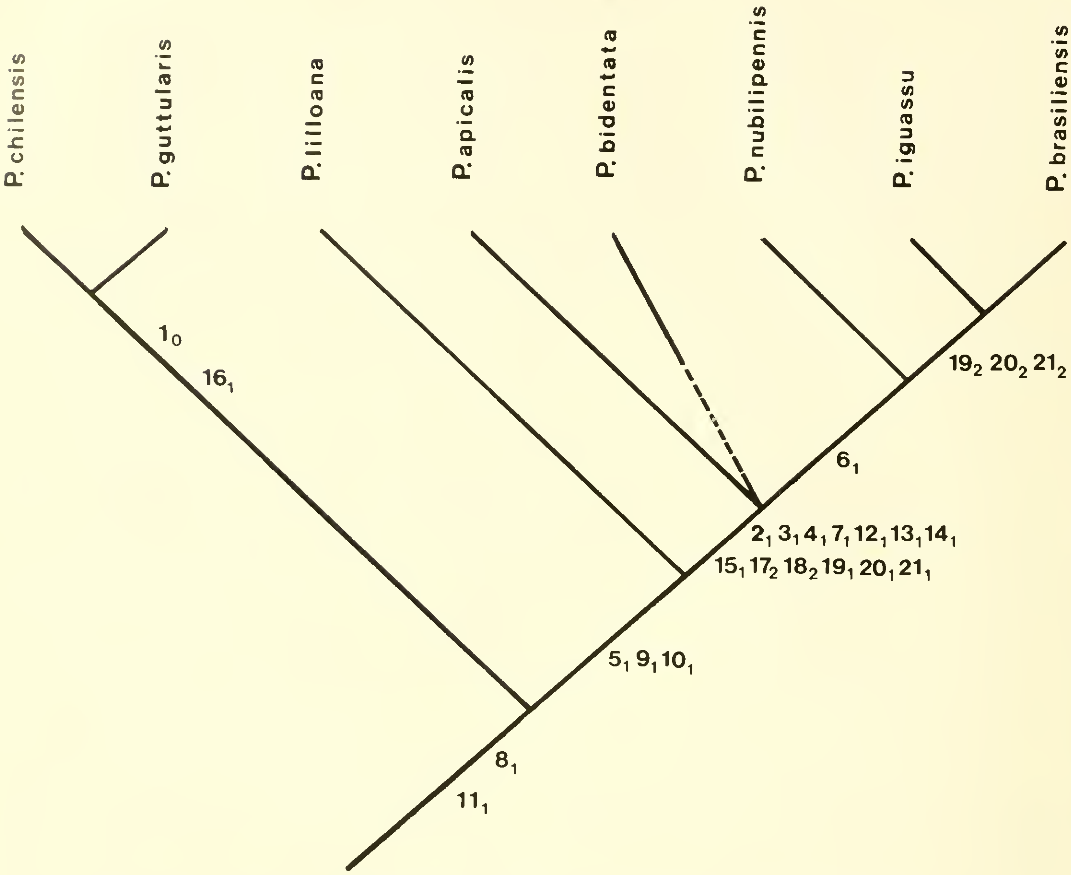


Fig. 3. Most-parsimonious cladogram generated from the analysis with *Dictyodes* as outgroup.

decayed snails, differing from the other three species: *P. chilensis, P. guttularis* and *P. lilloana.*

Synapomorphies that establish the monophyly of the first group (*P. chilensis* and *P. guttularis*) are the length of the second aristal segment that is twice as long as wide (character 1) and the absence of plumes in the arista (character 16) (Fig. 3).

The monophyly of the second clade is demonstrated by characters 9 and 10 respectively: shape of spermathecae (with the top and bottom flat to concave) and the development of the anterior spermathecae projection (well developed) (Fig. 2). The group formed by *P. apicalis, P. nubilipennis, P. iguassu, P. brasiliensis* and *P. bidentata* is established by characters 2, 3, 4, 5, 7, 12, 13, 14, 15, 17, 18, 19, 20 and 21 (Fig. 3). *P. iguassu* + *P. brasiliensis* are defined by character 19, concerning the shape of anterior extremity of the paramere; character 20, concerning the sinuosity of the ventral surface of the gonopod and character 21, about the shape of the extremity of the hypandrial process (Fig. 3).

The process of the fifth sternite of the male (character 8), present in *Protodictya* only, is a synapomorphy for the species of this genus, thereby establishing its monophyly.

ACKNOWLEDGMENTS

We are grateful to Drs. D. S. Amorim, M. S. Couri, W. N. Mathis, and L. Knutson for comments on the manuscript.

This paper is contribution number 715 from the Department of Zoology, Universidade Federal do Paraná (Curitiba).

LITERATURE CITED

Abercrombie, J. 1970. Natural History of Snail-killing Flies of South America (Diptera: Sciomyzidae Tetanocerini). Ph.D. thesis. Cornell Univ. 344 pp. Order No. 70-23, 095, Univ. Microfilms, Ann Arbor, Mich. (Diss. Abstr. Internat. B.) 31: 3456–3457.

Abercrombie, J. and C. O. Berg. 1978. Malacophagous Diptera of South America: Biology and immature stages of *Dictyodes dictyodes* (Sciomyzidae). Revista Brasileira de Entomologia 22(1): 23–32.

Farris, J. S. 1988. Hennig86 Reference, Version 1.5. Port Jefferson Station, New York.

Griffiths, G. C. D. 1972. The phylogenetic classification of Diptera Cyclorrapha, with special reference to the structure of the male postabdomen. Series Entomologica, 8. Dr. W. Junk, N.V., The Hague.

Knutson, L. V., G. C. Steyskal, J. Zuska, and J. Abercrombie. 1976. 64. Family Sciomyzidae. *In* Papavero, N., ed., A Catalogue of the Diptera of the Americas South of the United States. Mus. Zool. Univ. São Paulo. 24 pp.

Marinoni, L. and L. V. Knutson. 1992. Revisão do Gênero Neotropical *Protodictya* Malloch, 1933. Revista Brasileira de Entomologia 36(1): 25–45.

Neff, S. E. and C. O. Berg. 1961. Observations on the immature stages of *Protodictya hondurana* (Diptera: Sciomyzidae). Bulletin of the Brooklyn Entomological Society 56: 46–56.

Steyskal, G. C. 1950. The genus *Protodictya* Malloch (Diptera, Sciomyzidae). Proceedings of the Entomological Society of Washington 52(1): 33–39.

Steyskal, G. C. and L. Knutson. 1975. Key to the genera of Sciomyzidae (Diptera) from the Americas South of the United States, with descriptions of two new genera. Proceedings of the Entomological Society of Washington 77: 274–277.

Wiley, E. O. 1981. Phylogenetics: The Theory and Practice of Phylogenetic Systematics. Wiley, New York. 439 pp.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 418–424

DESCRIPTION OF A NEW *RHAGOLETIS* SPECIES FROM TROPICAL MEXICO (DIPTERA: TEPHRITIDAE)[1]

Vicente Hernández-Ortiz

Instituto de Ecología, A. C. Apartado Postal 63, Xalapa, Veracruz 91000 Mexico.

Abstract.—A new species of *Rhagoletis* from the humid tropics in Mexico is described. Specimens of ***Rhagoletis turpiniae***, n. sp., were collected in Xalapa and Los Tuxtlas, Veracruz, Mexico. Based on morphological characteristics of male and female terminalia, this new species is placed in the *cingulata* species group. Information on parasitoids and host plants of *R. turpiniae* is included, and two species of the plant family Staphyleaceae are recorded for the first time as a host for the genus *Rhagoletis* Loew.

Resumen.—En el presente trabajo se describe ***Rhagoletis turpiniae*** n. sp. con material procedente de dos localidades del estado de Veracruz, México (Xalapa y Los Tuxtlas). Esta nueva especie queda incluída en el grupo de especies *cingulata* con base principal en las características morfológicas de los genitales tanto de machos como hembras; se provee información detallada sobre sus plantas huéspedes y parasitoides asociados, destacando que por primera ocasión se registran dos especies de la familia Staphyleaceae como huéspedes del género *Rhagoletis* Loew.

Key Words: Tephritidae, *Rhagoletis,* new species, host plants, parasitoids

The genus *Rhagoletis* comprises about 57 species which are distributed in the Palearctic, Nearctic, and Neotropical regions, showing high preferences for temperate zones (Bush 1966, Foote 1984). Thirty-seven of all known *Rhagoletis* species (including the recently described *R. electromorpha* Berlocher (1984), and *R. ramosae* Hernández (1985)), are found in the American continent. According to the supraspecific classification by Bush (1966) and Foote (1981), *Rhagoletis* is represented by 10 species groups in the Nearctic and Neotropical regions. The Nearctic and Holarctic *pomonella, cingulata, tabellaria, ribicola,* and *alternata* species groups mainly are distributed in North America, of which only the species *R. pomonella* (Walsh) and *R. cingulata* (Loew) occur in Mexico; the *suavis* group is represented by five of the six known species, including two endemic ones (*R. zoqui* Bush and *R. ramosae* Hernández). The *nova, psalida, ferruginea,* and *striatella* species groups contain about 50% of all American species. They occur exclusively in Central and South America, except for *R. striatella* Wulp which is present in Mexico and the United States. In this paper, I describe a new species of the *cingulata* group, discuss the relationships between the species of this group, and present information about the host plants and parasitoids of *Rhagoletis turpiniae,* n. sp.

---

[1] This paper is a contribution to project "Sistemática, Biología y Ecología de los Diptera Tephritoidea de México II," supported by the CONACYT with reference number D112-903509.

MATERIALS AND METHODS

The description of *Rhagoletis turpiniae*, n. sp., is based on 99 adult specimens examined. Some of these specimens were collected in light traps, and others reared from fruits of *Turpinia insignis* (H. B. & K.) Tul and *T. occidentalis breviflora* Croat proceeding from two localities in the state of Veracruz, Mexico (Xalapa and Los Tuxtlas). Botanical material was compared with herbarium samples and identified by herbarium personnel at the Estación de Biología Los Tuxtlas (Refugio Cedillo T., MEXU), and the Dirección de Vegetación y Flora of Instituto de Ecología (Gonzalo Castillo, XAL). I follow the morphological terminology of McAlpine (1981) and Norrbom and Kim (1988a). Acronyms for institutions used in the text are as follows: CNC—Canadian National Collection, Ottawa; UNAM—Instituto de Biología de la Universidad Nacional Autónoma de México, México D.F.; IEXV—Instituto de Ecología, Xalapa, Veracruz; MSU—Michigan State University, East Lansing; USNM—National Museum of Natural History, Smithsonian Institution, Washington, D.C.

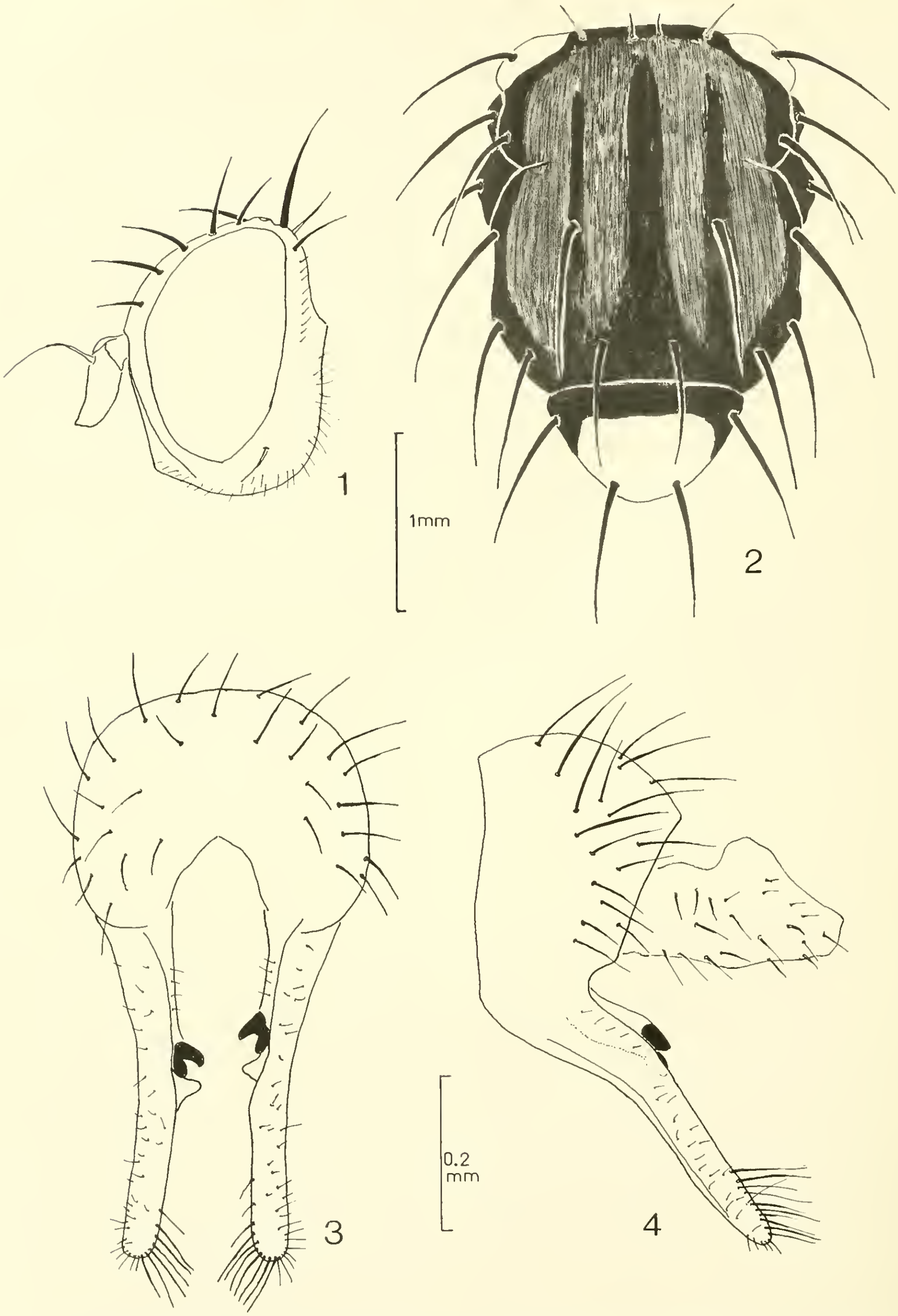
Rhagoletis turpiniae Hernández, NEW SPECIES

(Figs. 1–10)

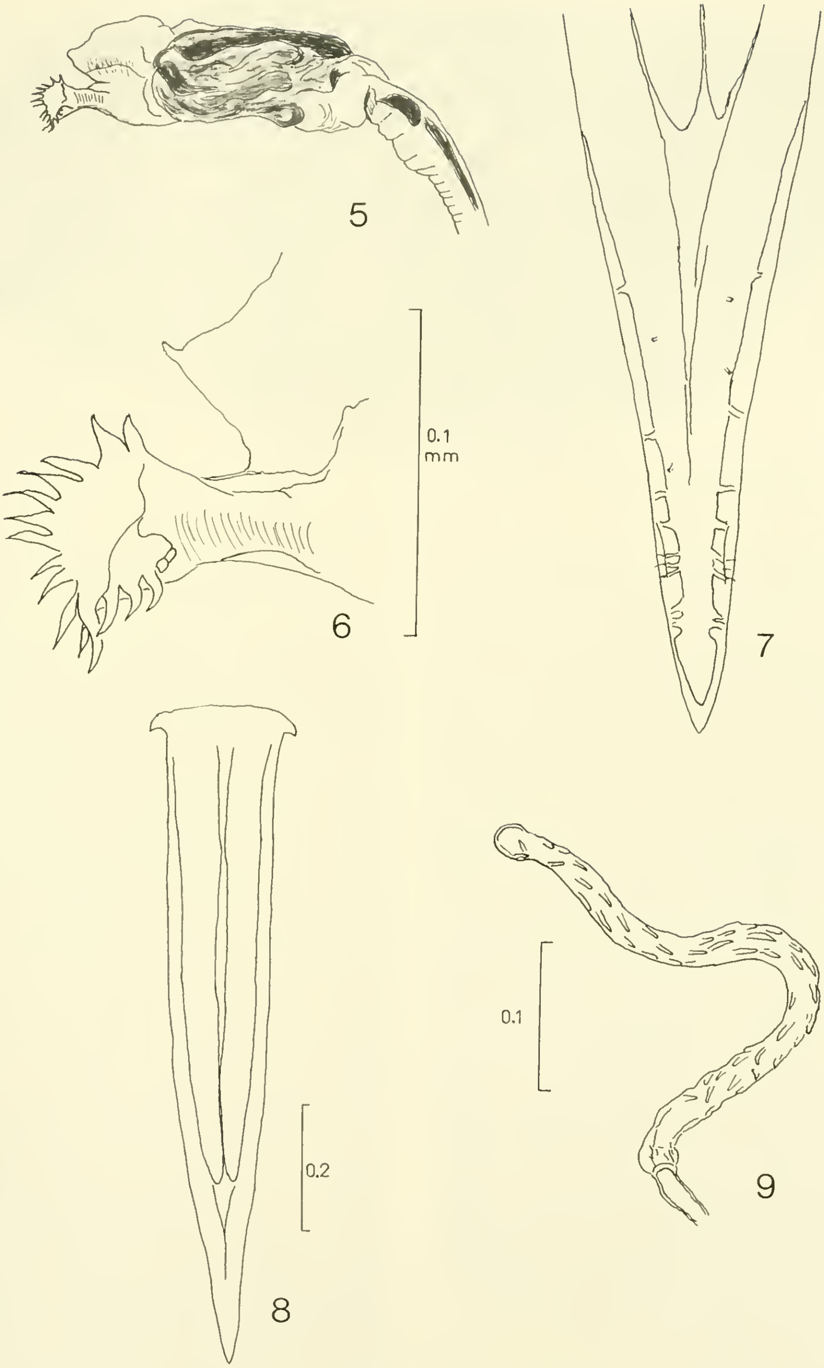
Type data: Holotype ♂ (IEXV) MEXICO: Veracruz, Xalapa, Jardín Botánico 1280 m, 10–15-VIII-1990, V. Hernández, R. Pérez and J. Valenzuela colls. "Ex-larva en frutos de *Turpinia insignis.*" Paratypes. Same data as holotype (17 ♂♂ and 23 ♀♀); 20–25-VII-1990 (6 ♂♂ and 10 ♀♀); MEXICO: Veracruz, Est. Biol. Los Tuxtlas 160 m, 14-VI-1990, R. Pérez and J. Valenzuela colls. "Ex-larva en frutos de *Turpinia occidentalis breviflora*" (3 ♂♂ and 5 ♀♀); same data as paratypes from Los Tuxtlas except not reared from host plant: 21–28-II-1985, A. Ibarra coll. (sex unknown); 12-III-1985, A. Ibarra and E. Ramírez colls. (2 ♂♂); 23-IV-1985, A. Ibarra and E. Ramírez colls. (3 ♀♀); 18–21-V-1985, A. Ibarra and E. Ramírez colls. (12 ♂♂ and 15 ♀♀); 9–16-VI-1986, A. Ibarra coll. (3 ♂♂ and 1 ♀); 2-VII-1987, V. Hernández coll. (2 ♀♀). 3 ♂♂ and 3 ♀♀ in CNC; 5 ♂♂ and 5 ♀♀ in UNAM; 3 ♂♂ and 3 ♀♀ in MSU; 3 ♂♂ and 3 ♀♀ in USNM; all other paratypes deposited in IEXV.

Diagnosis: Body blackish with most of head yellow; third antennal segment pointed at apex. Scutal microtrichial pattern consisting of four longitudinal bars all connected anteriorly; postpronotum white, pleuron entirely black except for a whitish band just below notopleuron. Fore femur wholly yellow but mid and hind femora blackish. Wing pattern with all transverse bands present, including anterior and posterior apical bands which are separated for a hyaline fascia that usually extends beyond vein R4+5; apical hyaline spot at end of R2+3 usually absent or extremely small in some specimens.

Description: Head yellow with frons and antenna reddish, face nearly straight in lateral view, ocellar tubercle slightly blackish. Head macrosetae black except postocellars and genal bristles yellow (Fig. 1); antenna about 0.6 times as long as face, apex of third segment sharply pointed. Thorax: mesonotum 2.37–2.62 mm long (Fig. 2), scutum with fine pollinose microtrichia yellow golden in pattern of four longitudinal bars joined anteriorly, black stripes between them slender; scutal setulae yellow; postpronotum whitish; scutellum with quadrate whitish medial spot, base black, including area of basal scutellar setae; halteres whitish; subscutellum and mediotergite black. Pleura entirely black except for whitish band immediately below notopleuron. Foreleg entirely yellow including coxa; midleg with femur blackish except yellow apex, tibia and tarsus mostly yellowish; hindleg with femur and tibia blackish, but tarsus yellowish. Wing: Length 3.7–4.9 mm (Fig. 10); all transverse bands present; sub-basal band slender and extended to inferior apex of cell bcu; discal and subapical bands wider than



Figs. 1–4. *Rhagoletis turpiniae.* 1, Lateral view of head. 2, Dorsal view of mesonotum. 3, Posterior view of male terminalia (proctiger omitted). 4, Same in lateral view.



Figs. 5–9. *Rhagoletis turpiniae.* 5, Distiphallus (glans). 6, Apex of distiphallus. 7, Aculeus tip. 8, Aculeus (ovipositor). 9, Spermathecae.

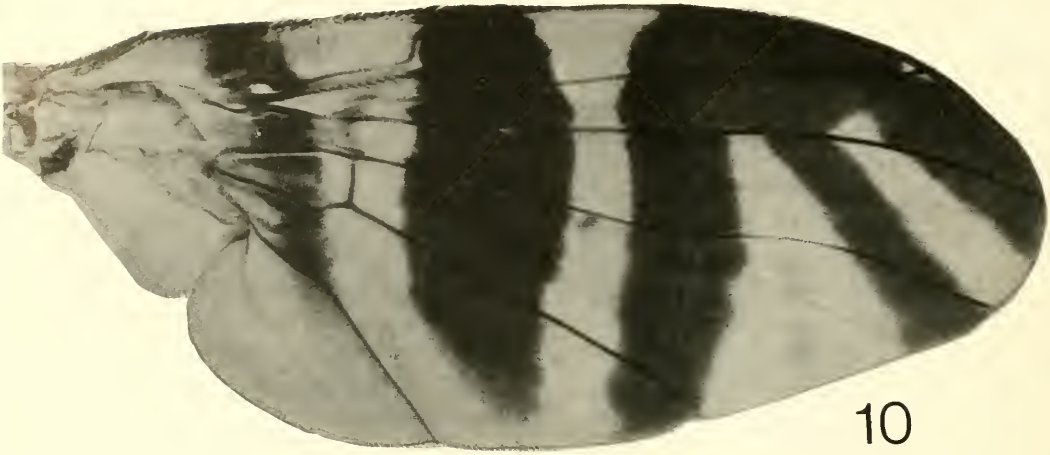


Fig. 10. Wing pattern of *Rhagoletis turpiniae.*

sub-basal and separated at posterior wing margin; anterior and posterior apical bands present and broadly joined to subapical band; accessory costal band absent. Hyaline fascia between apical bands usually as wide as these bands and usually (85% of specimens) extended anteriorly slightly beyond vein R4+5. Abdomen: Mainly black, except for whitish yellow transverse bands at posterior margins of tergites II–IV on male and II–V on female; syntergosternite VII of female entirely black and 1.5 times longer than preceding tergite; aculeus (ovipositor) 1.07–1.12 mm long (Figs. 7, 8) and sharply pointed at apex; spermathecae about 0.37–0.42 mm long, very elongated, with relatively few papillae on surface (Fig. 9). Male terminalia with epandrium blackish, outer surstylus very long and slender, apically rounded and with mesal tuft of long setae; prensisetae situated near midlength of outer surstylus (Figs. 3, 4); distiphallus (glans) with inferior apical appendage with a fringe of slender lobes at apical end (Figs. 5, 6).

Distribution: Known only from the state of Veracruz, Mexico.

Etymology: The name *turpiniae* indicates that this species breeds on plants of the genus *Turpinia* (Staphyleaceae).

Remarks and Phylogenetic Relationships

Rhagoletis turpiniae appears to belong in the *cingulata* species group which also includes *R. cingulata* (Loew), *R. indifferens* Curran, *R. osmanthi* Bush and *R. chionanthi* Bush. All of these species have the following characteristics: 1) wing pattern with sub-basal, discal and subapical transverse bands present, but accessory costal band absent; 2) outer surstylus very elongated with apical tuft of long setae; 3) distiphallus with distal fluted appendage with numerous lobes; 4) spermathecae elongated; 5) third antennal segment pointed at apex; 6) postocellar setae yellow. At least the second and third characters are autapomorphic for the *cingulata* group.

Rhagoletis indifferens is the only species whose populations are allopatric (western USA) from the other three species, which have sympatric populations (eastern and southeastern USA). Their minimal morphological differences make it hard to differentiate them. However, *R. turpiniae* can be separated from all 4 other species of the *cingulata* group by the following characters: 1) in *R. chionanthi, R. osmanthi* and *R. cingulata* all femora are predominantly or entirely yellow, and in *R. indifferens* all the femora are blackish; but in *R. turpiniae* the fore femur is yellow, and the mid and hind femora blackish; 2) the hyaline mark at the end of R2+3, which is always present and often large in the other species, is reduced or absent in *R. turpiniae*; and 3) the hyaline fascia between the anterior and posterior apical bands is not extended anteriorly beyond vein R4+5 in the other species as it usually is in *R. turpiniae*.

HOST PLANT RELATIONSHIPS

Most American *Rhagoletis* species are associated with plants in the families Rosaceae, Juglandaceae, and Solanaceae; less frequently with Cornaceae, Ericaceae, Cupressaceae, Saxifragaceae, or Berberidaceae (Berlocher and Bush 1982). Two species of the *cingulata* group (*R. cingulata* and *R. indifferens*) breed in species of *Prunus* (Rosaceae) whereas another two species (*R. chionanthi* and *R. osmanthi*) have been reared from species of *Chionanthus* and *Osmanthus* (Oleaceae). *Rhagoletis turpiniae* was found in fruits of two species of *Turpinia* (Staphyleaceae), a genus which occurs in tropical regions of America. Previously, a species of this genus was recorded in Panama as a host for species of the tropical genus *Anastrepha* (*T. occidentalis* (= *paniculata* Vent.) for *A. canalis* Stone, *A. fraterculus* (Wiedemann) and *A. turpiniae* Stone (Stone 1942, Norrbom and Kim 1988b)), but this is the first time a species of this family is recorded as a host plant for *Rhagoletis*. Larvae of *R. turpiniae* were reared from fruits of *Turpinia insignis* (H. B. & K.) Tul, commonly known as "huevo de gato," which is distributed from southern Mexico to Central America and the Antilles. A second sample was obtained from *Turpinia occidentalis breviflora* Croat, which is distributed from southern Mexico to Colombia and the Antilles. The first is an element of tropical deciduous forests (800–2000 m alt) and the latter is present in tropical rain forests (from sea level to 500 m alt) according to Sosa (1988).

Rhagoletis species are mainly distributed in temperate regions where they exhibit winter diapause; however, weather conditions at Los Tuxtlas are not extreme. *R. turpiniae* is a univoltine species presenting a long pupal period, due to *Turpinia* fruiting during about two months of the year. This reenforces that biological cycle adaptations in *Rhagoletis* species are strongly influenced by the fruiting phenology of the host.

PARASITOIDS

In continental America, some natural enemies have been reported for *Rhagoletis*, such as *Opius, Diachasma,* and *Biosteres* species (Braconidae, Hymenoptera). In the *cingulata* group, *Diachasma ferrugineum* (Gahan), *Opius frecuens* Fischer and *Biosteres melleus* (Gahan) parasitize *R. cingulata*; *Diachasma muliebre* (Muesebeck) and *Opius rosicola* Muesebeck attack *R. indifferens* (Wharton and Marsh 1978); whereas the other species of the group have no parasitoid records. In this study some parasitoids were recovered from pupae of *R. turpiniae*. The most common was an undescribed species of *Biosteres* near *sublaevis* Wharton (in the *mexicana* species group) reared from larvae in fruits of *Turpinia insignis* (Xalapa, Veracruz). One female of *Opius hirtus* Fischer was reared from larvae in fruits of *Turpinia occidentalis breviflora* (Los Tuxtlas); this represents the first record for this species attacking a *Rhagoletis* species, although previously it has been recorded from species of *Anastrepha*. Two specimens of a *Dicerataspis* species and *Ganaspis carvalhoi* (Dettmer) of Cynipidae (Hymenoptera) were also recovered.

ACKNOWLEDGMENTS

I am grateful to Gonzalo Castillo (Inst. Ecología, Xalapa) and Refugio Cedillo T. (Est. Biol. Los Tuxtlas) for determinations of botanical samples of Staphyleaceae; to

Robert A. Wharton (Texas A & M University, College Station) for identifying all parasitoid species; to Rogelio Pérez A. and Jorge Valenzuela (Inst. Ecología, Xalapa) for technical assistance on collecting fruits in both type localities. I thank Adolfo Ibarra and Enrique Ramírez for collecting the first specimens of this species at Los Tuxtlas. I also thank Allen L. Norrbom (Syst. Ent. Lab., USDA, Washington, D.C.) and Martin Aluja (Inst. Ecología, Xalapa, Veracruz) for valuable reviews of earlier versions of the manuscript.

LITERATURE CITED

Berlocher, S. H. 1984. A new North American species of *Rhagoletis* (Diptera: Tephritidae), with records of host plants of *Cornus*-infesting *Rhagoletis*. Journal of the Kansas Entomological Society 57(2): 237–242.

Berlocher, S. H. and G. L. Bush. 1982. An electrophoretic analysis of *Rhagoletis* (Diptera: Tephritidae) phylogeny. Systematic Zoology 31(2): 136–155.

Bush, G. L. 1966. The taxonomy, cytology and evolution of the genus *Rhagoletis* in North America (Diptera: Tephritidae). Bulletin of Museum of Comparative Zoology 134(11): 431–562.

Foote, R. H. 1981. The genus *Rhagoletis* Loew south of the United States (Diptera: Tephritidae). United States Department of Agriculture Technical Bulletin 1607. 75 pp.

———. 1984. Family Tephritidae (Trypetidae), pp. 66–148. *In* Soos, A. and L. Papp, eds., Catalogue of Palearctic Diptera, Vol. 9. Micropezidae-Agromyzidae, Budapest.

Hernández-Ortiz, V. 1985. Descripción de una nueva especie mexicana del género *Rhagoletis* Loew (Diptera: Tephritidae). Folia Entomológica Mexicana 64: 73–79.

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, coords., Manual of Nearctic Diptera, Vol. 1. Agriculture Canada, Monograph No. 27. Ottawa.

Norrbom, A. L. and K. C. Kim. 1988a. Revision of the *schausi* group of *Anastrepha* Schiner (Diptera: Tephritidae), with a discussion of the terminology of the female terminalia in the Tephritoidea. Annals of the Entomological Society of America 81: 164–173.

———. 1988b. A list of the reported host plants of the species of *Anastrepha* (Diptera: Tephritidae). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Hyattsville, MD. 114 pp.

Sosa, V. 1988. Staphyleaceae. *In* Flora de Veracruz. Publicación del Instituto Nacional de Investigaciones sobre Recursos Bióticos, Fascículo 57. 11 pp.

Stone, A. 1942. The fruitflies of the genus *Anastrepha*. United States Department of Agriculture, Miscellaneous Publication 439. 112 pp.

Wharton, R. A. and P. M. Marsh. 1978. New world Opiinae (Hymenoptera: Braconidae) parasitic on Tephritidae (Diptera). Journal of the Washington Academy of Sciences 68(4): 147–167.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 425–434

ANALYSIS OF KNOWN AND NEW HOST RECORDS FOR *TEPHRITIS* FROM CALIFORNIA, AND DESCRIPTION OF A NEW SPECIES, *T. JOANAE* (DIPTERA: TEPHRITIDAE)

RICHARD D. GOEDEN

Department of Entomology, University of California, Riverside, California 92521.

Abstract.—Thirty-three new rearing records are reported for six of the 12 known species of *Tephritis* known from California, and for the newly described species, *T. joanae* Goeden. Host records remain unknown for two species. The host-plant relations of 11 species for which hosts now have been reported are analyzed and compared for the first time. Six species apparently are monophagous or nearly monophagous, being restricted to a single host genus or known from one or few hosts. Five generalist species that attack hosts in more than one tribe, but are confined to Asteraceae, also are identified and discussed. Some unconfirmed host records for generalist, apparent generalist, and specialist species are questioned.

The host plants of *Tephritis* in California represent four tribes of Asteraceae: Anthemideae, Astereae, Helenieae, and Senecioneae, when questionable host records are discounted. Nine of the 11 species of *Tephritis* in California for which hosts are recorded attack at least one species in the tribe Astereae, the largest of 12 tribes of Asteraceae in California. Five California *Tephritis* may attack only Astereae.

Key Words: Insecta, *Tephritis,* Tephritidae, Asteraceae, flower-head feeders, host-plant specificities, monophagy, gall-formers, resource utilization

Neaspilota, Paroxyna, Tephritis, Trupanea, and *Urophora* (Diptera: Tephritidae) are the most commonly encountered genera among the native, nonfrugivorous, fruit flies of California (Goeden, unpublished data; Foote and Blanc 1963, Freidberg and Mathis 1986). California host-plant records for *Neaspilota, Trupanea,* and *Urophora* were augmented and analyzed by Goeden (1985, 1987, 1989, 1992). Goeden and Blanc (1986) provided new host records for *Paroxyna* from California. This paper reports new rearing records acquired since 1980 and analyzes these and published host records for native California species of *Tephritis.*

MATERIALS AND METHODS

Materials and methods used were described by Goeden (1985, 1992). Voucher specimens of tephritids reside in my research collection; pressed voucher specimens of uncommon or otherwise poorly represented host-plant species were deposited in the Herbarium of the University of California, Riverside. The holotype, allotype, and six paratypes of each sex of the new species, *Tephritis joanae* Goeden, described herein have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. Six additional paratypes of each sex also reared from *Haplopappus pinifolius* Gray were deposited in the collection of the California Academy of Sciences, and a pair was given to F. L. Blanc for deposit in his collection in thanks for his many past favors.

RESULTS

New rearing records are listed below for seven of 12 species of *Tephritis* known from California (Foote and Blanc 1963, 1979, Foote et al. 1993), including *Tephritis baccharis* (Coquillett), transferred to the genus by Stoltzfus (1977). Host records unreported by Wasbauer (1972), Goeden (1988a), Jenkins and Turner (1989), and Goeden and Headrick (1991a) are listed by genera and species in the manner of Goeden (1992). Unless otherwise noted, all flies were reared from ca. 1-liter samples of mature flower heads. Among multiple samples of a particular newly reported host-plant species, only the sample from which the most individuals of each fly species was recovered is reported. The plant nomenclature used largely follows Munz and Keck (1959) and Munz (1968, 1974). The insect nomenclature follows Foote (1960) and Foote and Blanc (1963, 1979), as amended by Stoltzfus (1977), and McAlpine (1981). Rearing records for the flies and their host plants are listed alphabetically.

Tephritis araneosa (Coquillett)

New host genera: Baccharis, Haplopappus.

New host records: Artemisia californica Lessing; 25 ♂ and 27 ♀; N section, Los Padres Nat. Forest at 610 m, Monterey Co.; 18.iv.1990. *Artemisia douglasiana* Besser; 44 ♂ and 76 ♀; above Perazo Meadow, NW of Truckee at 2000 m, Tahoe Nat. Forest, Sierra Co.; 10.ix.1986. *Artemisia tridentata* Nuttall; 1 ♀; SW of Monitor Pass at 2440 m, Toiyabe Nat. Forest, Alpine Co.; 10.ix.1992. *Baccharis sarothroides* Gray; 1 ♂; Whitewater Canyon, Riverside Co.; 15.x.1987. *Chrysothamnus parryi* (Gray) Greene; 1 ♂ and 8 ♀; SE of Barney Mountain at 1600 m, Lassen Nat. Forest, Shasta Co.; 24.viii.1989. *Chrysothamnus teretifolius* (Durand and Hilgard) Hall; 1 ♂ and 1 ♀; Campito Meadow, Inyo Nat. Forest, Mono Co.; 16.ix.1991. *Chrysothamnus viscidiflorus* (Hooker) Nuttall; 9 ♂ and 2 ♀; Cedar Flat, W of Westgard Pass at 2200 m, Inyo Nat. Forest, Inyo Co.; 29.vii.1986. *Haplopappus bloomeri* Gray; 2 ♂ and 44 ♀; Niagara Creek Campground at 1900 m, Stanislaus Nat. Forest, Tuolemne Co.; 8.vii.1988. *Haplopappus cuneatus* Gray; 16 ♂ and 17 ♀ reared; Lark Canyon, San Diego Co.; 16.x.1980.

Tephritis californica Doane

New host record: Baccharis sarothroides Gray; 3 ♂ and 1 ♀; W of Battle Mountain, S of San Diaguiano River and Lake Hodges at 120 m, San Diego Co.; 27.ix.1990.

Tephritis joanae n. sp.
(description follows)

New host genera: Haplopappus, Senecio.

New host records: Haplopappus ericoides (Lessing) Hooker and Arnott; 10 ♂ and 8 ♀; Orcutt, Santa Barbara Co.; 12.xi.1980. *Haplopappus pinifolius* Gray; 210 ♂ and 196 ♀ reared; Kitchen Creek, Cleveland Nat. Forest, San Diego Co.; 7.x.1981. *Senecio douglassii* (deCandolle); 28 ♂ and 28 ♀; La Posta, San Diego Co.; 15.x.1980.

Tephritis leavittensis Blanc

New host genera: Arnica, Artemisia.

New host records: Arnica amplexicaulis Nuttall; 182 ♂ and 257 ♀; Middle Canyon, E side of White Mountain at 2500 m, Inyo Nat. Forest, Esmeralda Co., Nevada (this location is very close to the California border); 25.vii.1989. *Arnica chamissonis* Lessing; 51 ♂ and 61 ♀; Campito Meadow at 3230 m on White Mountain, Inyo Nat. Forest, Mono Co.; 19.viii.1987. *Arnica longifolia* deCandolle; 5 ♂ and 13 ♀; Deadman Creek, W of Sonora Pass at 2800 m, Tuolemne Co.; 8.ix.1988. *Arnica sororia* Greene; 25 ♂ and 35 ♀; Deadman Creek at 2500 m, Inyo Nat. Forest, Mono Co.; 9.ix.1986. *Ar-*

temisia spinescens D. C. Eaton; ♀; Deep Spring Valley at 1660 m, Inyo Co., 23.iv.1992.

Tephritis ovatipennis **Foote**

New host genera: Achillea, Artemisia, Hulsea, Machaeranthera, Solidago.

New host records: Achillea millefolium L.; 1 ♂; Fish Creek Meadow, North section, San Bernardino Nat. Forest, San Bernardino Co.; 17.v.1989. *Artemisia ludoviciana* Nuttall; 1 ♂; Lower Deadman Creek Campground, Inyo Nat. Forest, Mono Co.; 21.vii.1987. *Artemisia tridentata* Nuttall; 2 ♀; Horse Meadow Campground, Sequoia Nat. Forest, Tulare Co.; 8.ix.1986. *Erigeron glaucus* Ker; 44 ♂ and 38 ♀; Ocean View Blvd., Pacific Grove, Monterey Co.; 9.iv.1987. *Erigeron lonchophyllus* Hooker; 3 ♂ and 2 ♀; Deadman Creek at 2400 m; Inyo Nat. Forest, Inyo Co.; 21.vii.1987. *Hulsea californica* Torrey and Gray; 171 ♂ and 164 ♀; atop Liebre Mountain, Angeles Nat. Forest, NW Los Angeles Co.; 14.vii.1982. *Hulsea vestita* Gray; 41 ♂ and 60 ♀; Deadman Creek at 2400 m, Inyo Nat. Forest, Inyo Co., 21.vii.1987. *Machaeranthera canescens* (Pursh) Gray; 2 ♂ and 1 ♀; above Mahogany Creek at 2300 m, Sequoia Nat. Forest (N section), Tulare Co.; 7.vii.1984. *Solidago canadensis* L.; 9 ♂ and 9 ♀; Dead Man Creek at 2500 m, Inyo Nat. Forest, Mono Co.; 9.ix.1986. *Solidago confinis* Gray; 4 ♂; Antelope Spring, Deep Spring Valley, Inyo Co.; 15.ix.1982.

Tephritis signatipennis **Foote**

New host genus: Aster.

New host record: Aster integrifolius Nuttall; 8 ♀; E of Ebbetts Pass at 2360 m, Toiyabe Nat. Forest, Alpine Co.; 30.vii.1992.

Tephritis stigmatica **(Coquillett)**

New host genus: Haplopappus.

New host records: Haplopappus propinquus Blake; 1 ♀; Mountain Springs Pass, SE San Diego Co.; 7.x.1987. *Haplopappus venetus* (von Humboldt) Blake; 1 ♂; Cardiff-by-the-Sea, San Diego Co.; 15.x.1980. *Senecio clarkianus* Gray; 3 ♂; Poison Meadows, 16 km from Bass Lake at 2000 m, Sierra Nat. Forest, Madera Co.; 16.viii.1988. *Senecio scorzonella* Greene; 2 ♀; Kaiser Pass at 2700 m, Sierra Nat. Forest, Fresno Co.; 17.viii.1988. *Senecio serra* Hooker; 6 ♂ and 7 ♀; S of Sawmill Flat, above N Fork Kings River at 2300 m, Sierra Nat. Forest, Fresno Co.; 22.vi.1989.

Discussion

Since 1980, I have reared nine of the 13 species of *Tephritis* currently reported from California (Foote and Blanc 1963, 1979, Foote et al. 1993) or newly described herein. Among the nine species from California reared by me or others (Wasbauer 1972), only *T. baccharis* is known to be a strictly monophagous, obligate gall former (Jenkins and Turner 1989, Goeden and Headrick 1991a). A single male specimen of *T. webbii* Doane was reared from a gall in the flower head of "goldenrod," *Solidago* sp. (Quisenberry 1951, Wasbauer 1972), but this is all that is known about the biology and host relationships of this species. *Tephritis stigmatica* also forms galls on branches and stems of *Senecio douglassii* (Goeden 1988a), and additionally infests the flower heads of this host, which are not galled (Foote and Blanc 1963, Tauber and Toshi 1965, Wasbauer 1972); otherwise, it presumably only has been reared from ungalled flower heads of several alternate host species (Foote and Blanc 1963, Tauber and Toshi 1965, Wasbauer 1972, and the present paper).

Tephritis arizonaensis Quisenberry was reported as reared variously from "terminal galls," "stem tip mines," and "female flowers" of *Baccharis sarothroides* Gray by Jenkins and Turner (1989); whereas, Goeden et al. (1993) found no galling, only branch-tip mining for spring (F_1) generations, and female *and* male flower head-feeding for fall (F_2) generations of this tephritid on this same host in southern California.

The "unpublished" host record for *T. sig-*

natipennis Foote from *Machaeranthera canescens* in Wasbauer (1972) has not been confirmed. As reported above, I have reared only *T. ovatipennis* from *M. canescens.* My recent rearing record from *Aster integrifolius* reported above was confirmed by rearing 2 ♀ from another sample of heads from the same host collected W of Sonora Pass at 2580 m, Toiyabe Nat. Forest, Alpine Co., again on 29.vii.1992.

The remaining four species of *Tephritis* for which host plants are known, i.e. *T. araneosa, T. californica, T. candipennis,* and *T. ovatipennis,* presumably only have been reared from flower heads; although, most details of their life histories, including whether gall formation also is involved, are unknown (Foote and Blanc 1963, 1979, Wasbauer 1972, Jenkins and Turner 1989). The life histories of several of these species currently are under study by me and my associates. Host plants still are unknown for the two remaining species of *Tephritis* reported from California: *T. labecula* Foote and *T. rufipennis* Doane (Wasbauer 1972, Foote et al. 1993).

The host specificities of the following florivorous species are assessed as oligophagous, i.e. attacking more than one genus in a single tribe, or as generalists, i.e. attacking different genera belonging to more than one tribe of Asteraceae (Goeden 1985, 1992):

Tephritis araneosa is an apparent generalist now known from eight genera and 14 species of hosts in the tribes Anthemideae, Astereae, and Senecioneae (Foote and Blanc 1963, 1979, Wasbauer 1972, and the present study). However, this interpretation discounts the host record for *Poa* sp. in the Graminae (Wasbauer 1972), from which no Tephritidae are otherwise known (Freidberg and Kugler 1989), as highly unlikely and probably erroneous. I have confirmed the host records in Wasbauer (1972) for *Artemisia dracunculus* L. and *Chrysothamnus nauseosus* (Pallas) Britton, but as yet have not confirmed records from *Arnica chamissonis* Lessing, *Erigeron pumilus* Nuttall, or *Grindelia* sp. The record for *A. chamissonis* in Wasbauer (1972) probably applies instead to *T. laevittensis,* shown in the present study to be closely associated with the genus *Arnica,* and described in Foote and Blanc (1979) as a member of a complex containing *araneosa,* which as discussed below, some specimens of *laevittensis* closely resemble. Similarly, the published rearing record for *E. pumilus* may rightly apply to *T. ovatipennis,* known now from three other species of *Erigeron*; the latter species also belongs to the "*araneosa* complex" recognized by Foote (1960) and Foote and Blanc (1979).

In preparing the present report, I ascertained that the aforementioned complex contains at least one additional, undescribed species, which I now describe using the format of Foote and Blanc (1979), the methods of measurement of Jenkins and Turner (1989), and the terminology in McAlpine (1981) for 12 specimens of each sex. The new species runs to *signatipennis* Foote (couplet 10) in the key to North American species of *Tephritis* in Foote et al. (1993). The following key to replace couplet 10 enables one to distinguish these closely related species (parenthesized additions and deletions mine):

10. Cell a_2 with dark markings extended at least halfway from vein A_2 to wing margin, often touching the margin 10a
– Cell a_2 entirely hyaline or at most narrowly dark along vein A_2 11
11. Wing (Fig. 1) with hyaline spot in basal end of cell r_{4+5} large, oval to quadrate, and extended from vein R_{4+5} to vein M (often broadly based on latter), usually contiguous with hyaline area in cell r_{2+3} directly anterior to it .... *joanae* Goeden, n. sp.
– Wing with hyaline spot in basal end of cell r_{4+5} smaller, round or oval, and not extended to vein R_{4+5}, but sometimes touching vein M .... *signatipennis* Foote

Tephritis joanae Goeden, New Species

Head.—In profile, 1.1–1.4 times as high as long, face distinctly protruding below an-

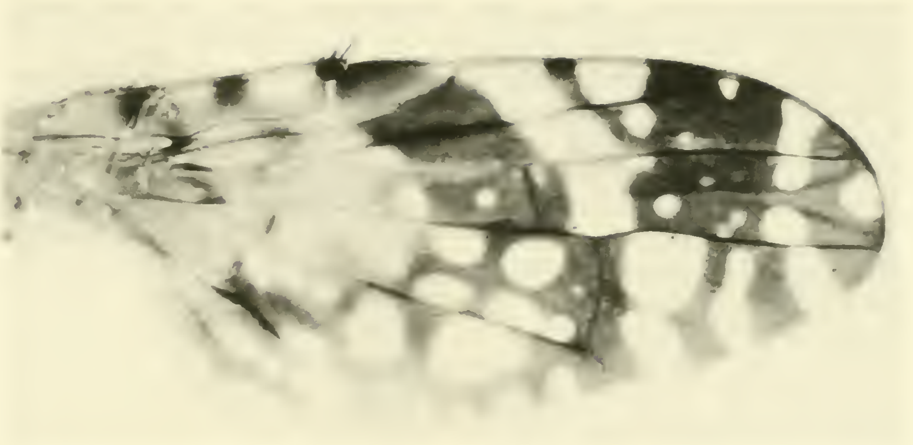


Fig. 1. Right wing of *Tephritis joanae*, female.

tennae, face and frons meeting at an angle of about 135°; gena below eye 0.14–0.18 times eye height, genal bristle and genal setulae white to dark brown; occiput swollen; frons dark yellow, about 0.6 mm wide at vertex, narrowing to about 0.5 mm at antennal bases, 0.4–0.5 mm long; the 2 frontal setae shining dark brown; posterior orbital seta white, 0.5–0.8 times as long as anterior; verticals ⅔–¾ as long as head height; face, including antennal foveae, dark yellow; palpi yellow, with 5–10 prominent black setulae apically; antenna 0.6–0.8 as long as face, arista dark brown except base dark yellow.

Thorax.—Scutum, scutellum, and pleural sclerites brownish gray pollinose, with 3 brown dorsolongitudinal stripes, 1 medial, and 2 more lateral and in line with dorsocentral bristles; scutellum darker centrally than marginally; complement of thoracic bristles usual for the genus, all black except posterior notopleural, white; subscutellum and mediotergite black and gray rather than brownish gray pollinose; scutal setulae white, inserted closer to each other than their average length; scutellum bare centrally, setulae present only laterally; halteres whitish. Legs entirely yellow; hind tibia of both male and female with parallel rows of black setulae and distinct anterodorsal row of dark brown to black setae on basal ⅔, the longest seta about as long as width of tibia; hind femur with black setulae on posterior fourth. Wing pattern as in Fig. 1, with a prominent hyaline area immediately distad of pterostigma extended from costal margin posterior to and touching vein M, thus, hyaline spot in basal end of cell r_{4+5} is oval to quadrate; dark area in pterostigma extended posteriorly without hyaline spots to vein R_{2+3}, thence to vein R_{4+5} with a few hyaline markings, and continued on to posterior margin with prominent hyaline spots of increasing size; cross vein r-m removed from crossvein dm-cu by about its own length; triangular extension of basal cubital cell almost equilateral; cell a_2 light brown to posterior margin between larger hyaline spots.

Abdomen.—All tergites dark gray pollinose except T_1, which has black spot medially, but otherwise is concolorous with brownish scutum and scutellum, rather than blackish mediotergite, other tergites without pattern; densely covered with colorless setulae inserted much closer to each other than their average length, becoming longer laterally and posteriorly; 4 long, brown or black setae laterally along posterior margin and 2 setae laterally on last abdominal tergite; oviscape flat, dark reddish brown to black, with setulae on basal ⅔ similar to those on abdominal tergites, apically with extremely fine short black hairs; in dorsal view about 2 times as long as last abdominal tergite and 0.9–1.3 as wide at base as long.

Holotype, female, Lake Morena, San Diego Co., Calif., 18.x.1980, reared from flower head of *Haplopappus pinifolius,* R. D. Goeden. Allotype, same data as holotype (USNM). Paratypes: CALIFORNIA: 29 females and 26 males, same data as holotype. Also reared from *H. pinifolius*: 12 ♂, 12 ♀; McCain Valley, San Diego Co.; 16.x.1980. 12 ♂, 12 ♀; Lark Canyon, San Diego Co.; 29.x.1980. 7 ♂, 8 ♀; Campo, San Diego Co.; 29.x.1980. 6 ♂, 6 ♀ mounted (paratypes) of 144 ♂, 133 ♀ reared (remainder discarded, as also noted below); N of Thomas Mountain, San Bernardino Nat. Forest (S section), Riverside Co.; 29.ix.1982, 6 ♂, 6 ♀ mounted of 210 ♂, 196 ♀ reared; Kitchen Creek, Cleveland Nat. Forest, San Diego Co.; 7.x.1981. 6 ♂, 8 ♀ mounted of 108 ♂, 111 ♀ reared; W of Boulevard at 1020 m, San Diego Co.; 6.xi.1986. 5 ♂, 7 ♀ mounted of 8 ♂, 8 ♀ reared; Cameron Corners at 910 m; San Diego Co.; 6.xi.1986. 6 ♂, 6 ♀ mounted of 157 ♂, 184 ♀ reared; Live Oak Springs on Tecate Divide at 1220 m, San Diego Co.; 8.x.1987. 6 ♂, 6 ♀ mounted of 7 ♂, 11 ♀ reared; Smith Canyon E of Campo at 990 m, San Diego Co.; 20.x.1987. Additional specimens identified, but not designated as paratypes, include those reared from: *H. ericoides*; 10 ♂, 8 ♀; Orcutt, Santa Barbara Co.; 12.xi.1980. 2 ♂, 1 ♀; Orcutt; 7.xii.1982. *Senecio douglassii*; 12 ♂, 12 ♀ mounted of 28 ♂, 28 ♀ reared; La Posta, San Diego Co.; 15.x.1980.

Etymology: Tephritis joanae is named for my wife, Joan, who for many years has tolerated with understanding my entomological activities and helped me to surmount the less understandable, human aspects of my profession.

Tephritis joanae belongs to the "*araneosa* complex" comprising *araneosa, candidipennis, leavittensis, ovatipennis,* and *signatipennis* (Foote 1960, Foote and Blanc 1979). All were available to me for comparative study as series of reared specimens from southern California, the type locality of *araneosa* (Coquillett 1894). As discussed by Foote and Blanc (1979), the principal differences among most species in this complex are the degree of infuscation of the wing patterns and attendant sizes of the hyaline areas. However, the dark band from the pterostigma to vein R_{4+5} is situated at right angles to the horizontal axis of the wing in most *candidipennis* and *leavittensis* (see comments below); whereas, this band extends obliquely to cover crossvein r-m in the other species, including *joanae.* Among the obliquely banded species, however, only *joanae* and *signatipennis* have anal cells darkened to or nearly to the posterior margin, but with large hyaline spots. These two species are distinguished readily by the size and shape of the hyaline spot in cell r_{4+5}, which in the former species is much larger and subquadrate as in *araneosa,* touching both veins R_{4+5} and M. Furthermore, *araneosa,* which was described by Coquillett (1894) from four females from southern California, has an oviscape about equal in length to the terminal abdominal tergite; whereas, in *joanae* the oviscape length is about twice the length of this tergite. Moreover, *araneosa* adults are shorter on average than *joanae.* Twelve each, males and females of *araneosa* from *Artemisia californica* averaged 2.5 ± 0.06 (range, 2.0–2.7) mm and 2.9 ± 0.06 (range, 2.7–3.3) mm in length, respectively, about 1 mm shorter than 12 males and 12 females of *joanae,* i.e. 3.5 ± 0.07 (range, 3.2–3.9) mm and 4.0 ± 0.04 (range, 3.7–4.2) mm, respectively, from *H. pinifolius.*

Thus, *araneosa,* as a presumed mixture of species has yielded still another new species (Foote and Blanc 1979), and probably contains at least one more unnamed species with an intermediate ratio of oviscape to last abdominal tergite of ca. 1.5, that if or when described by me elsewhere after additional study, may reduce the host range of *araneosa* to that of a nearly monophagous species associated with *Artemisia* spp. The life histories and immature stages of *T. araneosa, T. joanae,* and this apparent, but still undescribed species from *Chrysothamnus* and *Haplopappus* are under study by me and my associates and will be reported on separately in the future.

Tephritis californica now is reported from three species of *Baccharis* in the tribe Astereae and an unidentified species of *Senecio* in the tribe Senecioneae (Wasbauer 1972, Jenkins and Turner 1989, and the present study). I have reared this questionably generalist tephritid from the flower heads of *B. pilularis,* and as both male and female flies from large samples of male and female flower heads of *B. sarothroides.* The latter samples were taken from areas where these two, closely related, otherwise largely allopatric hosts, were sympatric; therefore, this record may have resulted from ovipositional "spillover" as is thought to occur in other tephritid genera (Goeden 1985, 1988b, Goeden, Headrick, and Teerink, unpublished data). Like Jenkins and Turner (1989), I have been unable to confirm the "unpublished" record in Wasbauer (1972) for *B. emoryi* Gray from two, large samples of mature flower heads that failed to yield any tephritid. Similarly, the "unpublished" record for *Senecio* sp. in Wasbauer (1972) remains unconfirmed, and is somewhat suspect, as only *T. joanae* and *T. stigmatica* have been reared by me from flower heads and galls on plants in this genus to date. Thus, in reality, *T. californica* probably is nearly monophagous on *B. pilularis.* The light morphs, i.e. F_1 flies, apparently emerge from still-undetected, galls or branch-tip mines on nonflowering, vegetative branches in the spring; whereas, the dark morphs, i.e. F_2 flies, emerge from flower heads in the fall (Jenkins and Turner 1989). This life history scenario is similar to that of *T. arizonaensis* on *B. sarothroides* in southern California (Goeden et al. 1993) and *T. palmeri* Jenkins on *B. neglecta* Britton and *B. halimifolia* L. in Texas (Jenkins and Turner 1989).

Tephritis candidipennis may be another species currently considered a generalist, that actually is a monophage. It is reported from two species of *Tanacetum* in the tribe Anthemideae, and one species each in the genera *Ambrosia* (tribe Heliantheae) and *Arnica* (tribe Senecioneae) (Wasbauer 1972). The "unpublished" record from *Ambrosia chamissonis* (Lessing) Greene in Oregon is questionable, based partly on my studies of the insect fauna of this native ragweed (Goeden and Ricker 1974). Other than this suspect record in Wasbauer (1972), no *Tephritis* is known from *Ambrosia,* from any other genus in the subtribe Ambrosiinae in North America (Goeden and Teerink in press, Goeden and Palmer in press), or from any other Heliantheae (Wasbauer 1972, and the present study). Again, I have never reared *T. candidipennis,* only *T. leavittensis* from *Arnica* spp., including *Arnica chamissonis* in the present study. Indeed, *T. candidipennis* may be nearly monophagous on *Tanacetum* spp. from which rearing records appear less ambiguous (Quisenberry 1951, Foote and Blanc 1963, Wasbauer 1972).

Tephritis leavittensis has been reared in California from flower heads of four species of *Arnica* in the tribe Senecioneae and *Artemisia spinescens* in the Anthemideae. These are the only rearing records known for this species described in part from specimens swept from *Arnica longifolia,* which thus provided an example of a sweep record indicative of a reproductive host-plant relationship, despite repeated admonitions to the contrary by me elsewhere (e.g. Goeden and Ricker 1986, Goeden 1988a, Headrick and Goeden 1991; but also see Goeden and Headrick 1991b).

Some of the *T. leavittensis* reared from *Arnica* spp., including parts of those series reported in the present study, had wings on which the "dark band covering the subcostal cell extended obliquely to cover vein r-m," i.e. it was not ". . . situated at right angles to the horizontal axis of the wing," the opposite of the key character described in Foote and Blanc (1979). Thus, the key character used to separate *leavittensis*, along with *candidipennis*, was invalid in 30 of the 129 (23%) mounted specimens reared from capitula of *Arnica* spp. housed in my collection during the present study. This ratio varied from one of six (17%) specimens mounted and reared from *A. sororia* collected 24.vii.1984, to nine of 32 (28%) specimens mounted of those reared from *A. sororia* collected 9.ix.1986, to seven of 22 (32%) specimens mounted of those reared from *A. chamissonis* collected 19.viii.1987, to two of 11 (18%) specimens mounted and reared from *A. longifolia* collected 8.ix.1988, to 10 of 38 (26%) specimens mounted and reared from *A. amplexicaulis* collected 25.vii.1989, to one of five (20%) specimens mounted and reared from *A. chamissonis* collected 17.ix.1991. These specimens keyed to *T. araneosa*, and provide another possible explanation for continuing records of *T. araneosa* from *Arnica* spp.

Tephritis ovatipennis is a generalist now known from seven genera and 12 species of host plants in three tribes, i.e. Anthemideae, Astereae, and Helenieae (Wasbauer 1972, and the present study). Included among these hosts are two species of *Artemisia*, a genus which, as noted above, also is attacked by *T. araneosa*. The sharing of host-plant genera and even individual host species by congeneric generalists was documented among species of *Trupanea* by Goeden (1992). *Tephritis ovatipennis* is the only Nearctic species in this genus reported from Helenieae. The record for *Corethrogyne filaginifolia* in Wasbauer (1972) has not been confirmed; however, another record for *Erigeron foliosus* (Wasbauer 1972) was confirmed, and augmented by rearing records for two other *Erigeron* spp. in the present paper.

Tephritis stigmatica is another generalist now known from five genera and 12 species in two tribes, Astereae and Senecioneae (Wasbauer 1972, and the present study). I have not confirmed the records for *Arnica chamissonis* and *Chrysopsis* (as *Heterotheca*) *breweri* in Wasbauer (1972), nor the record for *Aster canescens* (Pursh) Gray in Novak et al. (1967). The principal host genus of this fly appears to be *Senecio*. Six species of which are reported as hosts. On at least one of these, *T. stigmatica* forms branch and stem galls besides attacking flower heads, as noted above (Goeden 1988a). *Tephritis stigmatica* also shares the large and diverse host genus *Haplopappus* with *T. araneosa* and *T. joanae*, although different host-plant species are attacked by each of these species. The records for *T. stigmatica* also represent single specimens reared only once from each species of *Haplopappus*, and, therefore, could also have resulted from "spill-over" errors in oviposition mentioned above with *T. californica*.

Thus, the known host plants of *Tephritis* in California represent four tribes of Asteraceae: Anthemideae, Astereae, Helenieae, Senecioneae (discounting the questionable records noted above). Nine of 11 species of *Tephritis* from California for which host plants have been reported, i.e. all except *candidipennis* and *leavittensis*, attack at least one species in the tribe Astereae; five species apparently attack only Astereae, again discounting the questionable host record from *Senecio* for *T. californica*. Three of the four subtribes of Astereae in California are represented among hosts of *Tephritis*. The fourth subtribe, Bellidinae, contains only the naturalized English daisy, *Bellis perennis* L. The Astereae also is the largest of 12 tribes of Asteraceae in California, with the Helenieae and Senecioneae as the third and fifth largest (Munz and Keck 1959, Goeden 1992).

Tephritis thus shows a broader host range among tribes of California Asteraceae than *Neaspilota* and *Urophora*. The host plants of *Neaspilota* in California are mainly in the

Astereae, with at least one confirmed host plant in the tribe Cichoreae (Goeden 1989). The hosts of native *Urophora* in California are concentrated in the subtribe Solidagininae of the Astereae (Goeden 1987). The host plants of *Trupanea,* on the other hand, represent nine of the 12 tribes of Asteraceae found in California (Goeden 1985, 1992); whereas, the host plants of *Paroxyna* represent seven tribes of California Asteraceae (Wasbauer 1972, Novak 1974, Goeden and Blanc 1986, Goeden, unpublished data).

Knowing these host plant affinities may help to locate hosts of unreared *Tephritis* and unreared species in other genera occurring in California. Locating a good field population of an unstudied species of tephritid is the prime requisite for productive investigation of its life history and descriptions of its immature stages, as our recent efforts in California demonstrate.

ACKNOWLEDGMENTS

The technical support of D. H. Headrick, D. W. Ricker, and J. A. Teerink is gratefully acknowledged. The botanical expertise of A. C. Sanders, Curator of the Herbarium at the University of California, Riverside, who identified or facilitated identification of all plants mentioned in this paper, has been of fundamental help to my tephritid research. Taxonomic advice from F. L. Blanc, G. Gordh, and A. L. Norrbom helped me to include my first species description in this paper. If a few more descriptions follow, it will be because of their expert help and encouragement. I also readily acknowledge and sincerely thank G. Gordh, D. H. Headrick, K. Knio, A. L. Norrbom, and J. A. Teerink and an anonymous reviewer for their helpful comments on earlier drafts of this paper.

LITERATURE CITED

Coquillett, D. W. 1894. New North American Trypetidae. Canadian Entomologist 26: 71–75.

Foote, R. H. 1960. The genus *Tephritis* Latreille in the Nearctic Region north of Mexico: Descriptions of four new species and notes on others. Journal of the Kansas Entomological Society 33: 71–85.

Foote, R. H. and F. L. Blanc. 1963. The fruit flies or Tephritidae of California. Bulletin of the California Insect Survey 7, 115 pp.

———. 1979. New species of Tephritidae (Diptera) from the western United States, Mexico, and Guatemala, with revisionary notes. Pan-Pacific Entomologist 55: 161–179.

Freidberg, A. and J. Kugler. 1989. Fauna Palaestina. Insect IV. Diptera: Tephritidae. Israel Academy of Sciences and Humanities, Tel Aviv.

Freidberg, A. and W. N. Mathis. 1986. Studies of Terellininae (Diptera: Tephritidae): A revision of the genus *Neaspilota* Osten Sacken. Smithsonian Contributions to Zoology 434: 1–75.

Goeden, R. D. 1985. Host-plant relations of *Trupanea* spp. (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 87: 564–571.

———. 1987. Host-plant relations of native *Urophora* spp. (Diptera: Tephritidae) in southern California. Proceedings of the Entomological Society of Washington 89: 269–274.

———. 1988a. Gall formation by the capitulum-infesting fruit fly, *Tephritis stigmatica* (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 90: 37–43.

———. 1988b. Life history of *Trupanea imperfecta* (Coquillett) on *Bebbia juncea* (Bentham) Greene in the Colorado Desert of southern California (Diptera: Tephritidae). Pan-Pacific Entomologist 64: 345–351.

———. 1989. Host plants of *Neaspilota* in California (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 91: 164–168.

———. 1992. Analysis of known and new host records for *Trupanea* from California (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 94: 107–118.

Goeden, R. D. and F. L. Blanc. 1986. New synonymy, host, and California records in the genera *Dioxyna* and *Paroxyna* (Diptera: Tephritidae). Pan-Pacific Entomologist 62: 88–90.

Goeden, R. D. and D. H. Headrick. 1991a. Life history and descriptions of immature stages of *Tephritis baccharis* (Coquillett) on *Baccharis salicifolia* (Ruiz & Pavon) Persoon in southern California. Pan-Pacific Entomologist 67: 86–98.

———. 1991b. Notes on the biology, hosts, and immature stages of *Tomoplagia cressoni* Aczél in southern California (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 93: 549–558.

Goeden, R. D., D. H. Headrick, and J. A. Teerink. 1993. Life history and descriptions of immature stages of *Tephritis arizonaensis* Quisenberry (Diptera: Tephritidae) on *Baccharis sarothroides* Gray in southern California. Proceedings of the Entomological Society of Washington 95: (In press.)

Goeden, R. D. and D. W. Ricker. 1974. The phytophagous insect fauna of the ragweed, *Ambrosia chamissonis*, in southern California. Environmental Entomology 3: 835–839.

———. 1986. Phytophagous insect fauna of the desert shrub *Hymenoclea salsola* in southern California. 79: 39–47.

Goeden, R. D. and W. A. Palmer. 1992. Lessons learned from studies of the insects associated with Ambrosiinae in North America in relation to the biological control of weedy members of this group. *In* Delfosse, E. S. and R. R. Scott, eds., Proceedings of the Eighth International Symposium on Biological Control of Weeds, 2–7 February 1992, Lincoln University, Canterbury, New Zealand, DSIR/CSIRO, Melbourne, Australia. (In press.)

Goeden, R. D. and J. A. Teerink. 1992. Phytophagous insect faunas of *Dicoria canescens* and *Iva axillaris*, native relatives of ragweeds, *Ambrosia* spp., in southern California. Annals of the Entomological Society of America 85: (In press.)

Headrick, D. H. and R. D. Goeden. 1991. Life history of *Trupanea californica* Malloch (Diptera: Tephritidae) on *Gnaphalium* spp. in southern California. Proceedings of the Entomological Society of Washington 93: 559–570.

Jenkins, J. and W. J. Turner. 1989. Revision of the *Baccharis*-infesting (Asteraceae) fruit flies of the genus *Tephritis* (Diptera: Tephritidae) in North America. Annals of the Entomological Society of America 82: 674–685.

McAlpine, J. F. 1981. 2. Morphology and terminology—adults. *In* McAlpine, J. F., B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood, eds., Manual of Nearctic Diptera, Vol. 1. Monograph of the Biosystematics Research Institute 27: 9–63. Agriculture Canada, Ottawa.

Munz, P. A. 1968. Supplement to A California Flora. University of California Press, Berkeley.

———. 1974. A Flora of Southern California. University of California Press, Berkeley.

Munz, P. A. and D. D. Keck. 1959. A California Flora. University of California Press, Berkeley.

Novak, J. A., W. B. Stoltzfus, E. J. Allen, and B. A. Foote. 1967. New host records for North American fruit flies (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 69: 146–148.

Novak, J. A. 1974. A taxonomic revision of *Dioxyna* and *Paroxyna* for America north of Mexico. Melanderia 16: 1–53.

Quisenberry, B. F. 1951. A study of the genus *Tephritis* Latrielle in the Nearctic region north of Mexico. Journal of the Kansas Entomological Society 24: 56–72.

Stoltzfus, W. B. 1977. The taxonomy and biology of *Eutreta* (Diptera: Tephritidae). Iowa State Journal of Research 51: 369–438.

Tauber, M. J. and C. A. Toshi. 1965. Life history and mating behavior of *Tephritis stigmatica* (Coquillett). Pan-Pacific Entomologist 41: 73–79.

Wasbauer, M. W. 1972. An annotated host catalog of the fruit flies of America north of Mexico (Diptera: Tephritidae). California Department of Agriculture, Bureau of Entomology Occasional Papers No. 19. 172 pp.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 435–448

NEW GENERA AND NEW SPECIES OF COLPURINI (HETEROPTERA: COREIDAE) FROM THE FIJI ISLANDS AND NEW GUINEA

Harry Brailovsky

Departamento de Zoología, Instituto de Biología UNAM, Apartado Postal No. 701-53 México, 04510 D.F.

Abstract.—Three new genera and four new species from the Fiji Islands and New Guinea are described in the tribe Colpurini (Coreidae). Habitus view illustrations and drawings of the male and female genitalia are provided to help distinguish these taxa.

Key Words: Insecta, Heteroptera, Coreidae, Colpurini, new genera, new species, Fiji Islands, New Guinea

The Indo-Pacific Colpurini have received little comprehensive attention. Most of these taxa are in need of revision and reevaluation of characters. The putative relationships among these taxa will be better understood once the generic limits are redefined. Recent papers dealing with Colpurini include a revision of *Agathyrna* Stål (Dolling 1987), the description of a new species of *Hygia* (*Trichocolpura*) from West Malaysia (Maschwitz et al. 1987), the description of three new species from Sumatra and New Guinea (Brailovsky 1990), and the revision of the genus *Typhlocolpura* (Brailovsky et al. 1992).

In this paper, three new genera are erected for four new species: one from the Fiji Islands and three from New Guinea. Each genus is defined by its external habitus, as well as by the wing polymorphism and the female genital plates.

The following abbreviations are used for the institutions cited in this paper: BPBM (Bernice P. Bishop Museum, Honolulu, Hawaii); CAS (California Academy of Sciences, San Francisco, California); UNAM (Instituto de Biología, Universidad Nacional Autónoma de México, México D.F.); RNHL (Rijksmuseum Van Naturlijke Histoire, Leiden, Netherlands); SAMA (South Australian Museum, Adelaide); USNM (U.S. National Museum of Natural History, Washington, D.C.).

All measurements are given in millimeters.

Acarihygia Brailovsky, New Genus

Diagnosis.—*Lygaeopharus* Stål like *Acarihygia* Brailovsky, new genus, has the ocelli reduced or absent, tylus apically globose and truncate, buccula rounded without teeth or spines and abdominal sternites of female not decurved or narrowed. In *Lygaeopharus* the scutellum is triangular, with apex acute, the dorsal segments of the abdomen are only slightly convex, never strongly convex, abdominal sternite VII of the female has a plica and fissura, and gonocoxae I is shorter and more or less triangular with the apex blunt. *Acarihygia* is recognized by the mite-like appearance, the scutellum triangular with a rounded apex, a shorter pronotum, the abdomen strongly convex dorsally, female abdominal sternite VII without a plica or fissura, and gonocoxa I is large and squarish, with a protruding external margin.

Generic description.—Head: Longer than wide, pentagonal and dorsally slightly convex; tylus unarmed, apically globose, extending anteriorly to and laterally higher than juga; jugum unarmed, thickened and shorter than tylus; antenniferous tubercle unarmed, quadrate, robust, diverging anteriorly, apex truncated; side of head in front of eye unarmed and obliquely straight; antennal segment I robust, thickest, slightly curved outward, shorter than head; segments II and III cylindrical and slender; segment IV fusiform; segment II longest; length of segments I, III and IV subequal; ocelli absent; posterior pit between eyes deep and diagonally excavated; eyes globose and exposed; postocular tubercle moderately protuberant; buccula rounded, elevated, short, not projecting beyond antenniferous tubercle, without teeth and with the external edge thickened; rostrum long, reaching the middle third of abdominal sternite V; rostral segment IV longest, II longer or subequal to I and III the shortest; rostral segment I reaching posterior gular region.

Thorax.—Pronotum wider than long, trapeziform and clearly bilobed; anterior lobe longer than posterior lobe, each margin convexly rounded and moderately elevated; collar wide; frontal angles produced forward as small conical teeth; humeral angles rounded, not exposed; posterolateral border rounded and posterior border slightly concave; calli globose, separated along middle line by a slight triangular depression; posterior lobe with a deep circular depression located medially. Anterior lobe of metathoracic peritreme reniform, posterior lobe sharp, small. Discs of propleura, mesopleura and metapleura strongly convex; posterior border of metathorax with the upper third visible dorsally.

Legs.—Unarmed; tibiae cylindrical, longitudinal sulcus indistinct.

Scutellum.—Moderately triangular, wider than long, with apex rounded; disc almost flat.

Hemelytra.—Micropterous; wings reduced to small pads, widely separated, abdomen exposed mesially, clavus and corium fused, and membrane represented by a small flap.

Abdomen.—Conspicuously spherical; segments II–VI dorsally strongly convex, higher than connexivum; dorsal segment VII flat with connexival segment VII higher; connexival margin entire, posterior angle of segments not extended into a short spine.

Integument.—Body surface rather dull. Head ventrally, pronotum, scutellum, hemelytra, thorax, abdomen, and exposed parts of genital segments of both sexes punctate; head dorsally and connexival segments practically smooth. Head, pronotum, scutellum, hemelytra, thorax, and abdomen with short, decumbent, silvery bristlelike setae, intermixed with a few long erect setae located on the abdominal sterna; antennal segments and legs covered by long and short erect setae.

Male genitalia.—Genital capsule simple and globose, posteroventral edge entire and rounded (Figs. 6, 7).

Female genitalia.—Abdominal sternite VII without plica or fissura. Genital plates: Gonocoxae I squarish, large, with a convex and protruding external margin; paratergite VIII short, square, with visible spiracle; paratergite IX squarish, larger than paratergite VIII (Figs. 4, 5).

Etymology.—This generic name is used to denote the mite-like appearance of the included species. Gender feminine.

Type species.—*Acarihygia fijiana* Brailovsky, new species.

Acarihygia fijiana Brailovsky, NEW SPECIES

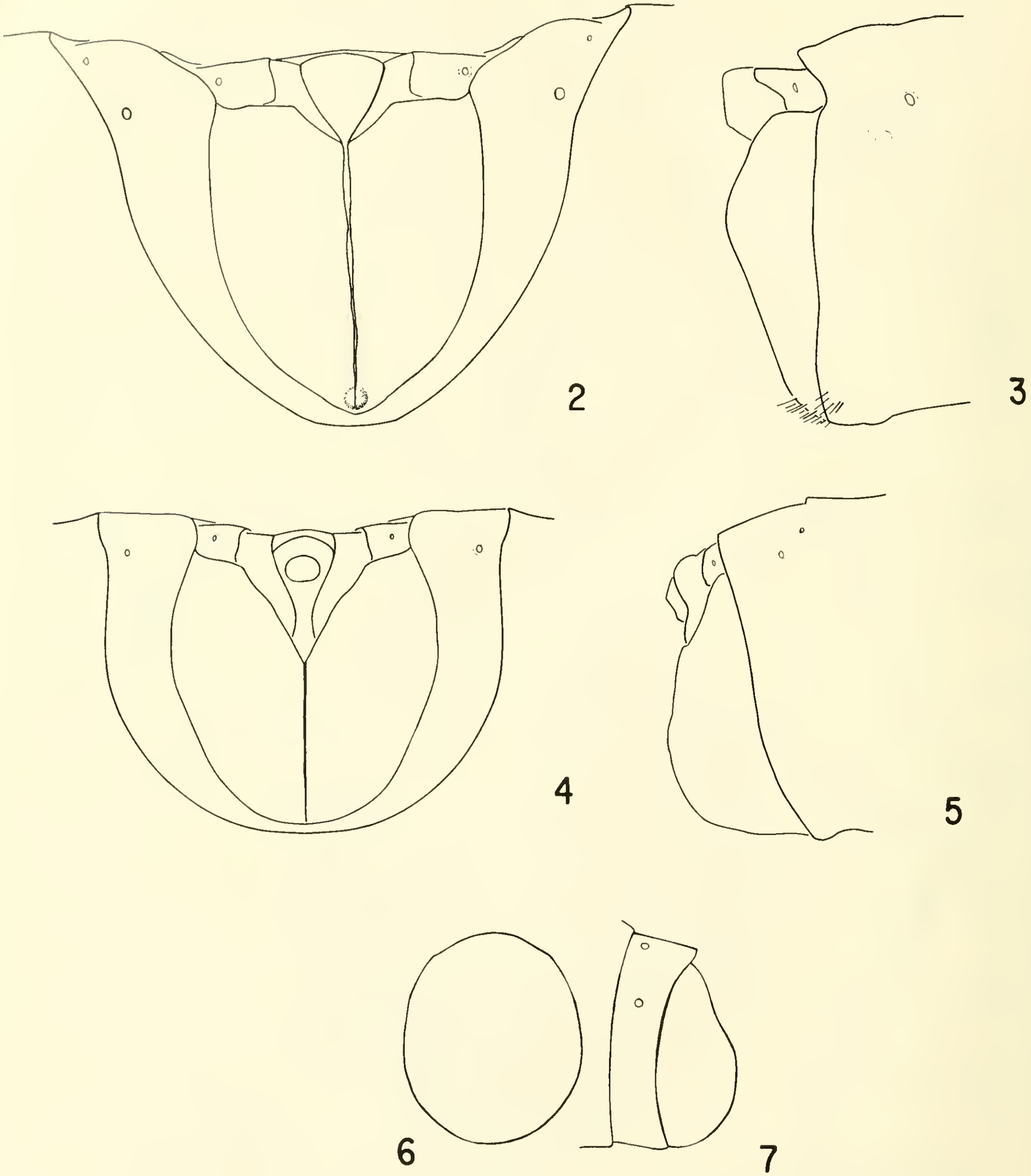
Figs. 1, 4–7, 21

Description.—Male: Head length 1.48; interocular space 0.77; width across eyes 1.33; preocular distance 0.93; length of antennal segments: I, 1.27; II, 1.89; III, 1.14; IV, 1.30. Pronotum: Total length of anterior lobe 0.83; total length of posterior lobe 0.18; total width of anterior lobe 1.08; total width

Fig. 1. Dorsal view of *Acarihygia fijiana.*

of posterior lobe 2.13. Scutellar length 0.58; width 1.08. Total body length 7.30.

Female: Head length 1.55; interocular space 0.81; width across eyes 1.37; preocular distance 0.96; length antennal segments I, 1.24; II, 1.86; III, 1.27; IV, 1.30. Pronotum: Total length of anterior lobe 0.87; total length of posterior lobe 0.18; total width



Figs. 2–7. Figs. 2, 3. Female genital plates of *Wygohygia stylata*. Fig. 2. Frontal view. Fig. 3. Lateral view. Figs. 4–7. *Acarihygia fijiana*. Figs. 4, 5. Female genital plates. Fig. 4. Frontal view. Fig. 5. Lateral view. Figs. 6, 7. Male genital capsule. Fig. 6. Frontal view. Fig. 7. Lateral view.

of anterior lobe 1.30; total width of posterior lobe 2.35. Scutellar length 0.58; width 1.11. Total body length 7.55.

Male.—Coloration: Body dark orange brown, with following areas pale yellow: apex of scutellum, posterior edge of connexival segments II to VII, rostral segments I–IV, coxae, trochanters, tarsi, anterior lobe of metathoracic peritreme, edge of acetabulae and scattered reflections in abdominal sternites II to VII; head dark brownish red; antennal segments I to III pale orange and IV orange with apex brownish red; femora brownish orange with 3 or 4 incomplete pale yellow rings; tibiae brownish orange with 1 or 2 pale yellow rings.

Female.—Coloration: Similar to male or with following variation: 1—dorsal coloration dark brownish red, 2—antennal segments I to III dark orange and IV pale orange with base and apex brownish orange, 3—femora pale yellow with 3 rings and several brownish orange discoidal spots, 4—tibiae brownish orange with 2 yellow rings, one subbasal other one near middle, 5—tarsal segment I brownish orange and segments II–III pale yellow and 6—rostral segments I to IV pale orange.

Type material.—Holotype: ♂, Fiji, Viti Levu Isl., 2–10 km., South of Nandarivatu (600–700 mts.), 4 August 1979, G. A. Samuelson (BPBM). Paratypes: 3 ♀♀, Fiji, Viti Levu Isl., Yayu nr. Nandarivatu (690 mts.), 4 July 1958, B. Malkin (BPBM, USNM, UNAM); 1 ♀, Fiji, Viti Levu Isl., Nandarivatu (810 mts.), 27 June to 4 July 1958, B. Malkin (BPBM).

Notes.—In *Brachylybas variegatus* (Le Guillou), the only other previously known species of colpurine recorded from the Fiji Islands, the ocelli are well developed, the apex of the tylus has distinct teeth or spines, the buccula has a sharp anterior projection, the pronotum is longer, the apex of the scutellum is acute, and the hemelytra are macropterous, with the clavus and corium well defined and the membrane well developed. In *A. fijiana* Brailovsky, new species, the ocelli are absent, the tylus is apically globose, the buccula is rounded and without teeth or spines, the pronotum is shorter, the scutellum is moderately triangular with the apex rounded, the hemelytra are micropterous with clavus and corium fused, and the membrane is represented by a small flap. In addition, the abdomen of *B. variegatus* is suboval, with dorsal segments flat and abdominal sternite V to VII of the female clearly decurved and narrowed at the middle line. In *A. fijiana,* the abdomen is strongly convex, with segments II to VI higher than connexivum, and abdominal sternites V to VII of the female are not decurved or narrowed.

Etymology.—This species is named for its occurrence on Fiji Islands.

Distribution.—Known only from the type locality in the Fiji Islands.

Kerzhnerhygia Brailovsky, NEW GENUS

Diagnosis.—*Acanthotyla* Stål. *Agathyrna* Stål, *Brachylybas* Stål and *Kerzhnerhygia* Brailovsky, new genus, are the only colpurine genera that have the apex of tylus projected with a short spine and abdominal sternite VII of female without plica or fissura. *Kerzhnerhygia* is distinguished by the large spine on the antenniferous tubercle, a second robust horn at the base of tylus, the unarmed mandibular plates, the prominently elevated calli separated along midline by a short longitudinal furrow, the posterior margin of the abdominal sternite VII of female projected on a triangular plate, and the elongate blade-shape ventral convexity of gonocoxa I (Figs. 8, 9, 12, 13). The other three genera have an unarmed antenniferous tubercle, a basally flattened tylus, prominent tubercles on the mandibular plates (some species currently placed in *Brachylybas* lack mandibular-plate tubercles), unelevated calli, a straight posterior margin on abdominal sternite VII, and the external margin of gonocoxa I lacking convexities.

Generic description.—Head: Length equal to width (across eyes) or wider than long, pentagonal and dorsally slightly convex; tylus projecting in front of jugum, upturned to form a small horn at apex; base of tylus with a second and more robust horn; jugum unarmed, thick and shorter than tylus; antenniferous tubercle armed with a conspicuous and large spine, converging or diverging anteriorly and with the apices acutely rounded; side of head in front of eye unarmed, straight and shorter than total length of eye; antennal segment I robust, thickest, curved outward and shorter than head; segments II and III cylindrical and slender; segment IV fusiform; antennal segment II the longest, segment IV the shortest and I longer than III; ocelli conspicuously pedunculate; preocellar pit deep and circular; eyes large, substylate; postocular tubercle protuberant; buccula rounded, short, not extending beyond antenniferous tubercle, with or without a sharp middle projection; rostrum reaching anterior third of abdominal sternite IV or VI; rostral segment IV longest or subequal to II, III slightly shorter than II and I the shortest; rostral segment I reaching posterior margin of the gula.

Thorax.—Pronotum wider than long, trapeziform, moderately declivent; collar wide; frontal angles produced forward as short conical teeth; anterolateral border obliquely straight to weakly convex; humeral angles rounded, not expanded; posterolateral and posterior border straight; calli prominently elevated, separated along midline by a short longitudinal furrow; posterior margin with a transverse ridge. Anterior lobe of metathoracic peritreme elevated and reniform, posterior lobe sharp, small.

Legs.—Ventral surface of femora unarmed or with two rows of long or short and acute spines; tibiae cylindrical and sulcate.

Scutellum.—Triangular, flat, slightly longer than wide; apex convex or not and subacute; disc with a T-shaped elevation.

Hemelytra.—Macropterous, extending to the posterior margin of the last abdominal segment or beyond; claval suture evident; apical margin obliquely straight with a short apical angle reaching the middle third of the hemelytral membrane; costal margin emarginated; membrane with a few of the veins furcate.

Abdomen.—Connexival segments strongly elevated, higher than margin of hemelytron at rest; posterior angle of each connexival segment complete, not extending on a short spine; abdominal sternite with medial furrow, projecting to posterior border of sternite IV or V.

Integument.—Body surface rather dull. Head, pronotum, scutellum, clavus, corium, thorax, abdominal sterna and exposed parts of genital segments of both sexes punctate. Head densely covered by long, decumbent, golden or silvery setae; pronotum, thorax and abdominal sternites with short, scattered, decumbent golden or silvery bristlelike setae; antennae and legs with few long erect setae; scutellum, clavus and corium practically glabrous.

Male genitalia.—Genital capsule: Posteroventral edge with two long, pointed or blunt lobes, curved outward and between them without or with a short and acute lobe (Figs. 10, 11). Parameres. Shaft robust, with the anterior lobe slightly convex and the posterior lobe long and slender (Figs. 14–17).

Female genitalia.—Abdominal sternite VII without plica or fissura, and with the posterior margin projected as a triangular plate; gonocoxa I conspicuously enlarged dorsoventrally and in lateral view, the external face has two convexities, the dorsal one width and rounded and ventral one elongated, much longer and blade-shaped; paratergite VIII short, square, with visible spiracle; paratergite IX squarish, larger than paratergite VIII (Figs. 8, 9, 12, 13). Spermatheca. Fig. 18.

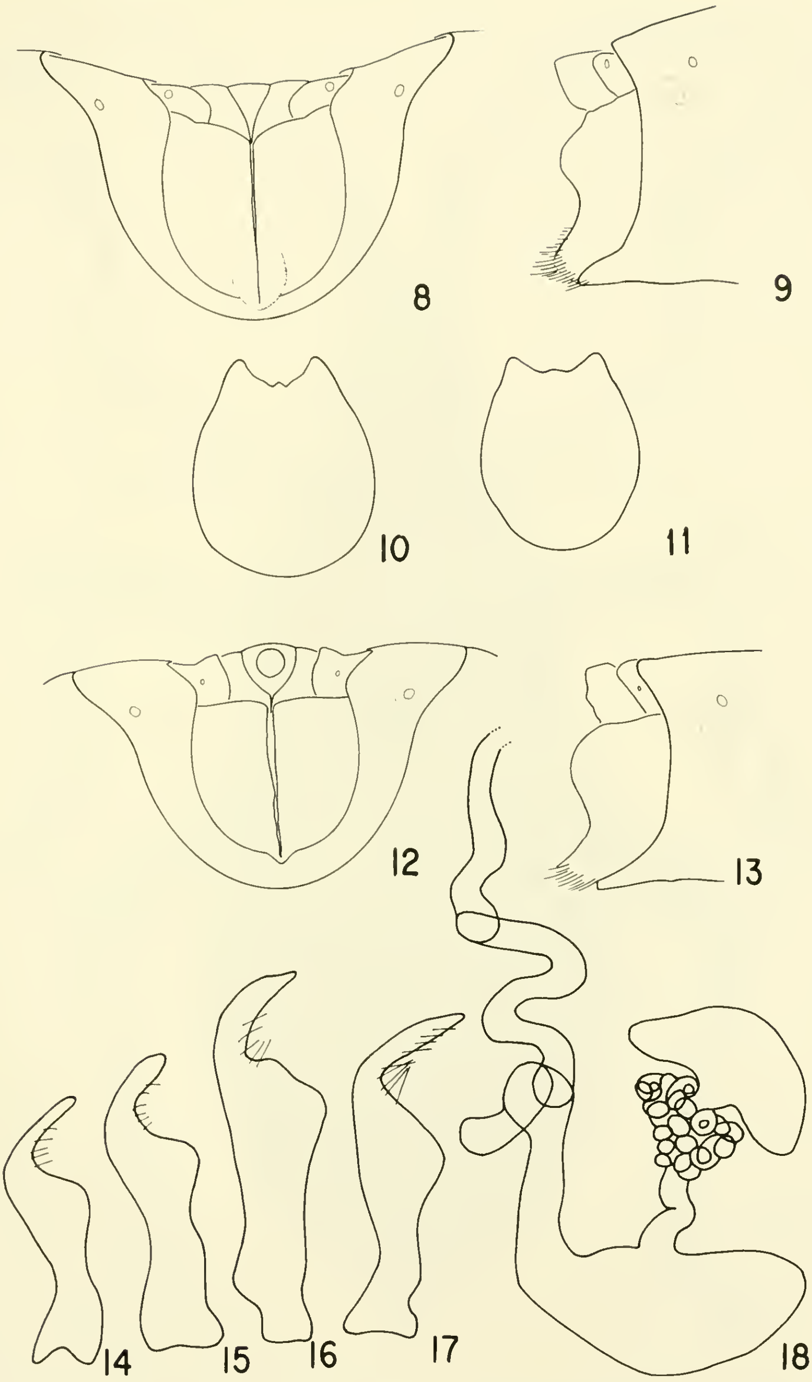
Etymology.—I am pleased to name this new genus for Dr. I. M. Kerzhner, distinguished Russian hemipterist. Gender feminine.

Type species.—*Kerzhnerhygia armata* Brailovsky, new species.

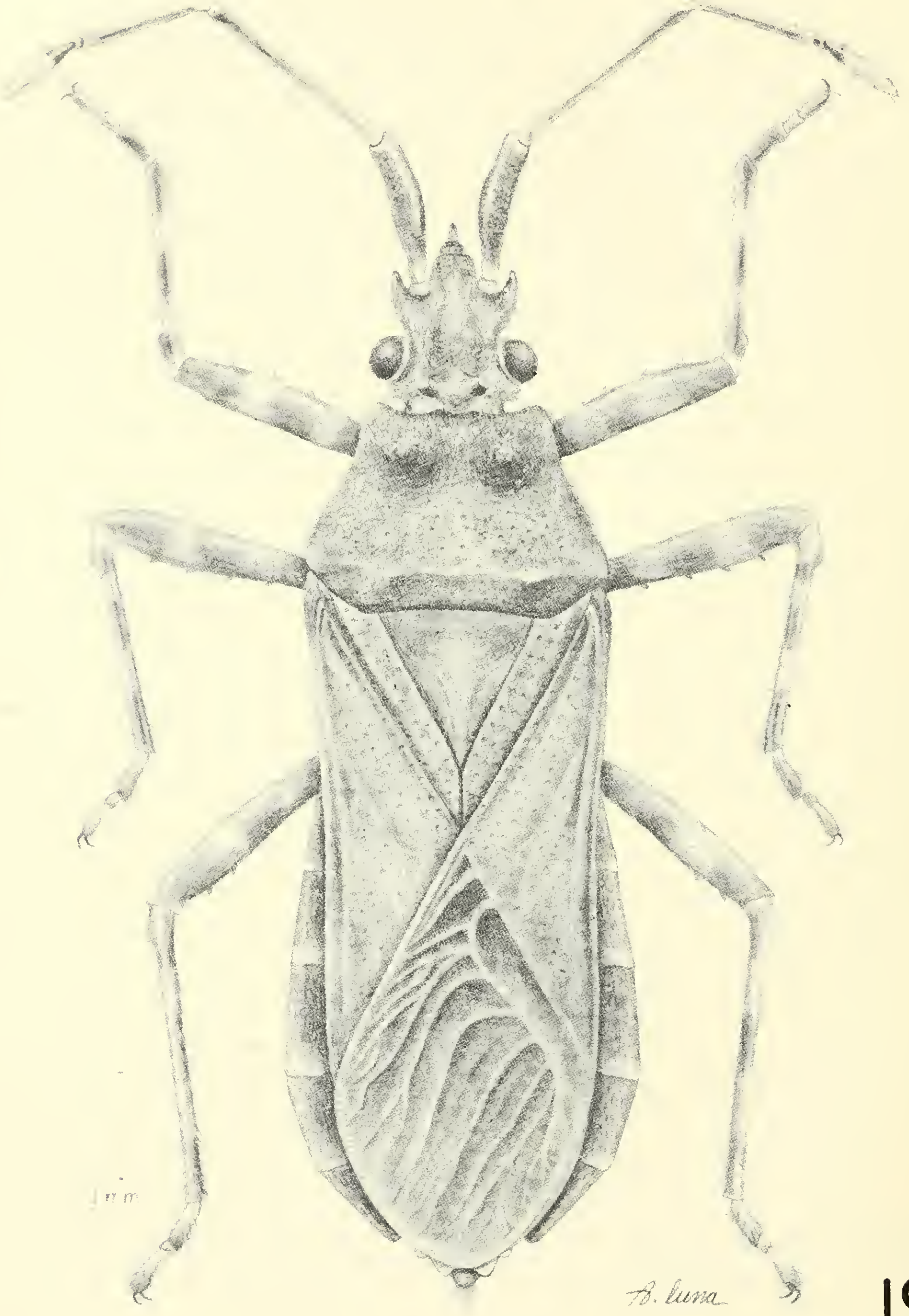
Kerzhnerhygia armata Brailovsky, New Species

Figs. 11–15, 18, 19, 23

Description.—Measurements: Male: Head length 1.45; interocular space 0.86; width across eyes 1.45; preocular distance 1.00; interocellar space 0.41; length antennal segments: I, 1.17; II, 1.76; III, 1.02; IV,

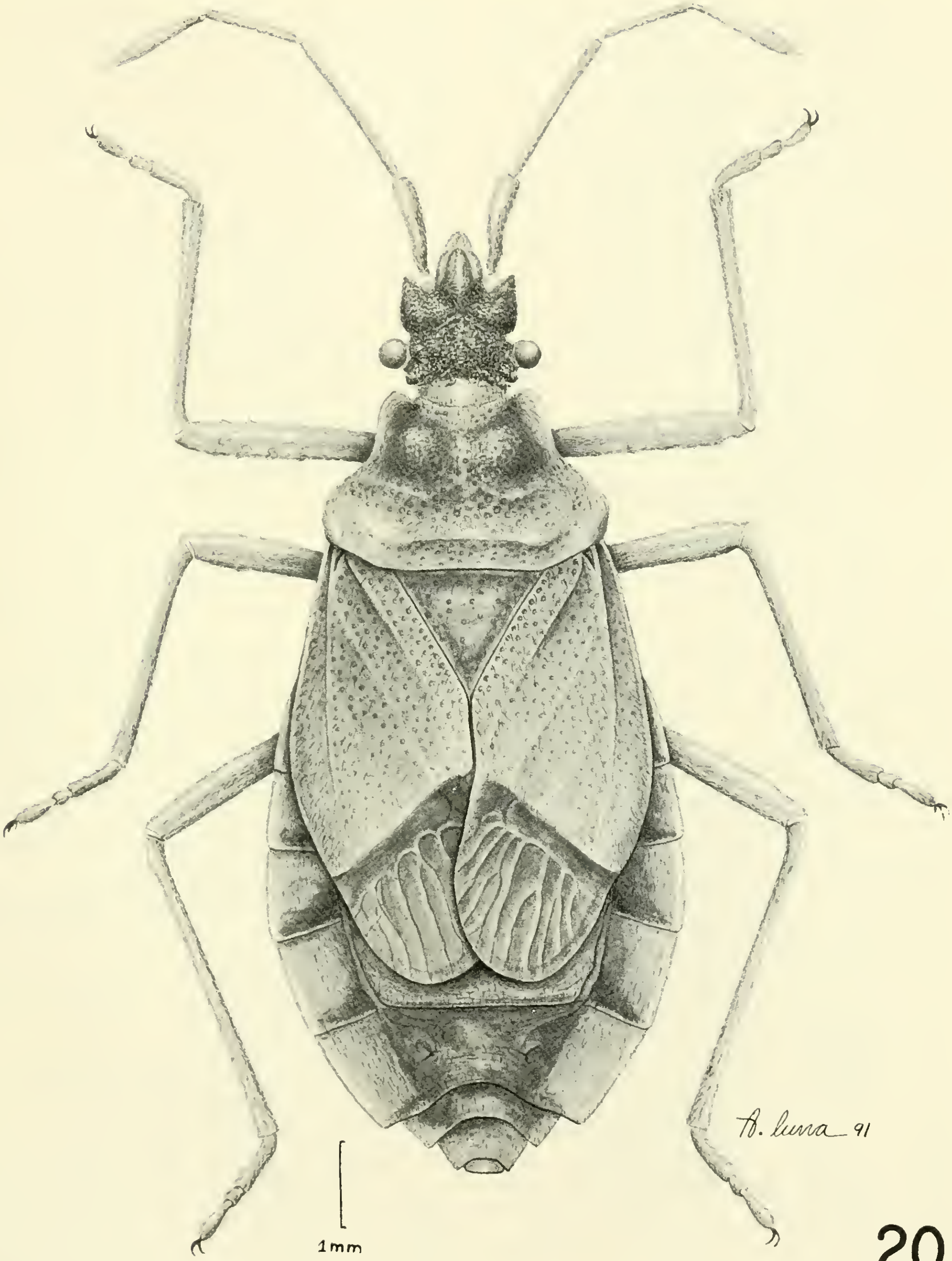


Figs. 8–18. Figs. 8–10. *Kerzhnerhygia robusta.* Figs. 8, 9. Female genital plates. Fig. 8. Frontal view. Fig. 9. Lateral view. Fig. 10. Male genital capsule in frontal view. Figs. 11–13. *Kerzhnerhygia armata.* Fig. 11. Male genital capsule in frontal view. Figs. 12, 13. Female genital plates. Fig. 12. Frontal view. Fig. 13. Lateral view. Figs. 14–17. Parameres. Figs. 14, 15. *Kerzhnerhygia armata.* Figs. 16, 17. *Kerzhnerhygia robusta.* Fig. 18. Spermatheca of *Kerzhnerhygia armata.*



19

Fig. 19. Dorsal view of *Kerzhnerhygia armata.*



20

Fig. 20. Dorsal view of *Wygohygia stylata*.

0.89. Pronotum: Total length 1.70; width across frontal angles 1.39; width across humeral angles 2.75. Scutellar length 1.30; width 1.21. Total body length 9.07.

Female.—Head length 1.55; interocular space 0.89; width across eyes 1.55; preocular distance 1.02; interocellar space 0.46; length antennal segments: I, 1.24; II, 1.86; III, 1.08; IV, 0.87. Pronotum: Total length 1.92; width across frontal angles 1.45; width across humeral angles 3.06. Scutellar length 1.55; width 1.48. Total body length 9.75.

Male.—Dorsal coloration orange chestnut brown with following areas pale yellow: antennal segment IV (except the base), dorsal aspect of postocular tubercle, anterolateral margin of pronotum, apex of scutellum and posterior margin of connexival segments III to VII. Hemelytral membrane amber with dark-brown veins; abdominal terga pale orange red. Ventral coloration: Bright orange red to bright orange chestnut brown, with following areas yellow: posterolateral angles of prothorax, external edge of acetabula, diffuse markings on mesothorax, metathorax and abdominal sternite and each laterotergite of sternal segments III to VII. Coxae and trochanters chestnut brown with yellow markings; femora and tibiae chestnut brown with two yellow rings; tarsi pale yellow chestnut brown; ventral surface of femora with a black apical spot; anterior lobe of metathoracic peritreme pale yellow, posterior lobe pale yellow with apex brown.

Male.—Head: Length equal to width; buccula with a sharp spiny middle projection; rostrum reaching anterior third of abdominal sternite V. Legs: Ventral surface of femora with two rows of long and acute spines. Genitalia.—Genital capsule: Posteroventral edge with two long and robust lobes, curved outward and a short lobe between them (Fig. 11). Parameres: Figs. 14–15.

Female.—Similar to male.

Variation.—Pronotal disc with yellow reflections, hemelytral membrane with inner and outer basal angle dark brown, apical third of tibiae pale brown, tarsi pale orange brown, dorsal head and pronotal calli bright red brown, rostrum extending from anterior third of abdominal sternite V to anterior third of VI, antenniferous tubercle armed with a large, robust spine, and the two rows of femoral spines medium to small.

Type material.—Holotype: ♂, New Guinea, N.E. Kokoda (400 mts.), 15–20 November 1965, J. Sedlacek (light trap) (BPBM). Paratypes: 1 ♀, New Guinea, N.E. Bainyik, nr. Maprik (225 mts.), 20–26 June 1961, J. L. & M. Gressitt (BPBM); 1 ♂, 1 ♀, New Guinea, Berhard Camp B (100 mts.), 5–9 April 1939, L. J. Toxopeus (Neth. Ind. American New Guinea Expedition) (RNHL & UNAM); 1 ♂, 3 ♀♀, New Guinea, Berhard Camp B (100 mts.), July 1938, 19 September 1938 & 1 November 1938, L. J. Toxopeus (Neth. Ind. American New Guinea Expedition) (RNHL & UNAM); 1 ♂, New Guinea N.E., Papua, Mt. Lamington (1300–1500 feet), C. T. McNamara (SAMA); 1 ♀, New Guinea S.E., Milne Bay Dist. Aguan Rd., to Bonenau (900–1500 mts.), 28 October 1974, J. L. Gressitt (BPBM); 1 ♀, New Guinea, Madang Province, Baiteta Rd., 22 km., W. of North Coast Rd. (60 mts.), 22 April 1989, stop # 89-86, D. H. Kavanaugh, G. E. Ball & N. D. Penny (CAS).

Etymology.—This species is named for the elongate spinelike shape of the antenniferous tubercle.

Distribution.—Known only from the type locality, New Guinea.

Kerzhnerhygia robusta Brailovsky, New Species

Figs. 8–10, 16, 17, 24

Description.—Male: Head length 1.27; interocular space 0.86; width across eyes 1.51; preocular distance 0.86; interocellar space 0.44; length antennal segments: 1.24; II, 1.73; III, 0.99; IV, 0.77. Pronotum: Total length 1.86; width across frontal angles 1.55; width across humeral angles 3.37. Scutellar length 1.55; width 1.51. Total body length 9.00.

21

22

23

24

Figs. 21–24. Dorsal view. Fig. 21. *Acarihygia fijiana.* Fig. 22. *Wygohygia stylata.* Fig. 23. *Kerzhnerhygia armata.* Fig. 24. *Kerzhnerhygia robusta.*

Female: Head length 1.30, interocular space 0.89; width across eyes 1.59; preocular distance 0.94; interocellar space 0.48; length antennal segments: I, 1.20; II, 1.76; III, 1.02; IV, 0.80. Pronotum: Total length 1.98; width across frontal angles 1.58; width across humeral angles 3.59. Scutellar length 1.70; width 1.67. Total body length 9.60.

Male: Dorsal coloration: Orange brown with following areas pale yellow: dorsal aspect of postocular tubercle, anterolateral margin of pronotum, diffuse markings on the middle third of pronotal disc and posterior margin of connexival segments III to VII. Head, pronotal calli and most of scutellum bright red brown; hemelytral membrane dark amber, with inner and outer basal angle and veins dark brown, abdominal terga pale orange red. Ventral coloration: Head bright red brown; rostral segments I to IV pale orange chestnut brown with yellow markings; thorax bright orange chestnut brown with diffuse yellow markings on prothorax, metathorax and external edge of acetabula; coxae, and trochanters orange chestnut brown; femora and tibiae chestnut brown with two yellow rings; tarsi chestnut brown with yellow reflections; anterior lobe of metathoracic peritreme yellow, the posterior lobe dark brown; abdominal sternites dark yellow with following areas black to dark red brown: punctures and pleural margins except the posterior border.

Male.—Head: Buccula rounded, without spiny projection at middle; rostrum short, reaching posterior third of abdominal sternite III. Legs: Femora unarmed. Genitalia.—Genital capsule: Posteroventral edge with two long robust lobes, curved to middle side and between them with a short lobe (Fig. 10). Parameres: Figs. 16, 17.

Female.—Similar to male, but with the following difference: Posterior tibiae pale yellow with two brown rings, one basal, the other near middle third.

Type material.—Holotype: ♂, New Guinea, Berhard Camp (50 mts.), 7 October 1938, J. Olthof (Neth. Ind. American New Guinea Expedition) (RNHL). Paratypes: 1 ♀, same data as for holotype (UNAM).

Etymology.—The specific epithet is used to the stout body of this species.

Distribution.—Known only from the type locality, New Guinea.

KEY TO THE KNOWN SPECIES OF *KERZHNERHYGIA*

1. Rostrum reaching anterior third of abdominal sternite V or VI; femora armed with two rows of long spines; buccula with a sharp projection at middle ...... *armata* Brailovsky, new species

– Rostrum reaching posterior third of abdominal sternite III: femora, unarmed; buccula rounded without projection at middle .... *robusta* Brailovsky, new species

Wygohygia Brailovsky, NEW GENUS

Diagnosis.—This new genus closely resembles *Homalocolpura* Breddin in having a bright and highly polished head and ventral surface, armed femora, unarmed tylus, a flattened scutellum, and plica and fissura on abdominal sternite VII of the female.

It differs in a number of important characteristics, among which are the following: 1—Eyes small, protrudent on short stalks. 2—Head quadrate. 3—Femora with only one or two short blunt spines. 4—Tibiae unarmed. 5—Buccula with sharp anterior projection. 6—Antenniferous tubercle externally armed. In *Homalocolpura* the eyes are sessile, the head is pentagonal, the femora have two rows of small spines running across ventral surface, the tibiae are armed, the buccula is rounded, and antenniferous tubercles are unarmed.

Generic description.—Head: Little longer than wide, quadrate and dorsally flattened; tylus unarmed, apically globose, extending anterior to and laterally higher than juga; jugum unarmed, thickened and shorter than tylus; antenniferous tubercle armed with a long robust spine; side of head in front of eye unarmed and slightly convex; antennal segment I, robust, thickest, slightly curved outward and shorter than head; segments II and III cylindrical and slender; segment IV fusiform; segment II longest; segment IV longer than I; segment III the shortest; ocelli small, not elevated; preocellar pit deep; eyes small, protrudent on short stalks; postocular tubercle protuberant; buccula rounded, short, not projecting beyond antenniferous tubercle, with a sharp anterior projection; rostrum long, reaching anterior third of abdominal sternite VII; rostral segment IV longest, II and III subequal and I the shortest; rostral segment I reaching posterior gular region.

Thorax.—Pronotum wider than long, trapeziform; collar wide; frontal angles produced forward as rounded, thickened lobes; humeral angles rounded, not expanded; posterolateral and posterior edge straight; calli transversely convex, separated along midline by a slightly longitudinal depression; posterior pronotal lobe with two lateral irregular convexities separated by a longitudinal depression; posterior margin with a transverse ridge. Anterior lobe of metathoracic peritreme reniform, posterior lobe sharp, small.

Legs.—Femora armed with one or two short, blunt, ventral, anteapical spines; tibiae cylindrical, dorsally with a vague longitudinal sulcus.

Scutellum.—Triangular, wider than long, with sharp apex.

Hemelytra.—Submacropterous, reaching the posterior third of abdominal segment VI; clavus and corium almost or quite fused; hemelytral membrane well developed with a few of the veins furcate.

Abdomen.—Connexival segments strongly elevated, higher than margin of hemelytron at rest; posterior angle of the connexival complete; abdominal sternites with the medial furrow extending to posterior border of sternite V.

Integument.—Mostly dull, with the head and ventral surface shining. Head, pronotum, scutellum, hemelytra, thorax, abdomen, and exposed parts of genital segments punctate; connexival segments smooth. Head, pronotum, scutellum, hemelytra and abdominal sternites with short decumbent silvery bristlelike setae, intermixed with long erect setae located on the pronotum and abdominal sterna; thorax nearly glabrous; antennal segments and legs covered by long and short setae.

Female genitalia.—Abdominal sternite VII with plica and fissura; plica triangular, reaching posterior third of sternite VII; gonocoxa I squarish and the longest; paratergite VIII short, square, with visible spiracle; paratergite IX square, little larger than paratergite VIII (Figs. 2, 3).

Etymology.—This species is named for the late Dr. Pedro Wygodzinsky.

Type species.—*Wygohygia stylata* Brailovsky, new species.

Wygohygia stylata Brailovsky, NEW SPECIES

Figs. 2, 3, 20, 22

Description.—Female: Head length 2.07; interocular space 1.27; width across eyes 2.05; interocellar space 0.68; preocular distance 1.42; length antennal segments: I, 1.36; II, 2.10; III, 1.24; IV, 1.96. Pronotum: Total length 2.29; width across frontal angles 1.95; width across humeral angles 3.78. Scutellar length 1.55; width 1.67. Total body length 12.04.

Dorsal coloration.—Head bright black with red reflections; antennal segments I to III dark orange chestnut brown and IV pale yellow with base darker; pronotum dark orange chestnut brown, with callar region bright brownish red; hemelytra pale orange chestnut brown; connexival segments orange with posterior margin black; abdominal terga orange red, with some scattered black areas. Ventral coloration.—Head bright black with red reflections; rostral segments, thorax, legs and abdomen bright brownish orange with following areas pale yellow orange: anterior lobe of metathoracic peritreme and pleural margins of the abdominal sternites III to VII; tibiae bright brownish orange with one or two pale yellow rings, not clearly differentiated.

Type material.—Holotype: ♀, New Guinea, N.W. Wisselmeren, Enarotadi (1800–1900 mts.), 25 July 1962, J. Sedlacek (BPBM).

Etymology.—The specific epithet of the species is used to refer to the protruding eyes.

Distribution.—Known only from the type locality, New Guinea.

ACKNOWLEDGMENTS

I thank the following colleagues and institutions for the loan of specimens and other assistance relevant to this study: Gordon M. Nishida (BPBM); Norman D. Penny (CAS); Jan van Tol (RNHL); Gordon F. Gross, E. G. Matthews and K. L. Gowlett Holmes (SAMA); Richard C. Froeschner (USNM). I also express special thanks to Ernesto Barrera (UNAM), Albino Luna (UNAM), Elvia Esparza (UNAM) and Felipe Villegas (UNAM) for the preparation of the dorsal view illustrations and to the Consejo Nacional de Ciencia y Tecnología, México (CONACyT) for financial assistance to visit the Bernice P. Bishop Museum in Hawaii.

Comments on the manuscript from two anonymous reviewers are greatly appreciated.

LITERATURE CITED

Brailovsky, H. 1990. Three new species of Indo-Pacific Colpurini (Hemiptera: Heteroptera: Coreidae). Pan-Pacific Entomologist 66(4): 292–300.

Brailovsky, H., E. Barrera, and W. Lopez-Forment. 1992. Revision of the genus *Tachycolpura* Breddin (Hemiptera: Heteroptera: Coreidae, Colpurini). Pan-Pacific Entomologist 68(2): 122–132.

Dolling, W. R. 1987. A mimetic coreid bug and its relatives (Hemiptera: Coreidae). Journal of Natural History 21: 1259–1271.

Maschwitz, U., B. Fiala, and W. R. Dolling. 1987. New trophobiotic symbioses of ants with South Asian bugs. Journal of Natural History 21: 1097–1107.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 449–452

DIEUCHES ARMATIPES (WALKER) (HETEROPTERA: LYGAEIDAE) NEWLY DISCOVERED IN THE WESTERN HEMISPHERE

THOMAS J. HENRY AND RICHARD C. FROESCHNER

(TJH) Systematic Entomology Laboratory, Plant Sciences Institute, ARS, USDA, % National Museum of Natural History, Washington, D.C. 20560; (RCF) Department of Entomology, MRC-127, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

Abstract.—The rhyparochromine lygaeid **Dieuches armatipes** (Walker) is reported in the New World from the Dominican Republic, Grand Cayman Island, Jamaica, and St. Kitts. Although these are the first confirmed records of this genus and species in the Western Hemisphere, Walker's original description is based on a specimen from "America." Thus, our records challenge the correctness of the recent designation of a neotype from Senegal, Africa. This species is said to be a pest of peanuts in Africa. A redescription and diagnostic information are provided to help distinguish it from other New World Lygaeidae.

Key Words: Heteroptera, Lygaeidae, new record, Western Hemiphere, West Indies, *Dieuches armatipes*

Five specimens of the rhyparochromine lygaeid *Dieuches armatipes* (Walker) have been intercepted by the U.S. Department of Agriculture's APHIS/PPQ personnel since 1984 from the Dominican Republic and Jamaica at ports of entry in the United States. Discovery of the first specimen did not provide convincing evidence that populations of this species occur in this Hemisphere. Additional interceptions and recent collections from Grand Cayman and St. Kitts islands by R. M. Baranowski and W. B. Steiner, however, indicate that *D. armatipes* is established in the West Indies.

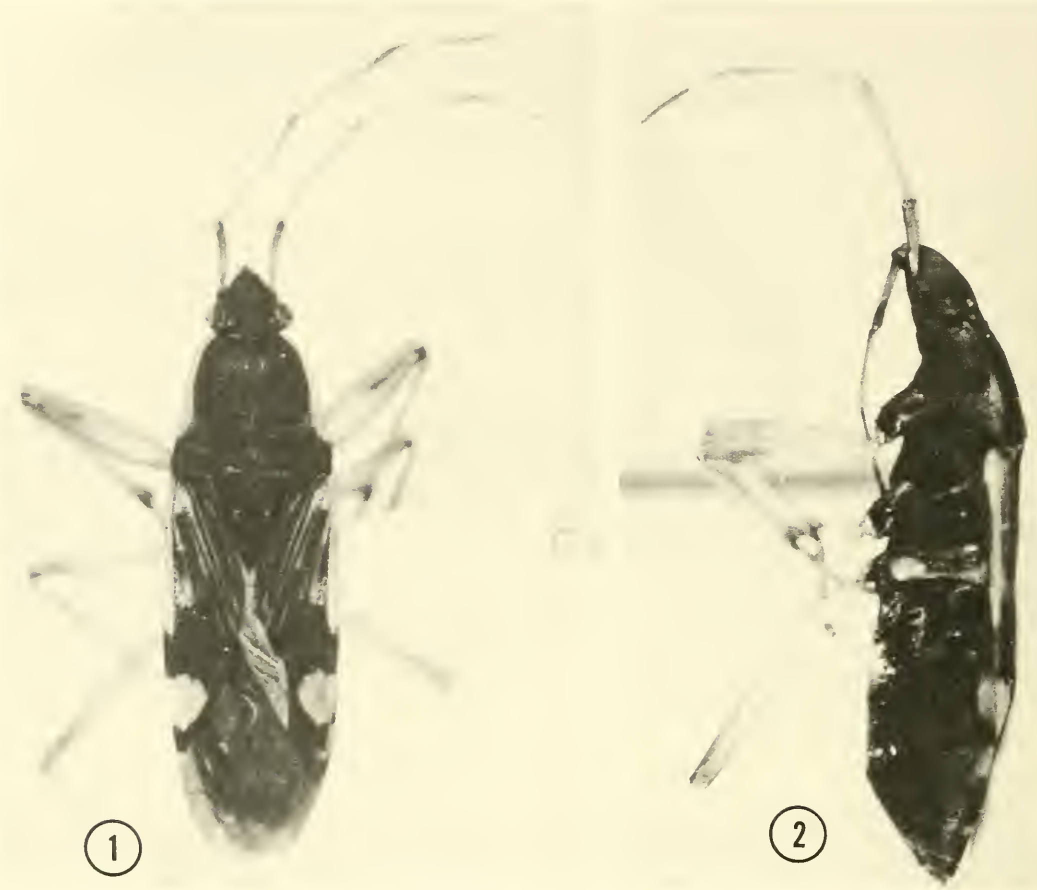
Members of the genus *Dieuches* Dohrn are restricted to the Old World where the majority of the 131 species treated by Eyles (1973) occur in the Afro-tropical Region. *Dieuches armatipes* is one of several species in the genus that have attained pest status. According to Eyles (1973), it has been recorded as a serious pest of peanuts in several localities of Africa where it reduces the oil content and causes the nuts to shrivel and become bitter. Apparently *D. armatipes* will attack peanuts in the ground and those stored in piles after harvest. It also has been associated with melons and peppers, but it may be that these crops stored in the field in crates at harvest merely provide an attractive hiding place for a bug that otherwise normally feeds on fallen seeds in and around a given crop.

In this paper we give the "first" New World records for *D. armatipes,* review its distribution and hosts, and redescribe and provide photographs of the adult to help recognize this adventive Old World bug.

Dieuches armatipes (Walker)
(Figs. 1, 2)

Rhyparochromus armatipes Walker 1872: 91.

Dieuches armatipes: Eyles 1973: 99 (redescription, neotype designation, synonymy, distribution, economic importance).



Figs. 1, 2. Female of *Dieuches armatipes.* 1, dorsal aspect. 2, lateral aspect.

Diagnosis.—*D. armatipes* can be distinguished from all other New World Rhyparochrominae by its large, slender size (more than 10.00 mm long), dorsal position of abdominal spiracles III–IV (tribal character), wide white band on antennal segment IV, and by the uniquely marked hemelytra (Fig. 1), having pale costal margins, pale veins, and a large pale subapical spot on the corium.

This species most likely could be confused with *Elasmolomus sordidus* (F.), the only other large member of the tribe Rhyparochromini known in the New World (from the Sao Paulo region of Brazil) (Slater 1972), but *E. sordidus* is generally yellowish brown with the head, anterior lobe of the pronotum, and basal third of the scutellum dark brown.

Dieuches armatipes keys to *Balboa ampliata* (Barber) [as *Dieuches occidentalis* Torre Bueno and now in Ozophorini] in Torre-Bueno (1946) based on the curved lateral abdominal sutures, the long combined lengths of rostral segments I and II, the widely placed trichobothria, the carinate lateral margin of the pronotum, the slender, nearly glabrous antennae, and weakly punctate pronotum, with the calli having weak, scattered punctures. It is readily separated from *B. ampliata* based on the rhyparochromine tribal character of dorsal spiracles on abdominal segments 3–4, and further by the larger size, more widely explanate pronotal margins, and by the wide white band on the basal half of antennal segment IV.

It keys to *Peritrechus* Fieber in Slater and Baranowski (1990) based on the incomplete, forward-curving, lateral abdominal sutures and dorsally placed abdominal spiracles 3–4. It is readily distinguished from this genus by the much larger size (*Peritrechus* spp. 6.00 mm or less), widely explanate pronotal margins, the white band on antennal segment IV, and the numerous spines on the profemora (3 or less in *Peritrechus*).

Description.—[measurements are for 4 ♀♀ and (in parentheses) 1 ♂]: Rhyparochrominae: Rhyparochromini: Elongate, subparallel, relatively large, length 10.00–10.67 mm (11.00 mm), width across widest area of hemelytron 2.88–3.46 mm (3.16 mm). *Head:* Length 1.44–1.56 mm (1.44 mm), width across eyes 1.60–1.68 mm (1.64 mm), vertex 0.84–0.88 mm (0.88 mm); fuscous, impunctate except for finely punctate central area of vertex; buccula short, narrow, gular groove short, extending only to level even with anterior margin of eye; antenniferous tubercle weakly declivent, arising at level even with lower ⅓ of eye; ocelli widely separated, set near inner posterior margin of eye. *Rostrum:* Length 4.32–4.44 mm (4.50 mm), extending to bases of mesocoxae. *Antenna:* Yellowish brown, segment I and apex of II darker brown, segment IV dark brown with a wide white band on basal half; segment I, length 1.08–1.12 mm (1.20 mm); II, 2.08–2.24 mm (2.32 mm); III, 2.00 mm; IV, 2.00 mm (2.12 mm). *Pronotum:* Length 1.96–2.24 mm (2.52 mm), basal width 2.52–2.84 mm (2.80 mm); trapeziform, dark brown or fuscous, with explanate lateral margins (narrower on anterior lobe than diameter of 1st antennal segment) and part of median line yellow; anterior lobe densely, but finely punctate, calli quadrate, weakly shining; posterior lobe deeply, but less densely punctured than anterior lobe, posterior margin truncate. *Scutellum:* Triangular, much longer than wide, apex extending to about middle of corium, fuscous, with apex and small spot on either side of middle yellow. *Hemelytron:* Extending to apex of abdomen in female and slightly beyond in male; largely fuscous, with basal ⅔ of costal margin, large subapical spot, and cubital, claval, and radial veins yellow; membrane dark brown or fuscous, with bases of veins yellow. *Ventral surface:* Fuscous, with distal part of acetabula, posterior edge of metapleural region, and lateral margins of abdominal segments 5 and 6 invaded by yellow; abdominal spiracles III and IV dorsal. *Legs:* Pale yellow, apices of pro- and mesofemora usually fuscous.

Taxonomic notes.—Eyles (1973) provided photographs (figs. 72, 73) and a line drawing (fig. 74) of the adult, figures of male and female genitalia (figs. 66–71), and a key to the species of *Dieuches*.

Distribution.—This species is known to range over most of Africa, north to at least Spain. It is one of five species of *Dieuches* (*D. armipes* (Fabricius), *D. mucronotus* (Stål), *D. schmitzi* Reuter, and *D. syriacus* Dohrn) that occur in the Mediterranean Region (Eyles 1973).

New World records.—*Dominican Republic:* 1 ♂, 1 ♀, intercepted at Elizabeth, New Jersey, 15 Feb. 1984, 1 May 1986 (U.S. Natl. Mus. Nat. Hist., Washington, D.C.—USNM); 1 ♀, intercepted at Ft. Lauderdale, Florida, 9 April 1986 (USNM); 1 ♀, intercepted at Miami, Florida, 2 Aug. 1990 (USNM). *Grand Cayman Island:* 1 ♀, South Sound, 20 June 1986, P. Fitzgerald (University of Florida, Homestead—UFH); 1 ♂, ♀, Rum Point, 19°22′N, 81°16′W, 22 Feb. 1993, W. E. Steiner & J. M. Swearingen (USNM). *Jamaica:* 1 ♀, intercepted at Miami, Florida, 27 May 1986 (USNM). *St. Kitts:* 1 ♂, Garvey's Estate, 14 Aug. 1989, Knight, Wallace, & Picard, BL trap (UFH); 1 ♂, Burkley's Estate, 4 May 1990, Knight, Wallace, & Picard, BL trap (UFH); 1 ♂, Agronomy Dept., 13 Aug. 1990, Knight, Wallace, & Picard, BL trap (UFH); 1 ♀, Cardi, 24 May 1990, Knight, Wallace, & Picard, BL trap (UFH).

Discussion.—Because the intercepted specimens were associated with three different crops (pineapple, *Ananas comosus* (L.) Merr.; melons, *Cucumis melo* L.; and peppers, *Capsicum* sp.), they were probably merely acting as "hitchhikers" trapped in fieldpacked containers, rather than serving as primary pests feeding on the produce itself.

The two specimens from Rum Point, Grand Cayman, were collected on a dune strand crest in leaf litter under the shrub *Scaveola plumieri* (L.) [Goodeniaceae] and adjacent clumps of searocket, *Cakile lanceolata* (Willd.) O. E. Schulz [Asteraceae]. Several other specimens also were observed (W. E. Steiner, Jr., pers. comm.) but not collected, indicating that *D. armatipes* was relatively common at this site.

Although our records apparently represent the first authentic ones from the Western Hemisphere, it is curious that Walker (1872: 91) described *D. armatipes* from "America. Presented by Capt. Friend." Eyles (1973) redesignated the type locality as Senegal, Africa, and disregarded Walker's type locality by stating "Purported to be from America, this was doubted by Distant (1901) and even earlier by Dallas (1852). . . ." We note that Van Duzee (1917) also rejected its New World presence with the notation "Not American."

The apparent ease in which this species stows away in commerce makes it quite plausible that *D. armatipes* arrived early in the New World in ship's cargo and ballast material during the 18th and 19th centuries. We feel that our findings now challenge the virtue of Eyles' decision to redesignate the type locality. Captain Friend's specimen certainly could have represented a legitimate record from "America."

ACKNOWLEDGMENTS

We are grateful to R. M. Baranowski (University of Florida, Homestead) for allowing us to report his specimens from Grand Cayman and St. Kitts islands, to J. A. Slater (University of Connecticut, Storrs) and Dr. Baranowski for their efforts to help us confirm the identification of this lygaeid and for reviewing the manuscript, and to W. B. Steiner, Jr. (USNM) for sharing with us his observations on *D. armatipes* from Grand Cayman. D. R. Smith (SEL, USDA, Washington, D.C.) and R. W. Hodges (SEL) also kindly reviewed the manuscript.

LITERATURE CITED

Dallas, W. S. 1851–1852. List of the Specimens of Hemipterous Insects in the Collection of the British Museum. Taylor & Francis, Inc., London. 1: 1–368 (1851); 2: 369–592 (1852), plates 12–15.

Distant, W. L. 1901. Rhynchotal notes XI. Heteroptera: Fam. Lygaeidae. Annals and Magazine of Natural History (7)8: 464–486, 497–510.

Eyles, A. C. 1973. Monograph of the Genus *Dieuches* Dohrn (Heteroptera: Lygaeidae). Otago Daily Times Ltd., Dunedin, New Zealand. 465 pp.

Slater, J. A. 1972. The occurrence of *Elasmolomus sordidus* (F), a potential pest of peanuts, in Brazil (Hemiptera: Lygaeidae). Biológico 38: 394–397.

Slater, J. A. and R. M. Baranowski. 1990. Lygaeidae of Florida (Hemiptera: Heteroptera). Arthropods of Florida and Neighboring Land Areas. Vol. 14. Florida Department of Agriculture & Consumer Services, Contribution No. 725. Gainesville, Florida. 211 pp.

Torre-Bueno, J. R. de la. 1946. A synopsis of the Hemiptera-Heteroptera of America north of Mexico. Part III. Family XI-Lygaeidae. Entomologica Americana 26: 1–141.

Van Duzee, E. P. 1917. Catalogue of the Hemiptera of America north of Mexico excepting the Aphididae, Coccidae and Aleurodidae. University of California Publications, Technical Bulletins, Entomology, Berkeley. 2: i–xvi + 902 pp.

Walker, F. 1872. Catalogue of the Specimens of Heteropterous-Hemiptera in the Collection of the British Museum. Part V. British Museum, London. 202 pp.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 453–456

NOTES ON THE MORPHOLOGY AND FAMILY RELATIONSHIPS OF LESTONIIDAE (HEMIPTERA: HETEROPTERA)

CARL W. SCHAEFER

Department of Ecology and Evolutionary Biology, University of Connecticut, U-43, Storrs, Connecticut 06269-3043.

Abstract.—Some hitherto undescribed features of the small Australian family Lestoniidae are discussed. These features include aspects of the male genitalia and the pregenital abdomen. The family is related to Plataspidae, but others' suggestions that it is also related to Scutelleridae are not confirmed.

Key Words: Hemiptera, Heteroptera, Pentatomoidea, Lestoniidae, Plataspidae, Scutelleridae, Morphology

Lestoniidae, a family of Australian Pentatomoidea, contains two species, *Lestonia haustorifera* China and *L. grossi* McDonald. Its family-level relationships and many aspects of its morphology have been ably described by China (1955) and McDonald (1969, 1970). In particular, China (1955), in describing the genus *Lestonia*, created for it a new subfamily in the Plataspidae; he later (China and Miller 1959) raised it to family rank. McDonald (1970) concluded Lestoniidae is indeed close to Plataspidae, and more distantly related to Scutelleridae.

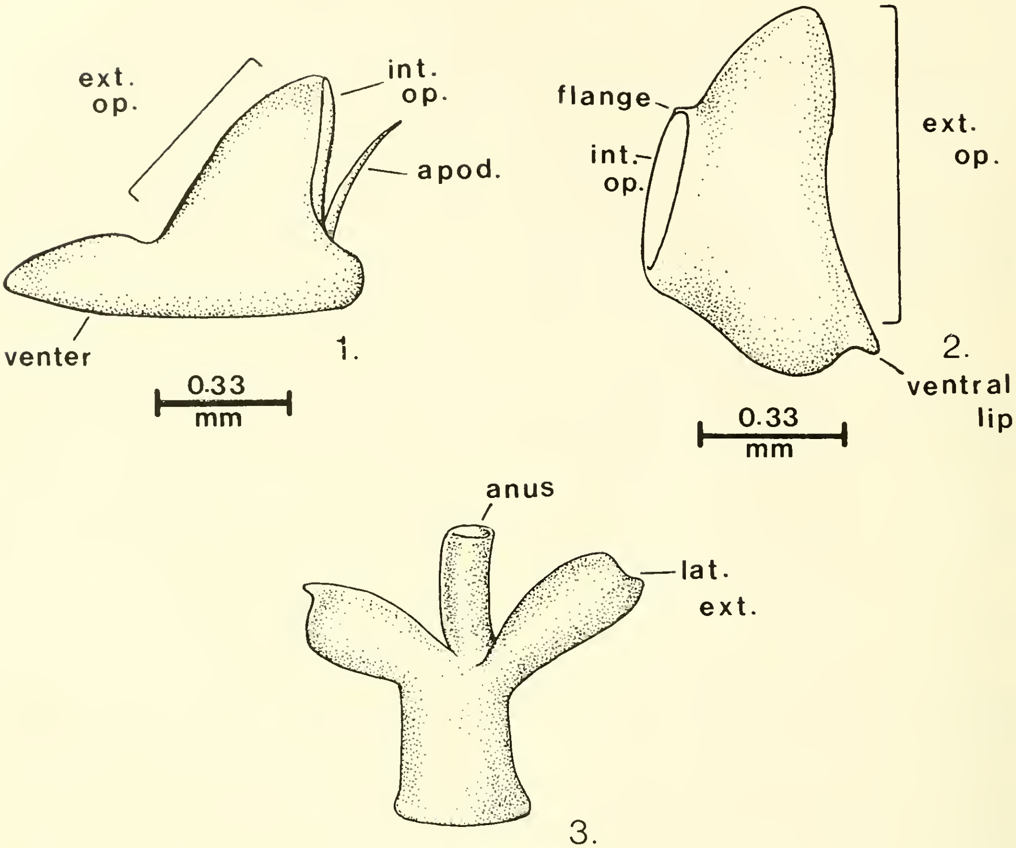
McDonald's (1969, 1970) illustrations of the male's genital capsule suggested to me a possible affinity of the family to a group of "primitive" pentatomoids centered on Cydnidae. Plataspidae is a member of this group, and perhaps Scutelleridae is related to it. Accordingly, when G. F. Gross generously sent me several specimens of *L. haustorifera*, I looked at several morphological features not mentioned in earlier work, to confirm or deny these affinities. This paper is therefore meant to complement the fine ones of China and McDonald, not to replace them.

METHODS

Genital capsules of male specimens, already soft from having been stored in alcohol, were very lightly treated with cold dilute KOH.

RESULTS

Abdomen.—Tergites 3–7 fused, inter-tergal sutures visible only in lateral third of segment, except second-third visible across entire tergum. Eighth paratergites of female completely fused on midline, extending posteriorly. No connexivum or inner laterotergites. Sternites 3–7 fused, intersternal sutures clearly visible only laterally, very faintly visible medially; except third-fourth visible across sternum, as slight internal ridge. Second sternite very narrow medially, and with rounded median apodeme extending anteriorly. Sixth sternite on either side of midline with round "gland-like" area in female; this smaller, comma-shaped, in male. McDonald (1970) describes three such pairs on sternites 5–7 (largest on 6) in *L. grossi*, but does not mention (1969) them in *L. haustorifera*.



Figs. 1–3. *Lestonia haustorifera*, male. 1. eighth segment (lateral view). 2. genital capsule (lateral view). 3. proctiger (dorsal view), apod. = apodeme, ext. op. = external opening, int. op. = internal opening, lat. ext. = lateral extension.

Trichobothria and spiracles.—Two pairs of trichobothria, on sternites 3–7. Trichobothria side by side, of same size, both lateral (ectal) to spiracle (*contra* McDonald [1970]). Spiracles more medial than in most Pentatomoidea. All spiracles towards anterior edge of small, pale brown, oval area; these areas not shown by McDonald (1970) for *L. haustorifera,* but shown by him (1969) for *L. grossi.*

Coxal combs.—None.

Metathoracic wing strigil.—None.

Male's eighth segment (Fig. 1).—Interior opening anterior, but venter somewhat expanded anteriorly, below internal opening. Stout apodeme arising external to segment, from venter of internal opening. Venter greatly expanded posteriorly, as a "scoop" covering nearly entire venter of genital capsule; that part of scoop expanded (not withdrawn into insect's body) of rougher texture than concealed part. Without remnant of spiracle.

Male's genital capsule (Fig. 2; also McDonald 1969, fig. 4, and McDonald 1970, fig. 2[1]).—External opening posterior; internal opening anterior and slightly dorsal, its edge produced as a slight flange. Ventral rim folded in parallel to ventral wall and apparently fused to it; ventral rim flared slightly as a ventral lip; ventral rim not expanded. Dorsal rim only somewhat expanded, it and

---

[1] In fig. 4 of McDonald (1969), "ventral margin" should be "dorsal margin."

lateral rim folded in perpendicular to their walls, meeting ventral rim smoothly. Cuplike sclerite and median projection tightly fused, this composite structure rising slightly above level of external opening; slight space intervening between composite structure and ventral rim infolding. Cuplike sclerite with well sclerotized lateral "arms." Without suspensory apodemes; suspensory plates of basal plate apparatus apparently articulating directly with arms of cuplike sclerite.

Male's paramere (see McDonald 1970, fig. 5).—Insertions displaced so tips lie dorsally, not ventrally (capsule's external opening directly posterior). Paramere tip blunt, with very small recurved point. Shaft straight, ending in long apodemelike extension opposite the flattened attachment apodeme.

Male's proctiger (Fig. 3).—Dorsum lightly sclerotized basally, sclerotization extending a little way laterally, but not ventrally. Pair lateral extensions arising subapically; these membranous, irregular in shape. Proctiger not modified for protection of aedeagus (as in "higher" Pentatomoidea).

Discussion

Family status of Lestoniidae.—The family has several features unusual in its superfamily, and a few that may be unique: the apodeme of the male's eighth segment; the lack of a suspensory apodeme on the cuplike sclerite of the male's genital capsule; the membranous appendages of the male's proctiger; the dorsal orientation of the parameres; the fusion of the female's eighth paratergites; the placement of both trichobothria lateral to the spiracle; (perhaps) the oval patches accompanying the spiracles, and the latter's more medial position; and the slight flange of the internal opening of the male's genital capsule. *Lestonia haustorifera* is unusual also in having a cupressaceous host plant, *Callitris preissi* (McDonald 1970, G. F. Gross, pers. commun. 1991), a plant whose genus is restricted to Australia and New Guinea (Willis 1973). Although several pentatomoids feed on members of the Cupressaceae, this is not a common host family. The host plant of *L. grossi* is unknown.

This combination of apomorphies fully confirms China and Miller's (1959) raising of Lestoniinae to family rank, and McDonald's (1969, 1970) acceptance thereof.

Family relationships of Lestoniidae.—As McDonald (1970) notes, the structure of the aedeagus, and the lack of flanges on the spermatheca and of a dilation of the spermathecal duct, exclude Lestoniidae from Pentatomidae and the families related to it. The spermathecal features are, he says, like those of Cydnidae, and one (the lack of flanges) like some Scutelleridae (but see below). The enlarged scutellum (China 1955) is also characteristic of Scutelleridae, but this occurs in several other groups (including a few pentatomids) as well.

The lestoniid aedeagus resembles that of Plataspidae (McDonald 1970). In addition, both families are members of a complex of pentatomoid groups (Cydnidae [sensu Dolling 1981, plus Parastrachiinae], Cyrtocoridae, Canopidae, Megarididae) defined by several features, especially of the genital capsule (Schaefer, in preparation). More particularly, Lestoniidae resembles Plataspidae in more of these capsule characteristics than it does any other member of the complex. However, Plataspidae and a few others of the complex have an exceptionally broad infolding of the capsule's dorsal rim; the infolding of Lestoniidae and the remainder is less broad. Lestoniidae may, therefore, link these two subgroups.

The duct of the spermatheca is simple (i.e., unswollen) in some members of the Plataspidae's subgroup, and in Lestoniidae. However, only in Lestoniidae and Megarididae (not a member of that subgroup) does the spermathecal bulb lack flanges (McDonald 1970, 1979). (McDonald's 1970 statement that Cydnidae also lack flanges is in error; see Pendergrast 1957 and McDonald 1966.) The simple spermathecal duct is probably plesiomorphic. Because the spermathecal bulbs of most relatives of the Pentatomoidea—as well as of most pentatomoids—have flanges (Pendergrast 1957), their absence here in Lestoniidae and Megarididae is probably apomorphic, but not necessarily autapomorphic.

Some members of this complex have a stridulitrum on the hind wing (Schaefer 1981), and others do not; Plataspidae does, but Lestoniidae does not. Many members also have coxal combs (presumably for cleaning the antennae); neither Lestoniidae nor Plataspidae have them. The amount of tergal and sternal fusion in Lestoniidae is like that of other pentatomoids. Lestoniidae lacks inner laterotergites, as do some other members of the complex. More unusual is the lack of a connexivum in Lestoniidae, a fact doubtless secondary and perhaps correlated with the small size of the insect and the great abdomen-covering development of its scutellum.

These results confirm China's (1955) and McDonald's (1970) conclusion that Plataspidae and Lestoniidae are phylogenetically close. A more comprehensive cladistic analysis is needed to show if they are sister groups.

McDonald (1970) believes Lestoniidae is distantly related to Scutelleridae. His evidence is the lack of spermathecal flanges in these families. However, Scutelleridae and Cydnidae do indeed have spermathecal flanges (Pendergrast 1957, Kumar 1965, McDonald 1966). Thus no feature allies Lestoniidae and Scutelleridae.

At least one scutellerid, the scutellerine *Chrysocoris purpureus* Westwood, shares some characteristics with the complex of Pentatomoidea to which Lestoniidae belongs (Schaefer, unpublished). However, I believe these similarities to be convergent, and they are not possessed by other scutellerids. Nevertheless, the relationship of Scutelleridae (or of some of its members) to this complex of Pentatomoidea, deserves further study.

Finally, the position of both trichobothria lateral to the spiracle places Lestoniidae in Ruckes's (1961) Group 6. Other members of this Group are Pentatomidae: Pentatominae and Discocephalinae, to neither of which is Lestoniidae related.

ACKNOWLEDGMENTS

I am deeply grateful to G. F. Gross for the specimens upon which this paper is based.

LITERATURE CITED

China, W. E. 1955. A new genus and species representing a new subfamily of Plataspidae, with notes on Aphylidae (Hemiptera, Heteroptera). Annals and Magazine of Natural History (12)8: 204–210.

China, W. E. and N. C. E. Miller. 1959. Check-list and keys to the families and subfamilies of the Hemiptera-Heteroptera. Bulletin of the British Museum (Natural History). Entomology 8: 1–45.

Dolling, W. R. 1981. A rationalized classification of the burrower bugs (Cydnidae). Systematic Entomology 6: 61–76.

Kumar, R. 1965. Contributions to the morphology and relationships of Pentatomoidea (Hemiptera: Heteroptera) Part I. Scutelleridae. Journal of the Entomological Society of Queensland 4: 41–55.

McDonald, F. J. D. 1966. The genitalia of North American Pentatomoidea (Hemiptera: Heteroptera). Quaestiones Entomologicae 2: 7–150.

———. 1969. A new species of Lestoniidae (Hemiptera). Pacific Insects 11: 187–190.

———. 1970. The morphology of *Lestonia haustorifera* China (Heteroptera: Lestoniidae). Journal of Natural History 4: 413–417.

———. 1979. A new species of *Megaris* and the status of the Megarididae McAtee & Malloch and Canopidae Amyot & Serville (Hemiptera: Pentatomoidea). Journal of the New York Entomological Society 87: 42–54.

Pendergrast, J. G. 1957. Studies on the reproductive organs of the Heteroptera, with a consideration of their bearing on classification. Transactions of the Royal Entomological Society of London 109: 1–63.

Ruckes, H. 1961. The diagnostic value of trichobothria in pentatomid taxonomy. Verhandlungen der XI. Internationalen Kongress von Entomologie (Wien 1960) 1: 35–37.

Schaefer, C. W. 1981. The sound-producing structures of some primitive Pentatomoidea (Hemiptera: Heteroptera). Journal of the New York Entomological Society 88: 230–235.

Willis, J. C. 1973. A dictionary of the flowering plants and ferns. Eighth edition (revised by H. K. Airy Shaw). Cambridge University Press.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 457–462

THE NEOTROPICAL LACE BUGS OF THE GENUS *VATIGA* (HETEROPTERA: TINGIDAE), PESTS OF CASSAVA: NEW SYNONYMIES AND KEY TO SPECIES

RICHARD C. FROESCHNER

Department of Entomology MRC-105, National Museum of Natural History, Washington, D.C. 20560.

Abstract.—Recognition of infrapopulation variations led to a review of *Vatiga* Drake and Hambleton resulting in six new synonymies: *V. cassiae* (Drake and Hambleton) is senior synonym of *V. lonchocarpa* (Drake and Hambleton); *V. manihotae* (Drake) is senior synonym of *V. celebrata* (Drake), *V. longula* (Drake), *V. sessoris* (Drake and Hambleton), *V. variana* Drake and Hambleton, and *V. vicosana* Drake and Hambleton. *Vatiga illudens* variety *varianta* (Drake) is elevated to species status. The four *Manihot* "species" reported as host plants for *Vatiga* are here accepted as comprising but one, *M. esculenta.* A key is provided for separating the five species of *Vatiga* here recognized.

Key Words: Heteroptera, Tingidae, *Vatiga,* new synonymies, new status, hosts, key

The species of the genus *Vatiga* Drake and Hambleton exhibit a decided preference for plants of the genus *Manihot* Miller, common name cassava (Euphorbiaceae), an important human food source in the American tropics. The four "species" of *Manihot* recorded as host plants of *Vatiga* are all considered as one by Rogers and Appan (1973), that is, *Manihot esculenta* Crantz (= *M. aipi* Pohl, *M. dulcis* Pax, and *M. utilissima* Pohl). The host records listed below, however, are as given on the specimen labels in case later students decide that several plant species are actually present. *Vatiga* also has been reported from two species of Fabaceae (*Bauhinia* species, *Lonchocarpa* species); it is not yet clear if these are simply "sitting" records or actually represent successful use of those plants as true hosts.

Frequent attempts to identify specimens of the genus *Vatiga* revealed important variations in certain series of individuals bearing identical label data. The assumption that all such similarly labeled individuals are members of a single population led to the conclusion that some species are quite variable, especially in the two sets of head spines or tubercles, the medioapical and the occipitals. In species with a single medioapical spine or short tubercle (Fig. 3), the presence is constant even though somewhat variable in length; but in species in which the medioapical armature consists of a pair of spines or tubercles, one on each side of the midline, those spines or tubercles could be elongate, blunt cylinders, be variously reduced, be absent, or lose one member of the pair and have the remaining member still occupying its position distinctly removed from the midline (Figs. 4, 5). The occipital pair, while always present, varied from blunt tubercles to elongate, blunt cylinders—the shorter form being the more common.

Recognition of this variability led to the conclusion that five of the names cataloged by Drake and Ruhoff (1965: 424–426) belong in synonymy and the subspecies deserves elevation to species rank. A key for separating the five species here considered valid follows the species' treatments.

Confirmation of the true status of the presently recognized *Vatiga* "species" must be derived by following progeny through several generations to ascertain the amount and significance of the variation in each line. The separation of *V. cassiae* (Drake and Hambleton) from *V. manihotae* (Drake) is very weak, being based wholly on the color pattern near the apex of the hemelytron; so far no series bearing the same label data contained both forms or intermediate conditions.

Genus *Vatiga* Drake and Hambleton
Fig. 1

Vatiga Drake and Hambleton, 1946: 10. Type species: *Vatiga vicosana* Drake and Hambleton, a junior synonym of *Leptopharsa manihotae* Drake, original designation.

Members of the genus *Vatiga* are readily recognized by their slender form (Fig. 1) combined with the laminae of the mesosternum (Fig. 2) being strongly, convexly incurved toward, and sometimes actually touching each other. The individuals range in length from 3.0–3.8 mm.

Vatiga cassiae (Drake and Hambleton)
Fig. 1

Tigava cassiae Drake and Hambleton 1934: 440 [new species: Brazil].

Tigava lonchocarpa Drake and Hambleton 1944: 125 [new species: Brazil]; Drake and Ruhoff, 1965: 425. NEW SYNONYMY.

Vatiga cassiae.—Drake and Hambleton 1946: 10; Drake and Ruhoff, 1965: 424.

Recognition character: This is the only species in the genus with a subapical area of pale veins and cells in the broad dark median stripe of the membrane.

Comments: Examination of the holotypes of both "species" and several dozen other specimens found no character that would justify keeping *Vatiga lonchocarpa* as a separate species. Undoubtedly, the different host given on each of the two original lots of specimens inspired the desire to describe the second species. Interestingly, the holotypes and some of the paratypes of each "species" were collected at Viçosa, Minas Gerais, Brazil, but one year apart. Except for the color intensity, which is predictably paler in teneral individuals, and an occasional specimen with shorter occipital spines (not reaching to medioapical spine), the characters of this species appear to be more constant than those in any other member of the genus.

Published reports and all specimens examined were from the state of Minas Gerais, Brazil. Unidentified species of *Manihot* and *Lonchocarpus* are the recorded hosts of *V. cassiae.*

Vatiga illudens (Drake)
Figs. 4, 5

Leptopharsa illudens Drake 1922: 370 [new species: Puerto Rico].

Atheas pallidus Barber 1923: 6 [new species: Puerto Rico]. Synonymized under *Leptopharsa illudens* by Barber 1924: 136.

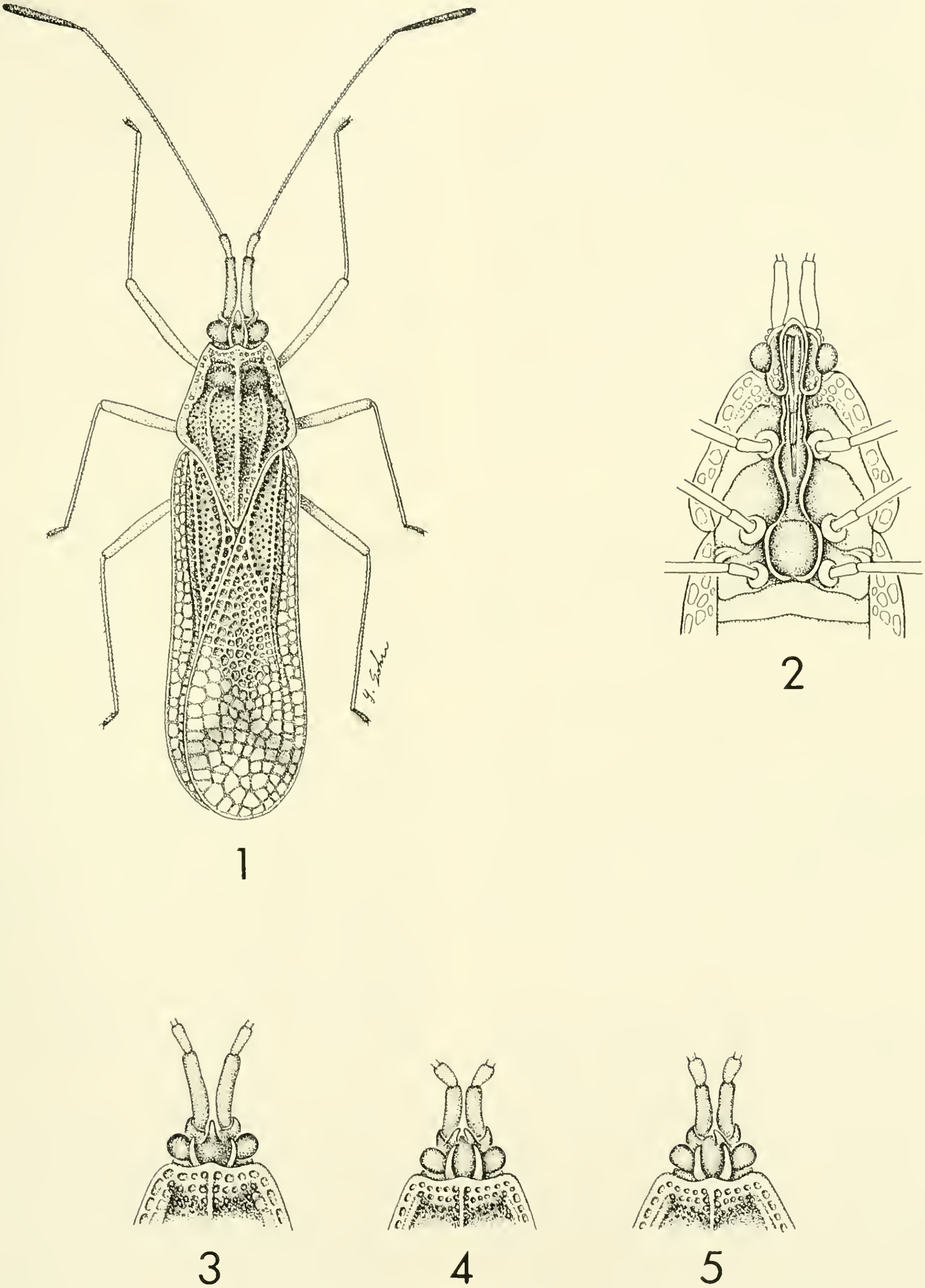
Vatiga celebrata Drake 1928: 53 [new species: Brazil]; Drake and Ruhoff 1965: 424. NEW SYNONYMY.

Vatiga illudens.—Drake and Hambleton 1946: 10; Drake and Ruhoff 1965: 424.

Vatiga variana Drake and Hambleton 1946: 11 [new species: Brazil]; Drake and Ruhoff 1965: 426. NEW SYNONYMY.

Recognition characters: The combination of the lack of, or presence of, a pair of medioapical tubercles on the dorsum of the head (if only a single tubercle is present it is not on the midline) coupled with the costal area being regularly biseriate from base to apex will permit recognition of this species.

Comments: Examination of the holotypes of *V. illudens, V. celebrata,* and *V. variana* found no separating features. Study of series of specimens with the same data label found



Figs. 1–5. Fig. 1. *Vatiga cassiae,* dorsal view. Figs. 2–3. *Vatiga manihotae.* 2, ventral view of head and thorax. 3, dorsal view of head. Figs. 4, 5. *Vatiga illudens.* 4, dorsal view of head with both medioapical spines, 5, dorsal view of head with left spine of medioapical pair missing.

both lengths of occipital spines may occur in the same series; most often the occipital spines reach or distinctly surpass the midlength of the eye.

Drake and Ruhoff (1965: 426) cataloged this species from the Greater Antilles (Cuba, Haiti, Dominican Republic, Jamaica, Puerto Rico), Lesser Antilles (St. Eustacius), and South America (Brazil). In addition, specimens at hand were from Colombia (Pto. Gaitlan, ex *Manihot esculenta,* Nariño, San Martin, Amazonas), Ecuador (Aqyarico, ex *M. esculenta,* Dureno), Guayana (Bartica District, Kartabo; Grove/Craig area, ex: "cassava"), Trinidad (Curepe; University W. I. field station, St. George Co.), and Venezuela (Barquisimeto, ex: *M. esculenta*; Chaguaramus, Monagas). The cataloged hosts were *Manihot dulcis, M. esculenta, M. utilissima* [all belonging together as *M. esculenta* according to Rogers and Appan 1973], and *M.* species.

Vatiga manihotae (Drake)
Figs. 2, 3

Leptopharsa manihotae Drake 1922: 371 [new species: Trinidad].

Leptopharsa longula Drake 1922: 371 [new species: Brazil]; Drake and Ruhoff 1965: 425. New Synonymy.

Tigava sesoris Drake and Hambleton 1942: 77 [new species: Brazil]; Drake and Ruhoff 1965: 426. New Synonymy.

Vatiga vicosana Drake and Hambleton 1946: 10 [new species: Brazil]; Drake and Ruhoff 1965: 426. New Synonymy.

Vatiga manihotae.—Drake and Hambleton 1946: 10; Drake and Ruhoff 1965: 425.

Recognition characters: The single, medioapical spine, or the length of antennal I being equal to the length of the head plus the collar, coupled with the absence of a pale area (including veins) subapically in the dark median stripe of the membrane will permit recognition of this species.

Comments: When Drake (1922: 371) originally described the two new species *L. longula* and *L. manihotae* he pointed out the similarities between them and then mentioned several small points for separating them. His type series consisted, respectively, of two and three specimens. Now with many more specimens available, including several series of specimens with the same label data (indicating a possible single population), the originally itemized differences are found to be bridged by intermediates, even in the length of the occipital spines, which vary from stout and reaching the midlength of the eye to slenderly tapering and reaching the base of an antenna. Side-by-side comparisons of such series found no constant separating characters, so the names must be synonymized.

The two names proposed in 1922 were described on the same page and thus both are available for the species. The name *manihotae* is here selected to indicate the most commonly reported host plant for the members of the genus.

The name *V. sesoris* is based solely on the holotype from Brazil. None of its characters will separate it from *V. manihotae* as treated here so the synonymy is necessary. Its original description compared it with *V. cassiae,* but it lacks the presence of a pale area in the dark membranal stripe of that species.

A third name, *V. vicosana,* must also be synonymized here because the holotype, which was available for this study, falls within the variations here accepted for *V. manihotae.* As the senior synonym of *V. vicosana, V. manihotae* now becomes the name for the type species.

This appears to be the most widespread member of *Vatiga*; Drake and Ruhoff (1965) cataloged it [combining all records, including those for the synonyms] from Cuba, Trinidad, Brazil, Peru, Paraguay, and Argentina, with hosts given as *Bauhinia* sp., *Manihot utilissima* [now a junior synonym of *V. esculenta*], and *Manihot* species. Specimens at hand add Colombia (Palmira, Valle, ex *M. esculenta*; Pto. Nariño, San Martin, Amazonas) and Venezuela (Guanare, estado Portuguesa; Mt. Marahuaca, north slope; Rio Loja, Zulia).

Vatiga pauxilla (Drake and Poor)

Leptopharsa pauxilla Drake and Poor 1939: 32 [new species: Argentina].
Vatiga pauxilla.—Drake and Ruhoff 1960: 29; 1965: 426.

Recognition character: This species is unique within the genus by virtue of having a single row of cells for the full length of the costal area.

Comments: The holotype from Argentina was the only specimen available for this study. No record of a host was encountered.

***Vatiga varianta* (Drake), New Status**

Leptopharsa illudens var. *variantis* [sic] Drake 1930: 25 [new species: Brazil].
Vatiga illudens var. *variantis* [sic].—Drake and Hambleton 1946: 10.
Vatiga illudens var. *varianta.*—Drake and Ruhoff 1965: 425.

Recognition character: In this species the costal area is mostly uniseriate with the widened area opposite the apex of the discoidal area mostly irregularly biseriate.

Comments: The holotype and more than a dozen other Brazilian specimens, all previously reported, were examined. Additional records include one from Colombia (Puerto Gaitán, Carimogoa, ex *Manihot esculenta*), and one from Brazil (Minas Gereis, ex *Manihot aipi*). Thus, the known host is *Manihot esculenta*.

KEY TO SPECIES OF *VATIGA*

1. Head medioapically with a single spine or prominent tubercle on midline. Antennal segment I distinctly longer than head. 2
– Head medioapically lacking armature, or with a pair of spines or tubercles, one on each side of midline, space between them may be filled with pruinosity and give the superficial appearance of a single structure (if one spine absent, the other is clearly set to one side and not on the midline of the head). Antennal segment I not longer than head 3
2. Hemelytron with mediolongitudinal dark area extending almost or quite to apex of membrane, subapically or apically forming a loop or "Y" enclosing an area wherein the veins as well as the cells are conspicuously paler (Fig. 1) .... *cassiae* (Drake)
– Hemelytron with mediolongitudinal dark mark not forming a loop or "Y" and hence not enclosing an area of pale veins and membrane .... *manihotae* (Drake)
3. Costal area regularly biseriate from base to apical fourth or more (occasionally with a tiny intercalary cell included) .... *illudens*
– Costal area not regularly biseriate to apical fourth 4
4. Costal area uniseriate for full length .... *pauxilla*
– Costal area mostly uniseriate with a short area opposite apex of discoidal area irregularly biseriate .... *varianta*

ACKNOWLEDGMENTS

Special thanks are gladly given to Dr. G. Coutourier, Paris, France, for providing the specimens that initiated this study and for much additional material; to Dr. R. M. Baranowski, Homestead, Florida, for providing large series from the West Indies; to Dr. J. J. Wurdack, Smithsonian Institution, for help with the botanical names; to Mr. T. J. Henry, USDA-SEL, and Dr. P. J. Spangler, Smithsonian Institution, for helpful reviews of the manuscript; to Mr. Young Sohn for the excellent illustrations; and to Ms. Silver B. West for able assistance in preparing the manuscript.

LITERATURE CITED

Barber, G. G. 1923. A preliminary report on the Hemiptera-Heteroptera of Porto Rico collected by the American Museum of Natural History. American Museum Novitates 75: 1–13.

———. 1924. Corrections and comments Hemiptera-Heteroptera. Journal of the New York Entomological Society 32: 133–137.

Drake, C. J. 1922. Neotropical Tingitidae with descriptions of three new genera and thirty-two new species and varieties. Memoirs of the Carnegie Museum 9: 351–378, pl. XXXIX.

———. 1928. New and little known Neotropical Tingitidae. Iowa State College Journal of Science 3: 41–56.

———. 1930. Some Tingitidae from Brazil (Hemiptera). Bulletin of the Brooklyn Entomological Society 25: 25–26.

Drake, C. J. and E. J. Hambleton. 1934. Brazilian Tingitidae (Hemiptera), Part I. Revista Entomologia, Rio de Janeiro 4: 435–451.

———. 1942. Seven new South American Tingitidae (Hemiptera). Revista Entomologia, Rio de Janeiro 13: 76–81.

———. 1944. Concerning Neotropical Tingitidae (Hemiptera). Journal of the Washington Academy of Sciences 34: 120–129.

———. 1946. New species and new genera of American Tingitidae (Hemiptera). Proceedings of the Biological Society of Washington 59: 9–11.

Drake, C. J. and M. E. Poor. 1939. Seven new American Tingitidae (Hemiptera). Bulletin of the Brooklyn Entomological Society 34: 31–35.

Drake, C. J. and F. A. Ruhoff. 1960. Tingidae: New genera, species, homonyms, and synonyms (Hemiptera). Great Basin Naturalist 20: 29–38.

———. 1965. Lacebugs of the world: A catalog (Hemiptera: Tingidae). United States National Museum Bulletin 243: I–VIII, 1–634, plates 1–56.

Rogers, D. J. and S. G. Appan. 1973. *Manihot manihotoides* (Euphorbiaceae). Flora Neotropica Monograph 13. 272 pp.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 463–467

DESCRIPTION OF *DISIPHON*, NEW GENUS, AND ITS TYPE SPECIES, *ASTEROCHITON DUBIENUS* BONDAR (HOMOPTERA, ALEYRODIDAE)

Louise M. Russell

USDA, Plant Sciences Institute, Systematic Entomology Laboratory, Room 6, Building 004, BARC-W, Beltsville, Maryland 20705.

Abstract.—***Disiphon***, new genus, is described, *Asterochiton dubienus* Bondar is redescribed and designated the type species of the genus. The species was found on *Psidium guajava* L. in Brazil. Characters are given for distinguishing ***Disiphon*** from other genera.

Key Words: Aleyrodidae, *Disiphon*, dorsal glands, Brazil

The description of *Disiphon* establishes a new genus for *Asterochiton dubienus* Bondar, a Neotropical species whose morphological characteristics differ from those of the genera to which it has been assigned previously. A redescription of *dubienus* aids in the recognition of the species.

Disiphon Russell, New Genus

Type species.—*Asterochiton dubienus* Bondar, by designation and monotypy.

Bondar (1923) placed *dubienus* in *Asterochiton* Maskell following the erroneous application of that name by Quaintance and Baker (1914). He (1928) transferred it to *Trialeurodes* Cockerell after discovering that Quaintance and Baker (1915) had corrected their earlier misuse of the two generic names.

Study of *dubienus* shows that it is not congeneric with *pergandei* Quaintance, the type species of *Trialeurodes,* or any other described genus, and thus merits a new generic placement.

Etymology.—*Disiphon,* masculine gender, is from the greek di, two, and siphon, tube, and refers to the two shapes of glands on the dorsum of the pupal case, the only known form of the genus.

Description.—Body somewhat oval in outline, flat dorsally and ventrally, membranous, pale.

Margin and submargin.—Margin dentate. Anterior and posterior marginal setae present. Submargin not separated from dorsal disk.

Dorsum.—A weak submedian ridge on thorax and anteriorly on abdomen. Median molting suture reaching body margin; transverse suture extending laterocaudad, area between its arms inverted V-shaped. Intersegmental sutures poorly defined; 8 segments present in median area of abdomen. Submedian depressions faint or invisible. Pockets shallow. Submedian cephalic, mesothoracic, metathoracic, eighth abdominal and caudal setae present. Glands of two shapes, each with a pore and porette in or near distal end. Vasiform orifice near midlength of abdominal segment VIII, subcircular or cordate; operculum nearly covering the orifice and lingula; lingula spatulate with minute spinules and a pair of minute setae. Caudal furrow and caudal ridges absent.

Venter.—Antennae 1-segmented, extending toward base of anterior legs, their apices obscure in available specimens. Rostrum possibly 1-segmented, setae or setal bases not observed near apex or anterior to rostrum. Legs weakly 2-segmented, minute setae or setal bases not observed near disks, posterior pair much stouter than other legs. Adhesive sacs not observed. Tracheal folds obscure. Thoracic and posterior abdominal spiracles minute, anterior abdominal ones not observed. Abdominal setae or setal bases present.

Discussion.—This description is based on three specimens representing three species, of which only *dubienus* has been described. The availability of the undescribed species, from Peru and Venezuela, aided in the delineation of the genus. All specimens are too imperfect to permit a completely satisfactory description of the species.

Disiphon resembles *Siphoninus* Silvestri in shape, texture of the derm and in having siphonlike glands. It can be separated from *Siphoninus* and other known genera by the following combination of characters: submedian mesothoracic and metathoracic setae present, first abdominal and elongate submarginal setae absent, a submedian ridge on the thorax and anteriorly on the abdomen, area between arms of the transverse molting suture inverted V-shaped, siphonlike glands of two shapes, operculum nearly covering the vasiform orifice.

Disiphon dubienus (Bondar)
(Figs. 1–5)

Asterochiton dubienus Bondar 1923: 179–180, Costa Lima 1928: 101.

Asterochiton dupien(!) Bondar 1923: 179.

Trialeurodes dubienus (Bondar) 1928: 31; Costa Lima 1930a: 86, 1930b: 42, 1936: 159; Mariconi and Soubihe Sobrinho 1961: 37; Silva et al. 1968: 119.

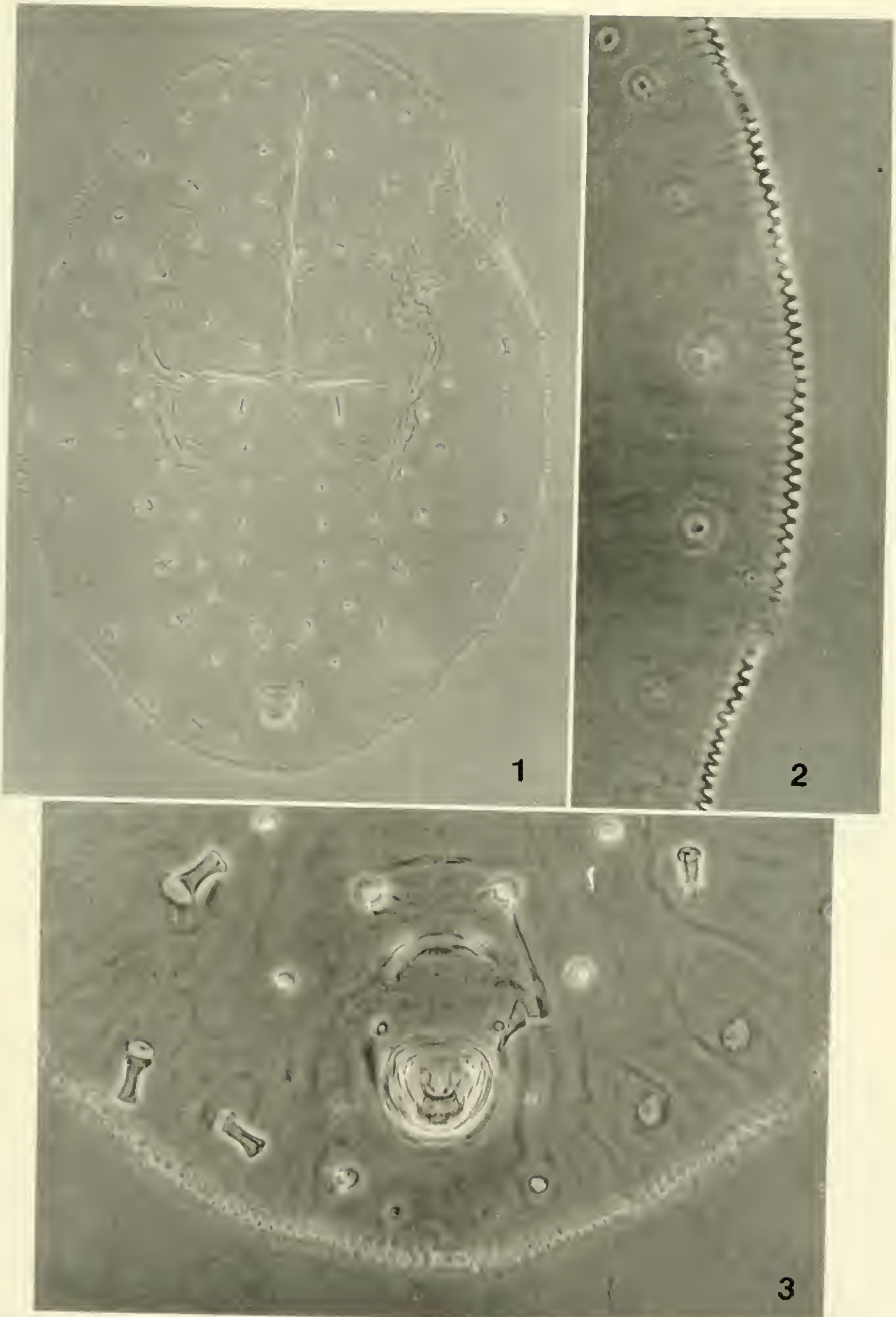
Trialeurodes dubiensis(!) (Bondar), Mound and Halsey 1978: 200.

Appearance in life unknown.

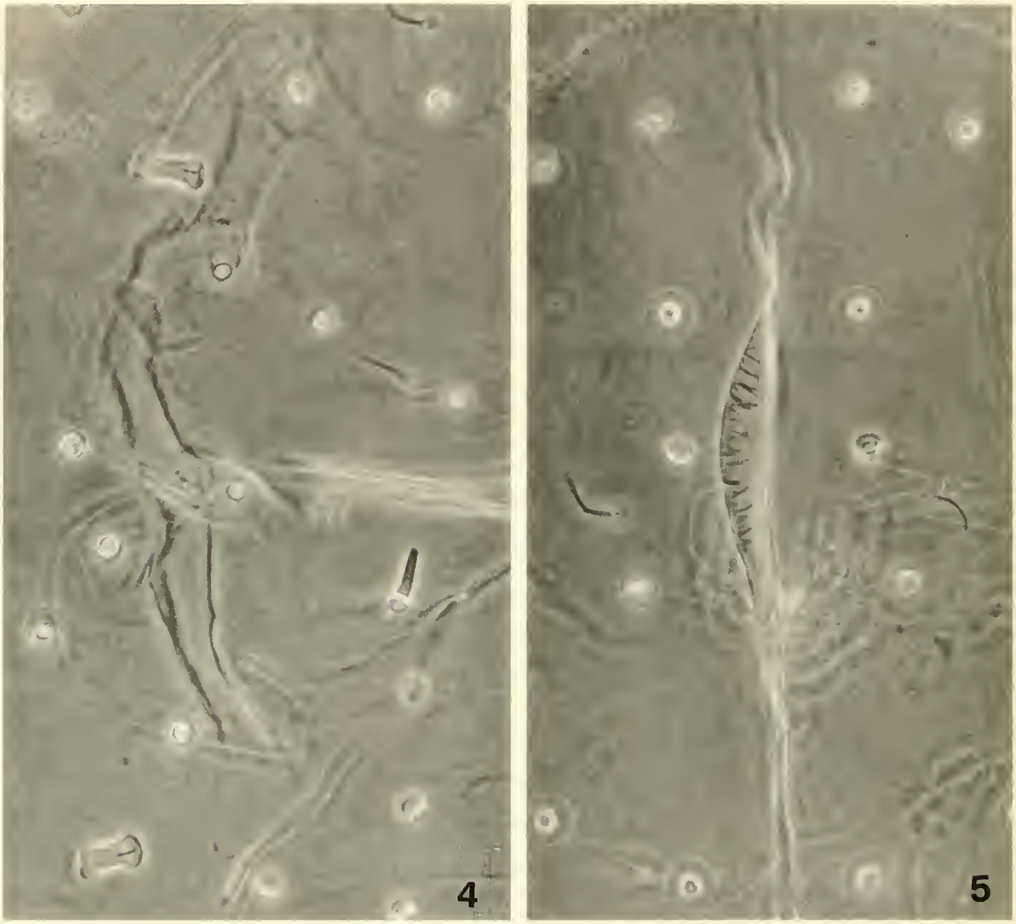
Body oval in outline, 0.78 mm long, 0.52 wide, yellowish (Bondar 1923).

Margin and submargin.—Anterior marginal setae 14 μ long, bases 50 teeth apart, posterior setae broken, bases 60 teeth apart. Teeth somewhat triangular, as long as basal width; narrowly rounded apically, 17–20 in 100 μ, 3 or 4 at tracheal pore areas slightly larger than others. A minute pore in notch between teeth or in base of some teeth. Submarginal ridges weak, approximately as long as teeth. Minute setal bases near distal end of some ridges, 3 on prothorax, 1 on each of abdominal segments II and III.

Dorsum.—Median molting suture with midlength section of one side expanded outward and transversely ridged; transverse molting suture extending laterocaudad from midpoint to abdominal segment IV or V. Submedian ridge curved outward, extending from prothorax to abdominal segment III. Cephalothoracic suture indistinct; meso-metathoracic suture well defined, other intersegmental sutures usually defined in median and submedian areas. Submedian depressions not observed. Pockets very shallow. Median length of cephalic segment slightly greater than combined length of thoracic segments; abdominal segment I slightly longer than II which is subequal to III–VII; VIII as long as combined length of IV–VII. Siphonlike glands of two shapes, elongate subcylindrical and short thimble-shaped; subcylindrical glands 16–20 μ long, 8–10 μ in diameter at ends, 6–7 μ at midlength; thimble-shaped glands 8–10 μ in length and diameter; glands arranged approximately as follows: 15 elongate subcylindrical subdorsal on one half of dorsum, 15 normal + 1 modified subcylindrical on other half; on each half, 6 subcylindrical outer submedian, 11 thimble-shaped central submedian and 9 thimble-shaped inner submedian. Minute, thick rimmed pores without associated porettes arranged approximately as follows on each half of body: cephalic segment 3 or 4 subdorsal; prothorax, meso- and metathorax each 1 or 2 subdorsal, 1 or 2 submedian; abdominal segments II and IV–VII each 0 or 1 central subdorsal or submedian. Submedian cephalic and mesothoracic setae slender, tapering, each about 24 μ long; metathoracic



Figs. 1–3. *Disiphon dubienus.* 1, pupal case (holotype); 2, section of margin, submargin and outer subdorsum; 3, posterior part of abdomen, subdorsal clear areas on right showing where subcylindrical glands were broken off.



Figs. 4, 5. *Disiphon dubienus.* 4, section of median and submedian area showing submedian ridge, parts of thoracoabdominal and transverse molting sutures, cephalic, mesothoracic and metathoraic setae, subcylindrical and thimble-shaped glands, and dark rimmed pore above posterior subcylindrical gland; 5, section of median area of cephalothorax showing folded, ridged area of median molting suture, thimble-shaped glands and cephalic setae.

stouter, broken but at least 25 μ, their bases slightly tuberculate; eighth abdominal setae broken at base, located laterocephalad of vasiform orifice, just distad of an imaginary longitudinal line through lateral margins of orifice; caudal setae broken at base, slightly closer to body margin than to vasiform orifice. Vasiform orifice slightly nearer seventh abdominal suture than posterior body margin, subcircular, 36 μ long and wide; rim 4 μ long across anterior end of orifice, thin and rising slightly above orifice elsewhere; inner walls with fine, narrow, vertical ridges, bottom smooth and extending slightly anterior to posterior margin of operculum; operculum subcircular, 28 μ long and wide; lingula extending to end of operculum.

Redescribed from a pupa case labeled "*Trialeurodes dubienus* n. sp. type Coll. Bondar." This specimen was collected from a leaf of goyabeira [*Psidium guajava* L., Myrtaceae] by G. Bondar. The species was described from one specimen.

The references to *T. dubienus* by Costa Lima, Mariconi and Soubihe Sobrinho, Mound and Halsey and Silva et al. cite only

Bondar's collection record. Later collections have not been recorded.

Siphoninus blanzyi Cohic (1968), a species not available for examination, is similiar to *dubienus* in having siphonlike glands of two shapes.

Acknowledgments

I am greatly indebted to A. B. Hamon, Florida Department of Agriculture and Consumer Services, Gainesville, and Michael Kosztarab, Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, for their helpful reviews of the manuscript. I am most grateful to colleagues of the Systematic Entomology Laboratory, PSI, ARS, USDA for their assistance—D. R. Smith for his critical review, R. L. Smiley for his comments, G. C. Steyskal for his opinion on the correct spelling of *D. dubienus* and M. B. Stoetzel for photographing the specimen.

Literature Cited

Bondar, G. 1923. Aleyrodideos do Brasil. 183 pp. (Bahia.)

———. 1928. Idem. 2ª Contribuicao. Boletim Laboratorio Pathologia Vegetal 5: 1–37. (Bahia.)

Cohic, F. 1968. Contribution a l'étude des aleurodes africains (3ᵉ et 4ᵉ notes). Cahiers Office Recherche Scientifique Technique Outer-Mer, Serie Biologie 6: 1–143.

Costa Lima, A. da. 1928. Segundo catalogo systematico dos insectos que vivem nas plantas do Brasil e ensaio de bibliographia entomologica brasiliera. Archivos Escola Superior Agricultura Medicina Veterinaria (1927)8: 69–301. (Aleyrodidae, pp. 89–101.) (Rio de Janeiro.)

———. 1930a. Supplemento ao 2° catalogo systematico dos insectos que vivem nas plantas do Brasil e ensaio de bibliographia entomologica brasiliera. O Campo 1(8): 84–91.

———. 1930b. Idem. O Campo 1(12): 41–46.

———. 1936. Terceiro catalogo dos insectos que vivem nas plantas do Brasil. Ministerio Agricultura Escola Nacional Agronomia. 466 + I–IV pp. (Aleyrodidae, pp. 144–159.) (Rio de Janeiro.)

Mariconi, F. A. and J. Soubihe Sobrinho. 1961. Contribuicao para o conhecimento de alguns insetos que depredam a goiabeira (*Psidium guajava* L.). Publicacao Cientifica Instituto Genetica Escola Superior Agricultura "Luiz de Queiroz;" 2: 35–67. (Piracicaba.)

Mound, L. A. and S. H. Halsey. 1978. Whitefly of the world. A systematic catalogue of the Aleyrodidae (Homoptera) with host plant and natural enemy data. British Museum (Natural History) Publication 787, 340 pp. (London, New York, Toronto.)

Quaintance, A. L. and A. C. Baker. 1914. Classification of the Aleyrodidae, Part II. United States Department Agriculture, Bureau Entomology, Technical Series 27 (part 2): 95–109.

———. 1915. Classification of the Aleyrodidae, Contents and Index. United States Department Agriculture Bureau Entomology, Technical Series 27: V–XI, 111–114.

Silva, A. G. d'Araujo e et al. 1968. Quarto catalogo dos insectos que vivem nas plantas do Brasil seus parasitos e predadores. Part. II. 622 pp. (Aleyrodidae, pp. 106–120.) (Rio de Janeiro.)

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 468–474

A NEW GENUS OF NEOTROPICAL AGALLIINAE (HOMOPTERA: CICADELLIDAE)

Christopher H. Dietrich

Systematic Entomology Laboratory, PSI, Agricultural Research Service, USDA, % U.S. National Museum NHB 168, Washington, D.C. 20560.

Abstract.—The Neotropical leafhopper genus ***Omanagallia***, new genus, with included species ***O. obscura***, new species from Brazil, and ***O. elongata***, new species from Argentina, is described, illustrated, and placed in the leafhopper subfamily Agalliinae. The new genus shares features of the head and wing with species of Eupelicinae, Evansiolinae, and Megophthalminae, but these resemblances apparently resulted from convergence.

Key Words: Leafhopper, morphology, phylogeny, systematics, classification

Species of the leafhopper subamily Agalliinae occur throughout the temperate and tropical regions of the world, but are most diverse in the New World tropics. Oman (1938) provided the first comprehensive review of the South American species incorporating genital morphology, and Kramer (1964) reviewed the generic classification. Davis (1975) reviewed the higher classification of the Agalliinae and declined to delimit tribes within the subfamily because of intergradations among genera for the characters studied. Hamilton (1983) synonymized Agalliinae and Megophthalminae (as Megophthalmini) without explicit justification and is not followed here.

The new taxa described herein key to Agalliinae in Evans' (1947) key and have most diagnostic features listed by Kramer (1964) and Davis (1975) for that subfamily. In Kramer's (1964) key, the new taxa would perhaps be identified as *Stenagallia* Evans or *Agalliopsis* Kirkaldy, but differ drastically from these and all other described agalliine genera. Features of the head, pronotum, and forewings also suggest affinities to the Megophthalminae, Evansiolinae, and Eupelecinae. Although the new taxa are based on a small number of specimens—one species is based on three females, the other on one male—their unique combination of morphological features warrants formal description. All specimens studied are in the Insect Collection of the United States National Museum, Washington.

Members of the new genus may be separated from other New World Agalliinae by the following key. Terminology for naming wing veins follows Evans (1946).

1. Forewing without opaque sclerotization, texture coarsely granulose, veins carinate, M_{1+2} absent (Fig. 13); hind tibia row IV without capitate setae .... *Omanagallia*, New Genus
1′. Forewing with opaque sclerotization, texture glabrous or shagreen, veins not carinate, at most weakly raised, M_{1+2} present; hind tibia row IV usually with capitate setae .... other New World Agalliinae (see Kramer 1964).

Omanagallia, New Genus
(Figs. 1–15)

Type species: Omanagallia elongata, **new species**, here designated.

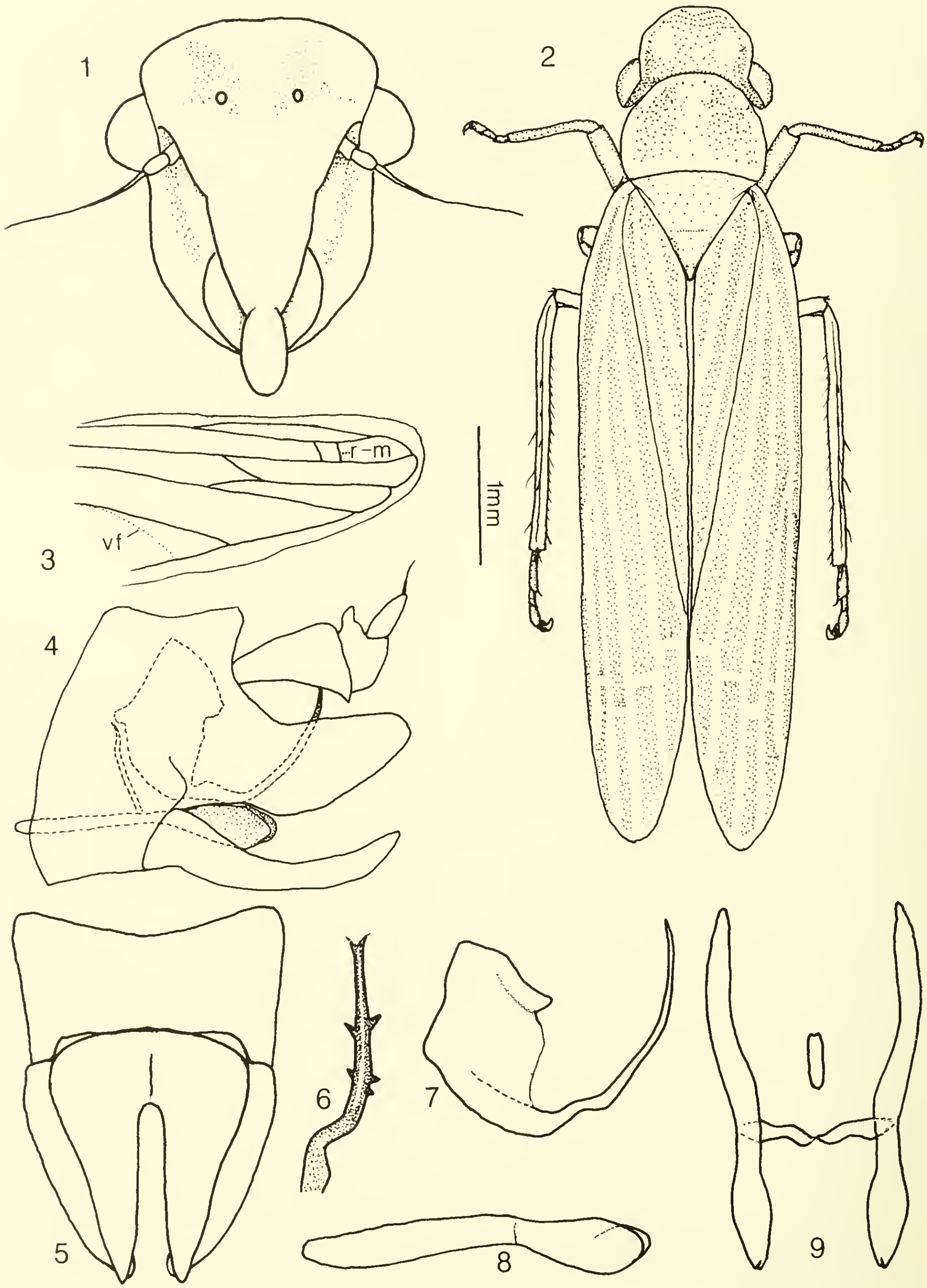
Description.—Color. Dull orange to yellow or tan, without distinct maculae; forewing membrane without distinct pigmentation. Head (Figs. 1, 2, 10–12). Beak attaining anterior margins of hind coxae; clypellus flat, elliptical, anterior margin exceeding ventral margins of genae, fused medially to frontoclypeus; frontoclypeus weakly convex or flat, muscle scars weak; postfrontal sutures absent; genae broad, arcuate laterally, concealing proepimera, bluntly carinate between lora and antennal pit, distance from lora to antennal pit subequal to length of lora; antennal ledge well developed, in anterior view partially concealing antennal base, in lateral view arcuate; antennal flagellum shorter than interocular distance; ocelli on face slightly nearer to eyes than to each other, distant from dorsal margin of head; crown weakly to strongly produced anterad or dorsad, slightly elevated anteromesad of eyes. Thorax. Pronotum (Figs. 2, 11, 12) depressed anteriorly and sublaterally, transversely rugose, posterior margin transverse or weakly emarginate; lateral margin bluntly carinate, not produced, length more than half maximum length of eye. Scutellum small, weakly convex. Forewing (Figs. 2, 13) with costal margin expanded basally, veins prominent, cells without opaque sclerotization, veins R_1 and M_{1+2} and crossveins m-cu_1 and m-cu_2 absent. Hind wing (Fig. 3) with R_{1+2} weak, one or two preapical r-m crossveins present, vannal fold diverging from Cu_2 distally. Legs. Prothoracic femur without rows of setae, tibia with dorsal surface semicylindrical or weakly flattened and without macrosetae, ventral surface with a few small preapical macrosetae in row III. Mesothoracic femur without preapical macrosetae, tibia semicylindrical with preapical setae in rows III and IV. Metathoracic femur (Fig. 14) with setal formula 2:1 or 2:0; tibia not flattened, macrosetae small, sparse, rows without distinct intercalary setae, row III macrosetae restricted to apical half of leg, row IV setae small and tapered, one preapical seta distinctly larger than others; tarsomere I subequal in length to combined length of tarsomeres II and III, plantar setae scattered or forming two poorly delimited bands, dorsoapical pair of setae small. Abdomen. Terga without median or submedian tuberosities. Male genitalia. (Based on *O. elongata*, **n. sp.**) Valve (sternum VIII, Fig. 5) subquadrate, fused to pygofer; pygofer, in lateral view (Fig. 4), subquadrate with apical lobe partially separated by ventrolateral membranous cleft, sparsely setose dorsoapically, macrosetae and dorsal hooks absent; subgenital plate lobes (Fig. 5) fused basally, evenly tapered toward apex, without macrosetae; style (Figs. 8, 9) linear, apodeme elongate; connective (Fig. 9) T-shaped, incompletely sclerotized; aedeagus (Figs. 6, 7) with shaft elongate, slender, and U-shaped. Female genitalia. (Based on *O. obscura*, **n. sp.**) First valvula with dorsoapical sculpturing reticulate (as in fig. 7A of Davis 1975); second valvula (Fig. 15) with weak sclerotization mesad of rami, dorsum with membranous notch at midpoint, dorsal margin with apical half finely serrate, ventral margin serrate preapically, margins evenly tapered from midlength to apex. Integumental fine structure. Head, pronotum, and scutellum finely shagreen; forewing membrane and veins coarsely granulose, granules arranged in diagonal rows (as in Eupelicinae).

Etymology.—The generic name is selected to honor Prof. Paul W. Oman for his lasting contributions to knowledge of the Agalliinae.

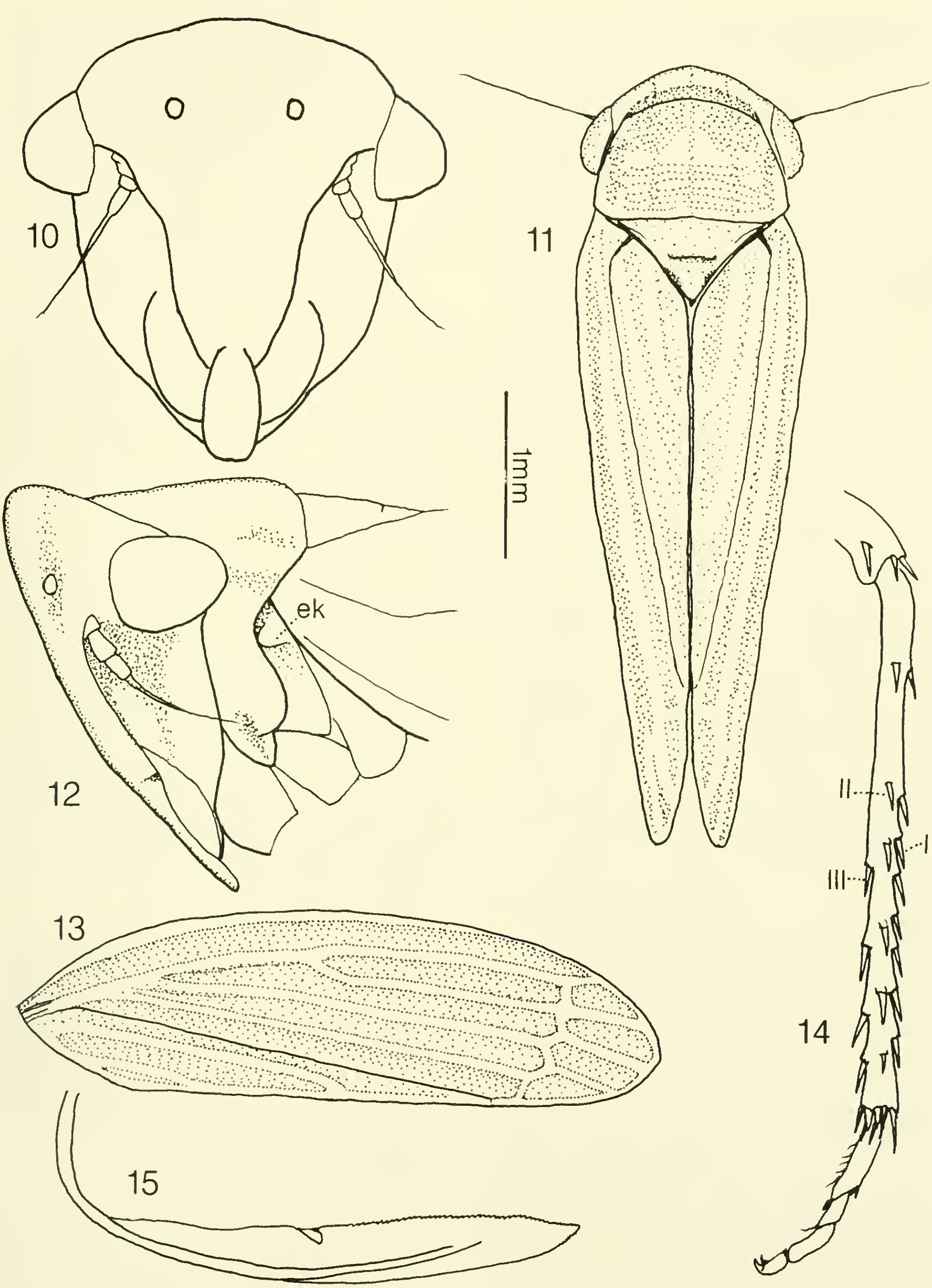
KEY TO SPECIES OF *OMANAGALLIA* DIETRICH

1. Head strongly produced anterad, crown flat; length of lateral margin of pronotum greater than maximum length of eye (Fig. 2); hind femur with macrosetal formula 2:0 .... *elongata*, **n. sp.**

1′. Head not produced anterad, crown rounded; length of lateral margin of pronotum slightly more than half maximum length of eye (Fig. 11); hind femur with macrosetal formula 2:1 (Fig. 14) .... *obscura*, **n. sp.**



Figs. 1–9. *Omanagallia elongata,* **n. sp.**, holotype ♂: 1, head, anteroventral view; 2, habitus, dorsal view; 3, hind wing apex, vf, vannal fold; 4, terminalia, lateral view (internal structures outlined with dashed lines); 5, abdominal sternum VIII, subgenital plates, and pygofer, ventral view; 6, aedeagal shaft, posteroventral view; 7, aedeagus, lateral view; 8, style, ventrolateral view; 9, styles and sclerites of connective, ventral view.



Figs. 10–15. *Omanagallia obscura*, **n. sp.**, holotype ♀: 10, head, anteroventral view; 11, habitus, dorsal view; 12, head and thorax, lateral view, ek, episternal knob; 13, right forewing; 14, left metathoracic leg (femoral apex, tibia, and tarsus), ventrolateral aspect; 15, 2nd valvula, lateral view.

***Omanagallia elongata,* New Species**
(Figs. 1–9)

Type locality: Tigre, Buenos Aires, Argentina.

Description.—Crown (Fig. 2) strongly produced anterad, depressed, with pair of submedial gibbosities, rugose anteriorly, in dorsal view with lateral margins diverging slightly anterodorsad of eyes, anterior margin arcuate, slightly sinuate near margins of frontoclypeus; frontoclypeus in anteroventral view slightly produced dorsomesad of ocelli. Pronotum (Fig. 2) with pair of broad submedial depressions, rugae indistinct, lateral margin longer than maximum length of eye. Hind wing (Fig. 3) with two preapical r-m crossveins, the most basad slightly closer to marginal vein than to fork of M. Metathoracic tibia with setal formula 3:2:4:18+. Male genitalia. Valve (Fig. 5) quadrate, fused to pygofer; plates (Fig. 5) subtriangular, fused mesally at base, lateral margins in ventral view concave; pygofer (Fig. 4) with posterior lobe broad, bluntly tapered, apex oriented posterodorsad; style (Figs. 8, 9) in lateral view with shank broad, apex auriculate, with small lateral preapical tooth; connective (Fig. 9) comprising posterior transverse sclerite attached to styles and median anterior sclerite attached to aedeagus. Aedeagus (Figs. 6, 7) with atrium situated dorsally, distant from styles; shaft in lateral view elongate, slender, U-shaped, in caudal view narrow and parallel sided with a few sharp, irregularly spaced, lateral teeth; gonopore apical, gonoduct clearly visible throughout length of aedeagus. Female. Unknown. Measurements (mm). Length including forewing, 5.6; pronotum width, 0.9; head width, 1.4; head height, 1.1; crown length, 0.4; forewing length, 4.5; prothoracic tibia length, 0.7; mesothoracic tibia length, 1.0; metathoracic tibia length, 1.6; metathoracic tarsus length, 0.5.

Material examined.—Holotype ♂ labelled: "BsAs/ Tigre/ IX.957. Daguerre; ARGENTINA/1968 Coll./ J. Daguerre; HOLOTYPE/ Omanagallia/ elongata/ Dietrich" [USNM].

Notes.—*Omanagallia elongata* resembles *Evansiola* China (Evansiolinae) in the structure of the head and pronotum, but differs in other features: ocelli present; forewing venation not reticulate, veins prominent; hind wings present.

***Omanagallia obscura,* New Species**
(Figs. 10–14)

Type locality: Corumba, Mato Grosso, Brazil [USNM].

Description.—Crown (Fig. 11) short, not flattened, in lateral view (Fig. 12) produced dorsad of anterior margin of pronotum; frontoclypeus concave dorsomesad of ocelli. Pronotum (Figs. 11, 12) depressed anteriorly and sublaterally, rugae on anterior half strongly curved anterad medially; lateral margin slightly longer than half maximum length of eye. Mesepisternum with dorsal knob (Fig. 12, ek). Hind wing with one r-m crossvein. Metathoracic tibia (Fig. 14) with setal formula 7-8:6:4-5:20+. Male. Unknown. Other features as described for genus. Measurements (mm). Length including forewing, 4.3; pronotum width, 1.0; head width, 1.2; head height, 1.2; forewing length, 3.6; prothoracic tibia length, 0.7; mesothoracic tibia length, 0.8; metathoracic tibia length, 1.6; metathoracic tarsus length, 0.5; ovipositor length, 0.9.

Material examined.—Holotype ♀ labelled: "Corumba, Brazil/ Matto [sic] Grosso/ 14–22 Dez. [sic] 1919/ Cornell Univ. Exp.; Cornell U./ Lot 569/ Sub 127; HOLOTYPE/ Omanagallia/ obscura/ Dietrich"; 1 ♀ paratype, same data [USNM]. Additional material: 1 ♀, Zelaya, Buenos Aires, Argentina, 13-viii-1958 (J. Daguerre) [USNM].

Note.—*Omanagallia obscura* resembles other Agalliinae in size and shape but is easily distinguished by its depressed pronotum and carinate forewing veins.

DISCUSSION

The monophyly of *Omanagallia* is supported by the strongly raised veins of the forewing and the absence of vein M_{1+2}. Al-

Table 1. Morphological comparison of *Omanagallia*, other Agalliinae, and Evansiolinae (+ = present/true; − = absent/false).

Feature	*Omanagallia*	Agalliinae[1]	Evansiolinae[2]
Head			
Vertex produced	+	+/−	+
Postfrontal sutures	−	+/−	−
Ocelli	+	+	−
Antennal ledges near dorsal margin of head	−	−	+
Pronotum			
Depressed	+	+/−	+
Lateral margin long	+	+/−	+
Mesepisternum			
Dorsal knob	+/−	+/−	−
Forewing			
Granulose	+	+	−
Short	−	+/−	+
Veins strongly carinate	+	−	−
Vein R_1	−	+/−	+
Vein M_{1+2}	−	+	+
Venation reticulate	−	+/−	+
Hind leg			
Femoral setal formula 2:0	+/−	−	+
Tarsomere I plantar setae in 2 rows	+/−	+/−	−
Male genitalia			
Valve fused to pygofer	+	+/−	−
Pygofer dorsal hooks	−	+/−	+

[1] Based on *Agalliota albidula* (Uhler), *Bergallia lateralis* Oman, *Agalita* sp., and *Euragallia furculata* Oman [USNM].

[2] Based on *Evansiola insularis* Evans and *E. kuscheli* (China) [USNM]. (Genitalia of *E. kuscheli* not examined.)

though the carinate venation and coarsely granulate texture of the forewing suggests an affinity to the Eupelicinae, features of the head (ocelli on face) and male genitalia (valve fused to pygofer, pygofer without oblique basolateral cleft, style slender and elongate) demonstrate that the new genus is more closely related to the Agalliinae, Evansiolinae, and Megophthalminae (see illustrations in Oman 1938, 1941, Linnavuori and DeLong 1977).

The produced head and depressed pronotum of the new genus suggest an affinity to the Evansiolinae and Megophthalminae, but each of these subfamilies has putative synapomorphies that are absent in *Omanagallia*. Species of the subfamily Megophthalminae, known only from Europe, Africa, and western North America, have the postfrontal sutures carinate and the transclypeal suture complete. Species of the monobasic subfamily Evansiolinae, known only from the Juan Fernández Islands (Chile), lack ocelli and hind wings, and have antennal ledges situated near the dorsal margin of the face. Thus, despite their similarities to *Omanagallia*, the Evansiolinae and Megophthalminae apparently represent distinct lineages.

Synapomorphies uniting the Agalliinae (sensu Davis 1975) as a lineage distinct from Evansiolinae have not been found, and the latter subfamily may have been derived from the former (Linnavuori and DeLong 1977).

Nevertheless, placement of *Omanagallia* in Agalliinae rather than Evansiolinae or Megophthalminae is supported by the presence of a dorsal knob on the mesepisternum of *Omanagallia obscura* (Fig. 12, ek), a putative synapomorphy found in *Brasa rugicollis* (Dozier) (fig. 65 of Kramer 1964) and many other Agalliinae, but lacking in Evansiolinae and Megophthalminae. Additional similarities of *Omanagallia* to other agalliines (Table 1) may be symplesiomorphic. Phylogenetic analyses of the Agalliinae and related subfamilies may eventually clarify the polarities of these characters.

The geographic disjunction between *Omanagallia* (southern Brazil, northern Argentina) and other Agalliinae having produced heads (*Agalita* Evans and *Stenagallia* Evans—Juan Fernández Islands) suggests that similarities between *Omanagallia* and the insular genera represent convergence rather than synapomorphy. This hypothesis is supported by the reduced size and reticulate venation of the forewing of the insular genera, putative synapomorphies not present in *Omanagallia.*

Placement of the two species of *Omanagallia* in separate genera might be justified based on the substantial differences in the shape of the head and the chaetotaxy of the hind legs. However, until additional species are discovered subdivision of the genus seems unwarranted.

Acknowledgments

I am indebted to H. D. Blocker, K. G. A. Hamilton, R. W. Hodges, S. Nakahara, M. W. Nielson, and M. D. Webb for their constructive criticism of earlier versions of the manuscript.

Literature Cited

Davis, R. B. 1975. Classification of selected higher categories of Auchenorrhynchous Homoptera (Cicadelliae and Aetalionidae). United States Department of Agriculture Technical Bulletin 1494: 1–52.

Evans, J. W. 1946. A natural classification of leafhoppers (Jassoidea, Homoptera). Part 1. External morphology and systematic position. Transactions of the Royal Entomological Society of London 96: 47–60.

Evans, J. W. 1947. A natural classification of leafhoppers (Jassoidea, Homoptera). Part 3: Jassidae. Transactions of the Royal Entomological Society of London 98: 105–271.

Hamilton, K. G. A. 1983. Classification, morphology and phylogeny of the family Cicadellidae (Rhynchota: Homoptera), pp. 15–37. *In* Knight, W. J., N. C. Pant, T. S. Robertson, and M. R. Wilson, eds., Proceedings of the 1st International Workshop Biotaxonomy, Classification and Biology Leafhoppers and Planthoppers of Economic Importance, London, 4–7 October 1982.

Kramer, J. P. 1964. New World leafhoppers of the subfamily Agalliinae: A key to genera with records and descriptions of species (Homoptera: Cicadellidae). Transactions of the American Entomological Society 89: 141–163.

Linnavuori, R. and D. M. DeLong. 1977. The leafhoppers (Homoptera: Cicadellidae) known from Chile. Brenesia 12/13: 163–267.

Oman, P. W. 1938. Art. XXII. A contribution to the classification of South American agallian leafhoppers. Annals of the Carnegie Museum 25: 351–460.

———. 1941. Revision of the Nearctic Megophthalminae (Homoptera: Cicadellidae). Journal of the Washington Academy of Sciences 31: 203–210.

———. 1949. The Nearctic leafhoppers (Homoptera: Cicadellidae): A generic classification and check list. Memoirs of the Entomological Society of Washington 3: 1–253.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 475–480

A NEW GENUS OF IASSINAE FROM SOUTHEASTERN BRAZIL (HOMOPTERA: CICADELLIDAE)

CHRISTOPHER H. DIETRICH

Systematic Entomology Laboratory, PSI, Agricultural Research Service, USDA, % U.S. National Museum NHB 168, Washington, D.C. 20560.

Abstract.—The Neotropical leafhopper ***Hoplojassus brasiliensis*** Dietrich, new genus, new species, is described, illustrated, and placed in the nominate tribe of the cicadellid subfamily Iassinae. *Hoplojassus* resembles other Iassini in overall shape and genital morphology, but certain features of the head, forewing, and leg are similar to those found in other cicadellid subfamilies. The unique combination of ancestral and derived features found in the new genus suggests that it represents a plesiomorphic lineage distinct from other Iassinae. The difficulties encountered in placing this genus accentuate the need for a revised higher classification of the Cicadellidae.

Key Words: Leafhopper, morphology, phylogeny, Penthimiinae, Hylicinae

The leafhopper species described herein keys to *Goblinaja* Kramer in Blocker's (1979a) key to New World genera of Iassini (as Iassinae), but differs considerably from this and all other described Iassinae. The unique combination of character states found in this species, represented by one male and two female specimens from southeastern Brazil, warrants its formal description and placement in a new genus.

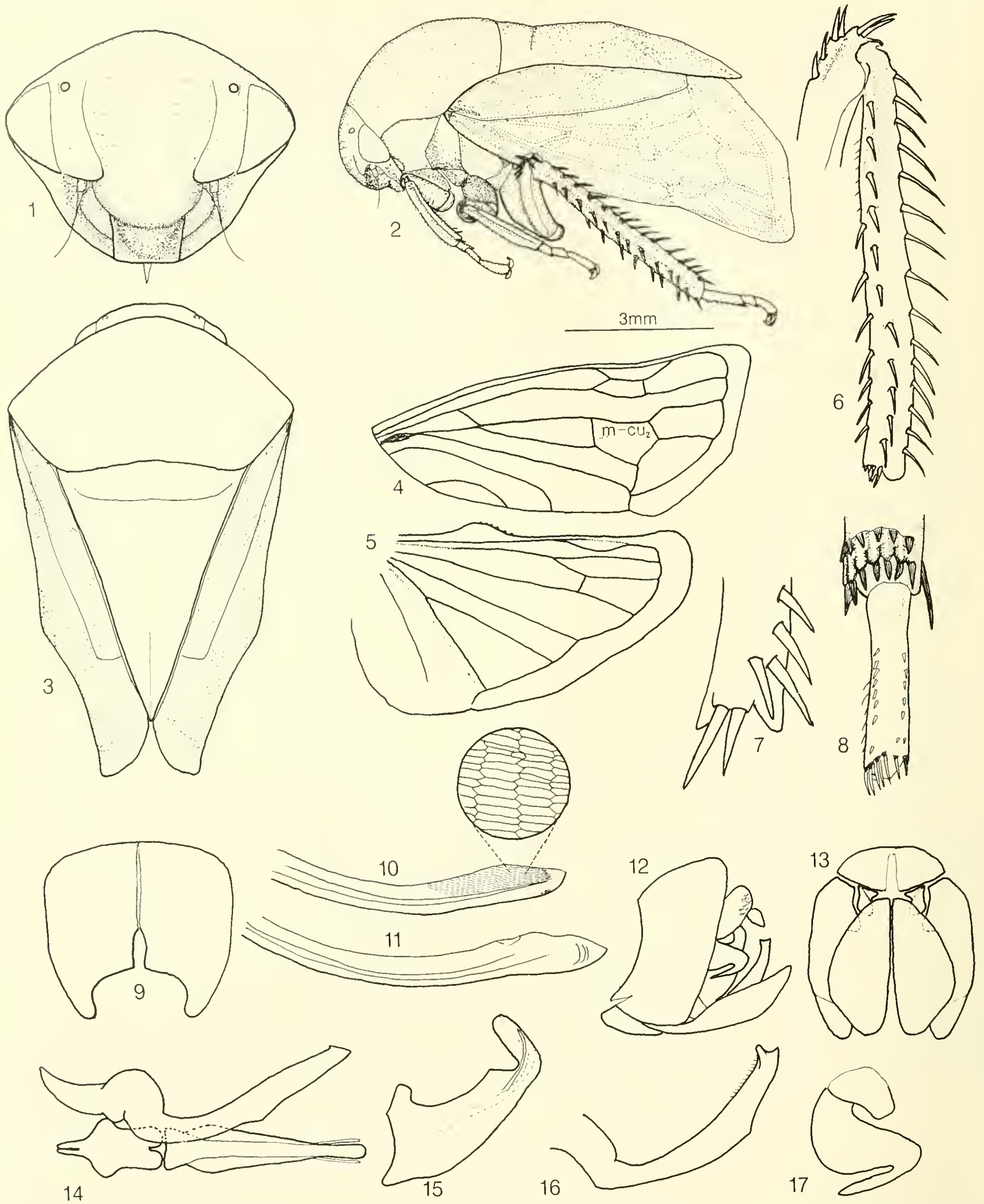
Terminology for wing venation and leg chaetotaxy follows Evans (1946) and Davis (1975), respectively.

Hoplojassus Dietrich, NEW GENUS
Figs. 1–17

Type species: Hoplojassus brasiliensis Dietrich, new species, by monotypy.

Diagnosis.—This genus is easily recognized by its large, robust form; and by its greatly enlarged scutellum, which surpasses the apex of the anal margin of the forewing at rest.

Description.—Head (Figs. 1, 2). Face, in anterior view, about half as wide as pronotum, evenly convex, without transverse striae, crown not differentiated; beak extended slightly beyond posterior margin of mesosternum; clypellus rectangular, gibbous medially, apex truncate, even with ventral margins of gena; transclypeal suture incomplete; lora flat, distance from lorum to antennal pit about half length of lorum; gena not strongly produced laterally, lateral margin weakly sinuate, largely concealing proepisternum; antenna short, length of flagellum less than half width of head; antennal ledge well developed, apex free, obliquely rounded, overlapping frontoclypeus; frontoclypeus convex, lateral margin not produced over antenna, muscle scars well developed, sulcate; postfrontal sutures slightly divergent, then curved mesad and fading near level of ocelli; coronal suture absent; weak groove present laterad of ocellus; ocelli on face near anterodorsal corners of eyes. Thorax. Pronotum (Figs. 2, 3) strongly convex, transverse striae very weak, lateral margin sharply carinate, posterior margin weakly emarginate. Scutellum (Figs.



Figs. 1–17. 1–11. *Hoplojassus brasiliensis,* **n. gen., n. sp.,** ♀ paratype (Corupa, Brazil): 1, head, anterior view; 2, habitus, lateral view; 3, same, dorsal view; 4, right forewing; 5, right hindwing; 6–8, left metathoracic leg—6, tibia and apex of femur, ventrolateral view; 7, apex of femur, dorsal view; 8, 1st tarsomere and apex of tibia, ventral view; 9, abdominal sternum VII; 10, 1st valvula, apical half, lateral view (detail of dorsal sculpturing enlarged); 11, 2nd valvula, apical half, lateral view. 12–17, holotype ♂ genitalia: 12, genital capsule, lateral view; 13, same, ventral view; 14, aedeagus, left style, and connective, posteroventral view; 15, aedeagus, lateral view; 16, style, lateral view; 17, hook of abdominal segment X, lateral view.

2, 3) large, posterior half keeled medially, impressed and irregularly rugose laterally, apex slightly surpassing apex of anal margin of forewing at rest. Forewing (Figs. 2–4) amber hyaline, without punctures or setae, with weak transverse fold on costal margin slightly distad of vein R_1; clavus broad, apex truncate; appendix broad, extending from claval apex to wing apex, then narrowed on costal margin; vein M_{1+2} absent; crossvein m-cu_1 short, M and Cu nearly contiguous near base; crossvein m-cu_2 present or absent, when present connected to Cu basad or distad of fork of Cu (cf. Figs. 2 and 4); forewing apices at rest not overlapped. Hind wing (Fig. 5) hyaline, crossvein r-m present, R_{4+5} and M_{1+2} not contiguous preapically; costal margin strongly arcuate near base; vannal fold closely paralleling Cu_2, not divergent toward wing margin; submarginal vein not continuing onto jugum. Legs. Prothoracic femur not flattened, with 2 apical and 2 preapical macrosetae, ventral setae scattered, rows weakly differentiated; tibia not flattened, row I carinate, rows I and II without preapical macrosetae, rows III and IV with 3 and 1 macroseta respectively. Mesothoracic femur with 2 apical macrosetae, ventral setae scattered, rows undifferentiated; tibial rows I and II without macrosetae, row I carinate, rows III and IV each with 3 or 4 macrosetae. Metathoracic femur (Figs. 6, 7) compressed, macrosetae 2:2:1:1, all subequal in size, situated on apical prominence; tibia (Figs. 6, 8) bowed laterad in ventral view, weakly twisted longitudinally, rows I–IV with approximately 15, 11, 7, and 3 black macrosetae, respectively, cucullate intercalary setae absent, row IV with about 20 smaller setae basad of, and interspersed among, preapical macrosetae, apical groups II and IV each with 1 macroseta, pecten (Fig. 8) with 6–7 non-cucullate macrosetae in preapical row and 5–6 cucullate macrosetae in apical row. Metathoracic tarsomere I (Fig. 7) as long as II and III combined; plantar surface with 2 widely spaced rows of small, non-cucullate setae; ventroapical row of cucullate setae oblique; dorsoapical setae absent. Female abdomen. Sternum VII (Fig. 9) 3× longer than sternum VI, with median longitudinal membranous cleft, apex emarginate, apicolateral margin produced into rounded lobe. Pygofer evenly clothed along apical and ventrolateral margin with setae of various widths, large macrosetae absent; base produced dorsomesally, ensheathing rami of 2nd valvulae. 1st and 2nd valvulae strongly united and difficult to separate, in lateral view, slender and evenly curved. 1st valvula (Fig. 10) with elongate-alveolate sculpturing dorsoapically; base in ventral view broad, heavily sclerotized except for small medial fenestra (hyaline area), mesal margin with horizontally oriented triangular dorsal flap. 2nd valvula (Fig. 11) with dorsal margin sinuate preapically, without teeth or serrations, preapical dorsal membranous area weak, apex with a few transverse striae; base of ramus extending caudad beyond connection with 2nd valvifer. Male genitalia. Genital capsule partially retracted into abdominal segment VIII, base of subgenital plates concealed; sternum VIII 2× longer than sternum VII. Pygofer (Figs. 12, 13) short, basolateral cleft weak, ventrolateral hooks absent; dorsoapical lobe present, articulated by flexible membranous hinge, broadly rounded, with several small macrosetae preapically. Segment X strongly sclerotized dorsally, membranous ventrally; ventrolateral hook (Figs. 12, 17) well developed, strongly sigmoid, tapered, apex in ventral view directed anterolaterad. Valve (Fig. 13) well developed, triangular, not fused to pygofer, with median longitudinal membranous cleft. Subgenital plates (Fig. 13) large, strongly constricted basally, obliquely ovoid apically, venter evenly clothed with coarse setae, macrosetae not differentiated, pseudostyles absent. Connective (Fig. 14) strongly sclerotized, with six lobes—two lateral, articulated with styles, two narrow anterior, and two broad posterior. Style (Figs. 14, 16) large, elongate; apodeme slender, sigmoid basally; shank curved dorsolaterad, ventral margin with angulate prominence near midlength, apex in lateral view concavely emarginate, dorsal margin with band of fine, short setae. Aedeagus (Figs. 14, 15) compressed; shaft tapered, directed posterodorsad, with lateral pair of long, slender, apically directed processes arising at apical ⅓; apex strongly recurved, rounded; anterodorsal margin with angulate prominence preapically; gonopore posteroapical. Integumental sculpturing. Body and wings largely glabrous, fine reticulate sculpturing present on legs; fore- and hind wing apices granulose.

Hoplojassus brasiliensis Dietrich, New Species

Figs. 1–17

Type locality: Rio de Janeiro, Brazil [Carnegie Museum, Pittsburgh, PA, USA].

Description.—Structural features as described for genus. Coloration. Dark reddish orange marked with black; venter of head, pro- and mesothoracic coxae, mesal areas of thoracic sterna, episterna, and metathoracic coxa, and macrosetae of legs black, male pronotum with small medial pair and larger lateral pair of black metopidial maculae; basal tarsomeres of legs yellow; forewing reddish hyaline basally with a few yellowish spots, apical half amber colored with brown apical macula. Genitalia. As described for genus. Measurements (mm). Length including forewing, ♂7.0, ♀8.3; pronotum width, ♂4.0, ♀4.9; head width, ♂2.1, ♀2.6; head height, ♂1.9, ♀2.0; forewing length, ♂5.6, ♀7.0; forewing width, ♂2.1, ♀2.9; prothoracic tibia length, ♂1.4, ♀1.6; mesothoracic tibia length, ♂1.6, ♀1.9; metathoracic tibia length, ♂3.9, ♀4.0; metathoracic tarsus length, ♂1.6, ♀1.7; ovipositor length, 4.1; subgenital plate length, 1.3.

Material examined.—Holotype ♂ labeled: "Rio de Jan./ Brazil/ Acc.-No. 2066; Oct.; Holotype/ Hoplojassus/ brasiliensis/ Dietrich"; ♀ paratype, same locality, Acc.-No. 2966, November. [Carnegie Museum, Pittsburgh, PA, USA]; one additional ♀ paratype, Corupa (Hansa Humbolt), Santa Catarina, Brazil, November, 1944, A. Maller, Coll., Frank Johnson, Donor [U.S. National Museum, Washington, DC, USA].

DISCUSSION

Placement of *Hoplojassus* in an appropriate family-group taxon is difficult, in part because different authors have recently proposed different classifications. Linnavuori and Quartau (1975) included the tribes Iassini, Scarini (as Gyponini), and Krisnini (and four other exclusively Old World tribes) in the subfamily Iassinae. Synapomorphies supporting the monophyly of this subfamily have not been found. The apical fusion of hind wing veins R_{3+4} and M_{1+2} (Evans 1947) unites the cosmopolitan tribe Iassini with the Old World tribes Hyalojassini, Platyjassini, Reuplemellini, and Trocnadini, but this feature is absent among the Krisnini (mostly Old World), Scarini (New World), and Selenomorphini (New Caledonia), and exceptions occur among the New World Iassini (*Scaroidana* Osborn, *Pachyopsis* Uhler). Blocker (1979a, b) and other authors have considered the New World tribes to represent separate subfamilies. Hamilton (1983) suggested that the subfamily Iassinae (sensu Linnavuori and Quartau 1975) is polyphyletic, and removed all but the nominate tribe to a separate subfamily. This classification is contradicted by the hind wing feature mentioned above, and has not been followed by other authors (Blocker and Webb 1990, Oman et al. 1990). Blocker and Webb (1990) concluded that a reclassification of iassine family groups is needed, but thus far, none has been attempted. For convenience, I follow the classification of Linnavuori and Quartau (1975).

The ligulate subgenital plates, enlarged male sternum VIII, and partially retracted male genital capsule of *Hoplojassus* suffice to place the genus in the subfamily Iassinae (sensu Linnavuori and Quartau 1975). These presumably apomorphic features also occur among species of the Ledrinae and Hylicinae, but the former have three apical macrosetae on the hind femur, and the latter have the body densely clothed with scales or setae, putative synapomorphies lacking in *Hoplojassus* and other Iassinae.

The robust form and evenly convex head of *Hoplojassus* suggest that it is most appropriately placed in the tribe Iassini (= Iassinae sensu Blocker 1979a, b). This placement is also supported by the morphology of the female genitalia. As in other Iassini (Hill 1970), the ovipositor of *Hoplojassus* is long, narrow, and sword shaped. The ovipositors of the Scarini, the only other iassine tribe of widespread occurrence in the New World, are broad medially (Hill 1970). The new genus differs from other Iassini in lacking well-defined dorsal teeth on the 2nd valvula, and the alveoles of the dorsal sculpturing of the 1st valvula are more elongate (Fig. 10) than those illustrated for *Jassus lanio* (L.) by Hill (1970).

In overall shape, *Hoplojassus* resembles the New World genera *Gargaropsis* Fowler and *Baldriga* Blocker. But unlike these genera, *Hoplojassus* retains a number of features thought to be primitive (Blocker 1979b). These include: 1) vertex without spots; 2) vertex not produced medially; 3) forewing vein separating appendix and 1st apical cell complete; 4) ventral margin of pygofer without dense row of setae; (5) subgenital plates broad, without pseudostyles; 6) style elongate; 7) aedeagus without apical processes; 8) pygofer margins parallel; 9) genital capsule only partially retracted into abdominal segment VIII; 10) subgenital plates not reduced. Additionally, *Hoplojassus* has hindwing veins R_{3+4} and M_{1+2} separate throughout their length. Among other New World Iassini, this feature occurs only in *Scaroidana* and *Pachyopsis* (and possibly *Scaropsia* Blocker), genera that Blocker (1979b) placed at the base of his cladogram.

Among the 26 apomorphies listed by Blocker (1979b) for genera of Iassini, *Hoplojassus* has five: 1) head narrower than pronotum; 2) forewing without setae; 3) male abdominal sternum VII 2× longer than sternum VI; 4) abdominal segment X with hooks; 5) ventrolateral pygofer hooks absent.

Placement of *Hoplojassus* on Blocker's (1979b) cladogram based on any of these features would require additional homoplasy. The presence of numerous plesiomorphies that are absent in most Iassini generally supports the placement of the new genus near the base of Blocker's cladogram. However, the presence of hooks on abdominal segment X suggests a relationship to the highly derived genera *Penestragania* and *Mogenola,* and the elongate male abdominal sternum VIII would place the new genus near *Garlica.* Such contradictory evidence suggests that the phylogenetic relationships among New World Iassini need reassessment.

Some features present in *Hoplojassus* that are unusual or unique among Iassinae may be plesiomorphic for the subfamily. Blocker (1979b) suggested that reduction in the number of hind femoral macrosetae occurred in the evolution of the Iassini; primitive genera have setal formula 2:2:1 and derived genera have setal formula 2:1:1, 2:1, or 2:0. In *Hoplojassus,* the macrosetal formula of the hind femur is 2:2:1:1. This formula is rare among other Iassinae, occurring only in the genera *Sulcana* DeLong and Freytag and *Coelogypona* DeLong and Freytag (tribe Scarini), but is common among species of other cicadellid subfamilies (e.g. Hylicinae and Penthimiinae). If Blocker's (1979b) polarization of this character is correct, then *Hoplojassus* may be among the most plesiomorphic taxa of the subfamily Iassinae.

Certain features of the head and wings of *Hoplojassus* are shared with the subfamilies Penthimiinae and Hylicinae. The ocelli of *Hoplojassus* are situated much more dorsolaterally than those of other iassines. The forewing of the new genus bears a transverse preapical fold and has a broad appendix that extends to the costal margin. These features are apparently absent among other Iassinae but occur frequently among the Penthimiinae and Hylicinae. In one specimen (USNM) of *H. brasiliensis,* crossvein m-cu_2 connects to the anterior branch of Cu, a striking resemblance to the usual venation of the Hylicinae. Presence of an abrupt transition between the reddish dorsal and black ventral parts of the head in *Hoplojassus* is similar to the usual condition in the Penthimiinae. An elongate scutellum is also present among the Penthimiinae (e.g. *Haranga* Distant) and Hylicinae (e.g. *Balala* Distant, *Sudra* Distant); but the scutellum of *Hoplojassus* is considerably more elongate than that of any other known leafhopper.

Despite these apparent affinities, *Hoplojassus* differs greatly from the subfamilies Penthimiinae and Hylicinae in the structure of the female genitalia (Hill 1970). The new genus also differs from other Iassinae in having the apex of the scutellum surpassing the apex of the anal margin of the forewing at rest, and in lacking forewing vein M_{1+2}. Thus, *Hoplojassus* may represent a lineage distinct from described cicadellid family-groups. Nonetheless, placement in the tribe Iassini, based on the similarly shaped head and genitalia (possibly plesiomorphic similarity), seems appropriate until the phylogenetic relationships among the tribes and subfamilies of Cicadellidae are more clearly understood.

ACKNOWLEGMENTS

I thank C. W. Young (Carnegie Museum) for lending specimens, and H. D. Blocker, P. H. Freytag, K. G. A. Hamilton, R. W. Hodges, M. W. Nielson, R. V. Peterson, and M. D. Webb for constructive criticism of earlier versions of the manuscript.

LITERATURE CITED

Blocker, H. D. 1979a. The Iassinae (Homoptera: Cicadellidae) of the Western Hemisphere. Journal of the Kansas Entomological Society 52: 1–70.

———. 1979b. A proposed phylogeny of New World Iassinae (Homoptera: Cicadellidae). Annals of the Entomological Society of America 72: 857–862.

Blocker, H. D. and M. D. Webb. 1990. The leafhopper genus *Bythonia* (Homoptera: Cicadellidae). Entomological News 101: 293–296.

Davis, R. B. 1975. Classification of selected higher categories of Auchenorrhynchous Homoptera (Cicadelliae and Aetalionidae). United States Department of Agriculture Technical Bulletin 1494: 1–52.

Evans, J. W. 1946. A natural classification of leafhoppers (Homoptera, Jassoidea). Part. 2. Aetalionidae, Hylicidae, Eurymelidae. Transactions of the Royal Entomological Society of London 97: 39–54.

———. 1947. A natural classification of leaf-hoppers (Jassoidea, Homoptera). Part 3. Jassidae. Transactions of the Royal Entomological Society of London 98: 105–271.

Hamilton, K. G. A. 1983. Classification, morphology and phylogeny of the family Cicadellidae (Rhynchota: Homoptera), pp. 15–37. *In* Knight, W. J., N. C. Pant, T. S. Robertson, and M. R. Wilson, eds., Proceedings of the 1st International Workshop on Biotaxonomy, Classification and Biology of Leafhoppers and Planthoppers of Economic Importance, London, 4–7 October 1982, Commonwealth Institute of Entomology, London.

Hill, B. G. 1970. Comparative morphological study of selected higher categories of leafhoppers (Homoptera: Cicadellidae). Unpublished Ph.D. dissertation, North Carolina State University, Raleigh, xi + 186 pp.

Linnavuori, R. and Quartau, J. A. 1975. Revision of the Ethiopian Cicadellidae (Hemiptera-Homoptera): Iassinae and Acroponinae. Fasc. 3, Etudes du Continent Africain, Fondation pour Favoriser Recherches Scientifiques en Afrique, Brussels, 172 pp.

Oman, P. W., W. J. Knight, and M. W. Nielson. 1990. Leafhoppers (Cicadellidae): A Bibliography and Generic Check-list and Index to the World Literature 1956–1985. C.A.B. International Institute of Entomology, Wallingford, Oxon, U.K. 368 pp.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 481–487

THE GENUS *LAEVICEPHALUS* (HOMOPTERA: CICADELLIDAE): HOSTS, BIOGEOGRAPHY, AND THREE NEW SPECIES

ANDREW L. HICKS AND ROBERT F. WHITCOMB

Insect Biocontrol Laboratory, Plant Sciences Institute, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland 20705.

Abstract.—The genus *Laevicephalus* is comprised of small deltocephaline leafhoppers of North American grasslands. Although most species are southwestern and/or Mexican, some are northern or eastern. Southwestern species are largely associated with chloridoid (Poaceae: Chloridoideae) grasses. Some species are monophagous; others are oligophagous. Oligophagy coefficients are presented for 15 species of prairie and/or southwestern grasslands. Three new species are described: ***L. warnocki*** from chino grama (*Bouteloua ramosa*) in Big Bend National Park in Texas, ***L. navajo*** from montane blue grama (*B. gracilis*) grasslands of the Mogollon Rim and Sacramento Mountains of Arizona and New Mexico, and ***L. nosabe*** from side-oats grama (*B. curtipendula*) in Durango, Mexico.

Key Words: Leafhopper, grasslands, oligophagy, monophagy

The genus *Laevicephalus* DeLong is comprised of small, usually green leafhoppers that have speciated extensively in North American grasslands. Ross and Hamilton (1972) proposed a phylogenetic scheme that divided the genus into five species groups. Although the genus is especially diverse in southwestern and Mexican grasslands, some lineages occur primarily in northern and eastern grasslands. Extensive collections in the southwestern United States (Whitcomb et al. 1987, 1988, Lynn and Whitcomb 1987) have produced a large number of host records and biogeographic data on this genus. In this paper, we present host data for *Laevicephalus* species, and describe three previously unrecognized species.

HOST DATA

Host and biogeographic data on the genus *Laevicephalus* was accumulated in the course of a host-by-host, region-by-region sampling of grasslands (Whitcomb et al. 1987). Methods for collection (Whitcomb et al. 1986) and computerization of the accessions (Lynn and Whitcomb 1987) have been previously described. Oligophagy coefficients, computed as previously described (Whitcomb et al. 1987, Whitcomb and Hicks 1988), represent fractions of insects occurring on plant hosts at various (family, subfamily, genus, and species) levels. Oligophagy coefficients at the genus and species levels are presented in Table 1 for 15 species of *Laevicephalus* that appear to be relatively host specific. Some species, particularly those of more mesic and eastern grasslands, showed patterns that cannot be interpreted in terms of single host grasses. Eastern species with complex feeding patterns include *L. peronatus* Ross and Hamilton, *L. sylvestris* (Osborn and Ball), and *L. acus* (Sanders and DeLong). *L. tritus* Beamer and Tuthill, a southwestern species, was taken on a variety of grasses. *L. unicoloratus* (Gillette and Baker) is a characteristic species of tallgrass prairie, often feeding on *Andropogon* spp. or related warm-season grasses.

Table 1. Oligophagy coefficients (O_i) for the genus *Laevicephalus*.[1]

Laevicephalus Species	Host Genus	O_{gen}	Host Species	O_{sp}	n
aridus Oman	*Bouteloua*	0.835[1]	*eriopoda*	0.777	121
curvus Knull	*Eragrostis*	0.938	*trichodes*	0.938	16
exiguus Knull	*Bouteloua*	0.960	*gracilis*	0.356	101
			hirsuta	0.317	
inconditus Knull	*Bouteloua*	0.969	*curtipendula*	0.969	32
melsheimerii (Fitch)	*Danthonia*	1.000	spp.	1.000	68
minimus (Osborn & Ball)	*Bouteloua*	0.894	*curtipendula*	0.521	94
			gracilis	0.234	
mexicanus Ross & Hamilton	*Bouteloua*	0.973	*curtipendula*	0.973	37
navajo Hicks and Whitcomb	*Bouteloua*	0.866	*gracilis*	0.866	15
obvius Knull	*Bouteloua*	0.927	*gracilis*	0.588	330
warnocki Hicks and Whitcomb	*Bouteloua*	1.000	*ramosa*	1.000	70
opalinus Ross and Hamilton	*Bouteloua*	1.000	*gracilis*	0.836	73
			curtipendula	0.110	
parvulus (Gillette)	*Buchloë*	0.998	*dactyloides*	0.998	807
salarius Knull	*Distichlis*	0.921	*spicata*	0.921	126
tritus Beamer and Tuthill	*Bouteloua*	0.512	*curtipendula*	0.433	82
vannus Knull	*Bothriochloa*	0.547	spp.	0.547	86

[1] Oligophagy coefficients (Whitcomb et al. 1987) represent the fraction of all insects collected on the indicated taxon. Only species for which adequate sample sizes are available are included in the analysis.

GEOGRAPHIC DISTRIBUTIONS

Despite our extensive surveys, the geographic distributions of many *Laevicephalus* species are still undetermined, since the ranges of many species extend into Mexico, where collection efforts have been inadequate. Some patterns are of particular interest. In Fig. 1, we present distributional records for four closely related *Bouteloua* specialists. Two of the species are strict specialists on side-oats grama [*Bouteloua curtipendula* (Michx.) Torr.], whereas two others colonize blue grama (*Bouteloua gracilis* Willd. ex H.B.K.). In Fig. 2, we have mapped the type localities for species described herein.

DESCRIPTIONS OF NEW SPECIES

Laevicephalus warnocki **Hicks and Whitcomb, NEW SPECIES**

(Figs. 2, 3)

Male.—Length, 2.24–2.68 mm, vertex length 0.16–0.27 mm, head width 0.67–0.79 mm, interocular width 0.24–0.32 mm. Head much wider than pronotum, crown narrow, bluntly rounded. Plates subtriangular, lined laterally with uniseriate macrosetae. Styles evenly curved apically with inconspicuous denticulations (Fig. 3A). Aedeagus in lateral aspect (Fig. 3B) the same width throughout, slightly convex. In ventral aspect, shaft straight, with two pairs of processes, one pair apical, slender, recurved, subapical pair subtriangular with concave margins. Shaft apex broadly blunt, gonopore apical (Fig. 3D). Dorsal apodeme (= atrial arm) bisinuate, parallelling shaft, ⅔ length of shaft. Pygofer elongate, exceeding plates, dorsally convex, slightly concave ventrally, with numerous scattered macrosetae.

Color stramineous; tegmina subhyaline, unmarked.

Female.—Length, 2.76–3.04 mm, vertex length 0.20–0.40 mm, head width 0.81–0.91 mm, interocular width 0.32–0.42 mm. Habitus similar to male, but with crown more produced and strongly angled, faint pair of arcs often present at apex. Seventh sternum (Fig. 3C) roundly produced, ⅔ as long as broad, posterior margin weakly trilobed, median lobe slightly less produced than lateral lobes.

Color as in male.

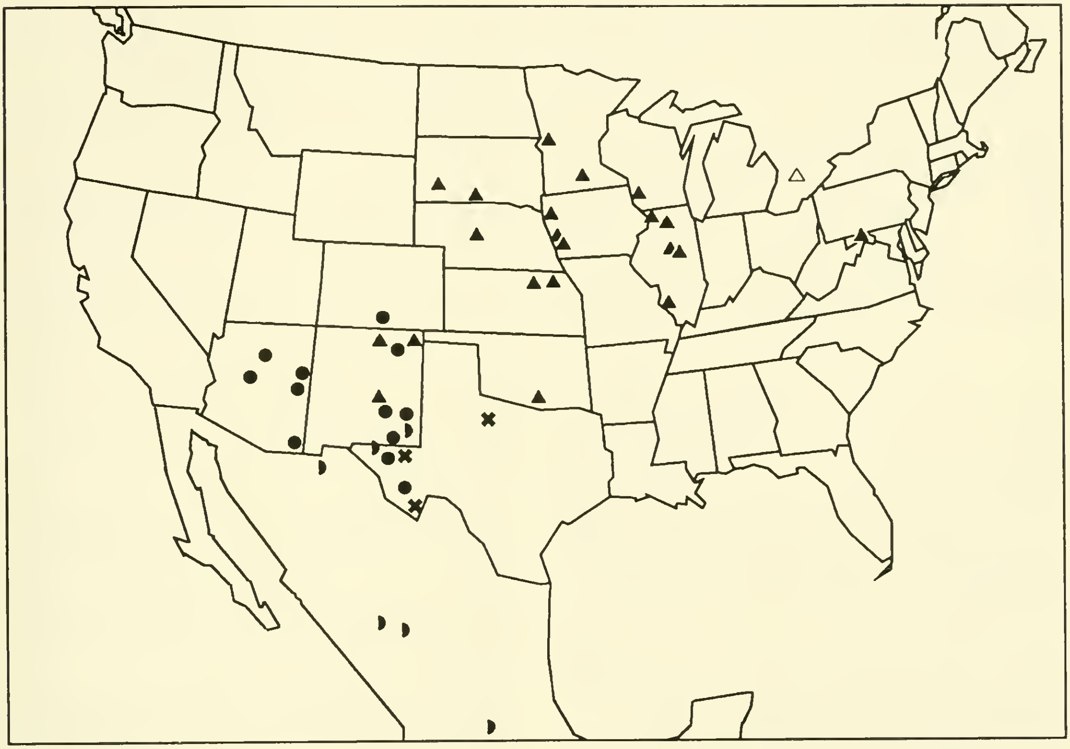


Fig. 1. Records for four species of *Laevicephalus* that specialize on *Bouteloua.* Two of the species occur mainly on side-oats grama (*Bouteloua curtipendula*). *Laevicephalus minimus* (▲ and △, the latter of which is a CNC record) is distributed throughout the true prairie, where it specializes on *Bouteloua curtipendula.* However, in the Colorado and New Mexico Rockies, it feeds on blue grama (*B. gracilis*). Another species, *L. inconditus* Knull (×) occurs in Chihuahuan grasslands, and *L. opalinus* (●), which more often occurs on blue than side-oats grama, is distributed in Southwestern grasslands west of the Chihuahuan region. *Laevicephalus mexicanus* (◑), previously known only from near Mexico City, has been collected on side-oats grama in southeastern New Mexico, a region in which all four of these species occur.

Type material.—*Holotype male:* Texas: Brewster Co., Big Bend National Park, Panther Junction, 26 August, 1985, 3500 ft, R. F. Whitcomb and A. L. Hicks, IPL 002081, on *Bouteloua ramosa* Vasey, deposited in NMNH, Washington, D.C. *Paratypes*: Texas: Big Bend National Park, same data as holotype, IPL 002081, 82, and 83, 25 males, 6 females. Texas: Big Bend National Park, Chisos Mtns., 5000 ft, August 4, 1984, R. F. Whitcomb and A. L. Hicks, IPL 000818, 1 male; Texas: Big Bend National Park, 2600 ft, August 25, 1985, IPL 002055, 8 males, 3 females. Deposited in BARC, Beltsville, Maryland; California Academy of Sciences, San Francisco; Canadian National Collection, Ottawa, Ontario; Kansas University, Snow Museum, Lawrence; Kansas State University, Manhattan; Monte L. Bean Museum, Brigham Young University, Provo, Utah; Ohio State University, Columbus; and NMNH.

Diagnosis.—The male genitalia of *L. warnocki* are similar to those of *L. salarius* Knull, to which it keys in the treatment of Ross and Hamilton (1972), and *L. canyonensis* Knull. However, *L. warnocki* can be differentiated from both of these species by the morphology of the subapical processes, which in ventral view have a straight anterior margin. Also, *L. canyonensis* is readily separable from *L. warnocki* and *L. salarius* on the basis of its coronal stripes.

Host.—This species has been collected

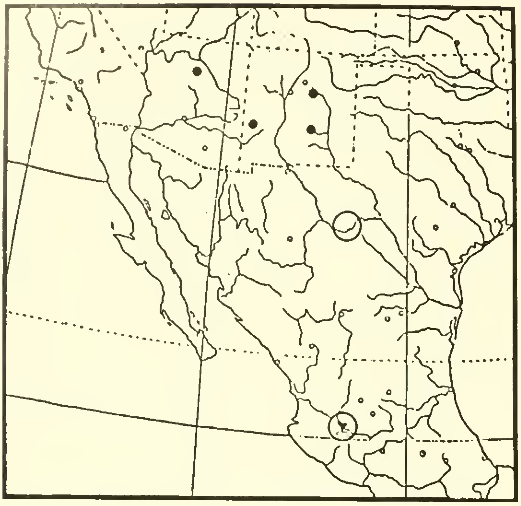


Fig. 2. Localities for new species. Large dots are localities for *L. navajo,* open circle for *L. warnocki,* and circle with inverted triangle for *L. nosabe.*

only in Big Bend National Park, where it apparently specializes on chino grama, *Bouteloua ramosa.*

Etymology.—We have named this species for Dr. Barton Warnock, who assisted us in many ways with the botany of trans-Pecos Texas.

Laevicephalus navajo Hicks and Whitcomb, New Species
(Figs. 2, 4)

Male.—Length, 3.0–3.36 mm, vertex length 0.36–0.40 mm, head width 0.88–0.97 mm; interocular width 0.32–0.44 mm. Head much wider than pronotum, anterior margins straight, apex acute. Plates subtriangular, lined laterally with uniseriate macrosetae. Style apices evenly curved laterad, apical denticulations inconspicuous or absent (Fig. 4A). Aedeagus in lateral aspect (Fig. 4B) strongly arched, tapering gradually toward apex. In ventral aspect (Fig. 4D), shaft narrow and straight, abruptly widened to pair of acute retrorse processes (Fig. 4D); shaft bluntly rounded with slight medial indentation; gonopore ovoid, subapical on ventral surface of shaft (Fig. 4C). Dorsal apodeme parallelling shaft, attaining ½ length of shaft, recurved apically. Pygofer elongate, exceeding plates, dorsally flattened, slightly concave ventrally, with numerous scattered macrosetae.

Tawny brown or fulvous, tegmina semihyaline but with cells margined widely with dark brown. Crown with variable markings with apical dark brown arcs. Face tawny and unadorned, marked with brown transverse lines.

Female.—Length, 3.36–4.04 mm. Vertex length 0.36–0.48 mm; head width 0.88–0.99 mm, interocular width 0.36–0.48 mm. Habitus as in male. Seventh sternum (Fig. 4D) with posterior margin wedge-shaped with slightly embrowned blunt apex.

Color as in male.

Type material.—*Holotype male:* Arizona: Coconino Co., Red Lake (north of Williams), 6400 ft, 13 Sept., 1986, R. F. Whitcomb, IPL 002714, on blue grama (*Bouteloua gracilis*), deposited in NMNH. *Paratypes:* Same collection data as holotype, 1 male, 3 females; New Mexico: Lincoln Co., Ft. Stanton, 7600 ft, 9 Sept. 1987, R. F. Whitcomb, IPL 003536, on *Muhlen-*

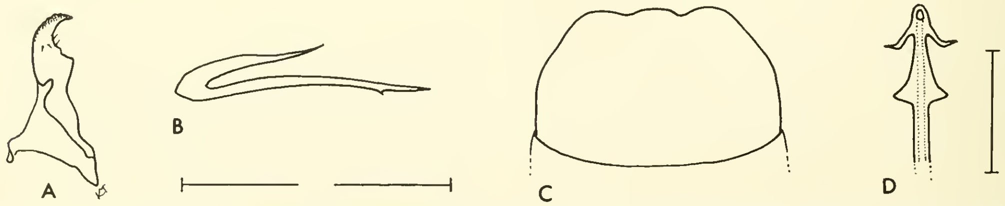


Fig. 3. *Laevicephalus warnocki* Hicks and Whitcomb n. sp. (Scale lengths in parentheses.) A. Style, broad aspect (0.5 mm); B. Aedeagus, lateral aspect (0.5 mm); C. Female sternum VII (0.5 mm); D. Apex of aedeagus, detail, ventral aspect (0.1 mm).

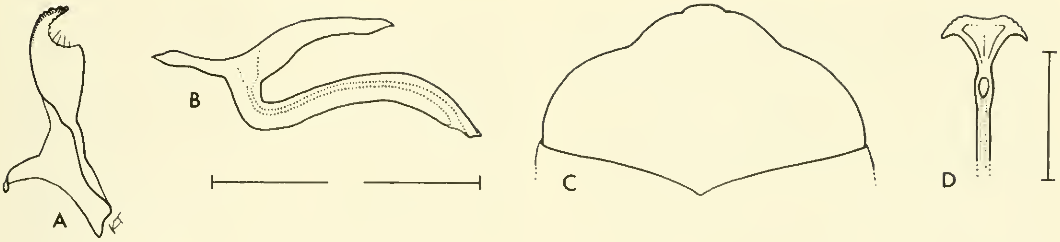


Fig. 4. *Laevicephalus navajo* Hicks and Whitcomb n. sp. (Scale length in parentheses.) A. Style, broad aspect (0.5 mm); B. Aedeagus, lateral aspect (0.5 mm); C. Apex of aedeagus, detail, ventral aspect (0.1 mm); D. Female sternum VII (0.5 mm).

bergia pauciflora Buckl., 1 male, 1 female. New Mexico: Sante Fe Co., Edgewood, 6600 ft, 29 August 1987, R. F. Whitcomb, IPL 003390, on *B. gracilis,* 3 males, 2 females, 1 immature; New Mexico: Catron Co., Aragon, 7340 ft, 16 August, 1987, IPL 001759, A. L. Hicks, on *B. gracilis,* 1 male; New Mexico: San Miguel Co., Villanueva, 6000 ft, 13 Aug. 1987, IPL 001745, on *B. gracilis,* A. L. Hicks, 1 male. Deposited in NMNH, Washington, D.C.

Diagnosis.—*L. navajo* can be distinguished from all other members of the genus by its dark brown color. It will key (Ross and Hamilton 1972) to *L. vannus* Knull, but can be distinguished from this species by the decurved, laterally compressed aedeagus. The morphology of its male genitalia suggest that it is a sister species to *L. longus* Knull, from which it can be distinguished by the configuration of the aedeagal apex.

Host.—This species has been collected in Arizona and New Mexico from chloridoid grasses, especially *Bouteloua gracilis.* However, its relative scarcity in many accessions from this grass, even within its range, suggests complex habitat requirements.

Etymology.—We have named this species for the Navajo tribe of Native Americans, upon whose lands (in part) this species occurs.

Laevicephalus nosabe **Hicks and Whitcomb, New Species**

(Figs. 2, 5)

Male.—Length, 2.92–3.00 mm, vertex length 0.28–0.36 mm, head width 0.80–0.84 mm, interocular width 0.32–0.36 mm. Head much wider than pronotum, crown narrow, anterior margins straight, apex acute. Plates subtriangular, lined laterally with uniseriate macrosetae. Styles in broad aspect curved laterad to truncate dentate apex (Fig. 5A). Aedeagus in lateral aspect (Fig. 5B) narrow,

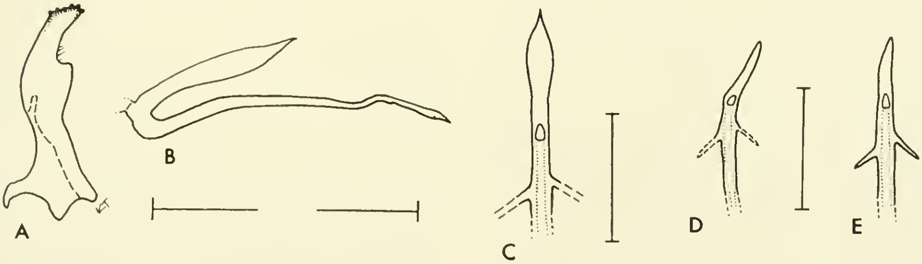


Fig. 5. *Laevicephalus nosabe* Hicks and Whitcomb n. sp. (Scale length in parentheses.) A. Style, broad aspect (0.5 mm); B. Aedeagus, lateral aspect (0.5 mm); C. Apex of aedeagus, broad aspect (0.1 mm); D. same, showing broken processes (0.1 mm); E. same, showing processes entire (0.1 mm.).

weakly arched, with straight midsection and decurved apex. In ventral aspect, aedeagus straight, curving and twisting slightly in distal quarter, curving slightly dextrad. Two tiny retrorse processes (broken in one specimen, Fig. 5D), the right slightly distad from the left in ventral broad aspect (Fig. 5E), occurring at ⅕ the shaft length from the apex. Dorsal apodeme ½ length of shaft and slightly divergent. Gonopore minute, preapical, on ventrolateral surface; aedeagal apex (Fig. 5C) diamond-shaped distad of the gonopore, slightly wider than shaft, and dorsoventrally flattened. Pygofer with shallow indentation on ventral surface dorsad of lateral lobe of style, with scattered macrosetae.

Head and pronotum bright yellow-green to pale green. Crown with fuscous arcs at apex, otherwise unmarked.

Female.—Unknown.

Type material.—*Holotype male:* Mexico: Durango, 24.5 mi southeast of Durango, 6.5 mi west of Nombre de Dios, Mexican Highway 45, 6400 ft, Oct. 1, 1988, A. L. Hicks, IPL 002822, deposited in NMNH. *Paratypes:* 2 males, same collection data, deposited in NMNH.

Diagnosis.—The male genitalia of *L. nosabe* are similar to those of *L. ustulatus* Ross and Hamilton, from which *nosabe* can be differentiated by the configurations of the aedeagal apices. The aedeagal spines in *nosabe* are more developed. The diamond-shaped apex of the aedeagus, which is widest beyond the apical processes, distinguishes *nosabe* from all other members of the *tritus* species group, and particularly, from *tritus,* to which it will key in the treatment of Ross and Hamilton (1972).

Host.—The type series was collected from a mixed association of grasses in which side-oats grama, *Bouteloua curtipendula,* was dominant.

Etymology.—The Spanish "no sabe," used to express doubt or lack of knowledge, seemed appropriate for this species, which is—like so many Mexican species represented by only a few specimens—enigmatic.

Discussion

Availability of phylogenies for the genera *Flexamia* DeLong (Whitcomb and Hicks 1988) and *Athysanella* Baker (Blocker and Johnson 1988, Blocker and Johnson 1990a, b) has permitted a preliminary analysis of the biogeography and evolutionary history of those genera (Whitcomb et al. 1990). The preliminary phylogeny of Ross and Hamilton (1972) suggests that two relatively small lineages of the genus (the sylvestris and poudris groups) evolved in northern and/or eastern grasslands. Two groups (parvulus and minimus), like *Flexamia* and *Athysanella,* clearly evolved with warm-season grasses in the American Southwest and Mexico. The preliminary phylogeny should be revised to include currently known species, including those described herein and *L. satchkatchewanensis* Hamilton and Ross (1975) by objective analysis.

Geographic records for *Laevicephalus* suggest that distributions of many species are partly or largely Mexican. Many of the species appear to occur throughout the Mexican highlands from Mexico DF into the southwestern United States. Further acquisitions from Mexico would clearly improve our understanding of this genus.

The host records presented in Table 1 suggest that some *Laevicephalus* species are highly host specific. On the other hand, there is a clear tendency for host specificity of grassland cicadellids to be much more pronounced in northern parts of their range (Whitcomb et al. 1987). It is therefore especially important that host records be obtained from the southern periphery of the range of *Laevicephalus* species, where they may have more generalized host selection.

The host affinities of the species depicted in Fig. 1 is of special interest. All are members of the minimus subgroup, a monophyletic clade identified by Ross and Hamilton (1972). All feed on side-oats grama, but two species also feed on blue grama, and one of these occurs most often on blue grama. It is possible that the forms of *L. minimus* (Osborn and Ball) found in the Rockies on blue grama, apparently allopatric with the eastern side-oats forms, are a cryptic species. The division of *L. opalinus* Ross and Hamilton into cryptic but sympatric specialists of the two gramas appears less plausible. Although intrageneric crossovers are frequently encountered in host relationships of grass-feeding leafhoppers, blue and side-oats grama are extremely different in growth form and floral morphology. Other leafhopper genera, such as *Flexamia* and *Laevicephalus,* make this crossover rarely if ever. Perhaps the ability of *minimus* and *opalinus* to make this crossover reflects a long tenure of the lineage in the mixed *Bouteloua* grasslands of northern Mexico and the American Southwest.

A thoughtful revision of this genus, and a comparison of its evolutionary history with other genera, would improve the understanding of the ecology and evolution of insects in southwestern grasslands.

ACKNOWLEDGMENTS

We thank Barton Warnock for help with the grassland biology of trans-Pecos Texas, where the species named for him was discovered. We also thank Bruce Triplehorn, K. G. A. Hamilton, M. Nielson, H. D. Blocker and Kathleen McCormick for comments on the manuscript. We thank Pamela Cubbage for invaluable field assistance and moral support on collecting trips in Arizona and Mexico; Mike Fleming of Big Bend National Park; and Rosemary Smith and Eric Weber for logistical support for the Mexican collecting trips.

Illustrations. We especially thank Karen Teramura for her discussions of the representation of leafhopper morphology, and for her excellent illustrations.

LITERATURE CITED

Blocker, H. D. and J. W. Johnson. 1988. Classification of the subgenus *Athysanella,* genus *Athysanella* (Homoptera: Cicadellidae: Deltocephalinae). Great Basin Naturalist Memoirs 12: 18–42.

———. 1990a. Classification of *Athysanella* (*Gladionura*) (Homoptera: Cicadellidae: Deltocephalinae). Journal of the Kansas Entomological Society 63: 9–45.

———. 1990b. Classification of *Athysanella* (*Amphipyga*) (Homoptera: Cicadellidae: Deltocephalinae). Journal of the Kansas Entomological Society 63: 101–132.

Hamilton, K. G. A. and H. H. Ross. 1975. New species of grass-feeding deltocephaline leafhoppers with keys to the Nearctic species of *Palus* and *Rosenus.* Canadian Entomologist 107: 601–611.

Lynn, D. E. and R. F. Whitcomb. 1987. A computerized file for cicadellid host acquisitions, pp. 269–272. *In* Wilson, M. R. and L. R. Nault, eds., Proceedings of the 2nd International Workshop on Leafhoppers and Planthoppers of Economic Importance. Commonwealth Institute of Entomology, London.

Ross, H. H. and K. G. A. Hamilton. 1972. A review of the North American genus *Laevicephalus* (Hemiptera: Cicadellidae). Annals of the Entomological Society of America 65: 929–942.

Whitcomb, R. F. and A. L. Hicks. 1988. Genus *Flexamia*: New species, phylogeny, and ecology. Great Basin Naturalist Memoirs 12: 224–323.

Whitcomb, R. F., J. Kramer, M. E. Coan, and A. L. Hicks. 1986. Ecology and evolution of leafhopper-grass relationships in North American prairies, savanna, and ecotonal biomes. Current Topics in Vector Research 4: 125–182.

Whitcomb, R. F., A. L. Hicks, D. E. Lynn, K. Allred and H. D. Blocker. 1987. Geographic variation in host relationships of leafhoppers (Homoptera: Cicadellidae) in North American grasslands, pp. 293–295. *In* Wilson, M. R. and L. R. Nault, eds., Proceedings of the 2nd International Workshop on Leafhoppers and Planthoppers of Economic Importance. Commonwealth Institute of Entomology, London.

Whitcomb, R. F., A. L. Hicks, H. D. Blocker, and J. P. Kramer. 1988. Host specificity: A major mechanism enhancing insect diversity in grasslands. Paper 11.06. *In* Davis, A. and G. Stanford, eds., The Prairie: Roots of Our Culture; Formulation of Our Economy. Proc. 10th North American Prairie Conference, Denton, Texas, 1986. Native Prairies Association, Wheatland, Texas.

Whitcomb, R. F., H. D. Blocker, D. E. Lynn, and A. L. Hicks. 1990. Evolution of life history traits in grassland cicadellids: analysis of a five taxon natural experiment. Proceedings of the 3rd International Workshop on Leafhoppers and Planthoppers of Economic Importance. Wooster, Ohio, August, 1990. (Abstract).

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 488–503

NOMENCLATURAL NOTES ON GENERA OF NORTH AMERICAN EULOPHIDAE (HYMENOPTERA: CHALCIDOIDEA)

Michael E. Schauff and John LaSalle

(MES) Systematic Entomology Laboratory, ARS, PSI, % U.S. National Museum, NHB 168, Washington, D.C. 20560; (JL) International Institute of Entomology, % Dept. of Entomology, The Natural History Museum, London SW7 5BD, UK.

Abstract.—The systematic placement of the genera in the subfamilies Eulophinae and Euderinae of the Eulophidae (Hymenoptera: Chalcidoidea) of North America were reviewed. Two new genera are described: ***Cristelacher*** and ***Dasyeulophus***. Thirty genera are included in the Eulophinae and five in the Euderinae. Four new generic synonymies are proposed in the Eulophinae: *Notanisomorpha* Ashmead = *Hemiptarsenus* Thomson; *Mirolynx* Girault and *Pseudolynx* Girault = *Aulogymnus* Förster; *Cirrospiloideus* Ashmead = *Elachertus* Spinola. One new generic synonymy in the subfamily Entedoninae is proposed: *Aabacharis* Schauff = *Eprhopalotus* Girault. Nine genera are recorded from North America for the first time: *Colpoclypeus* Lucchese, *Cristelacher* Schauff and LaSalle, Gen. n., *Dasyeulophus* Schauff and LaSalle, Gen. n., *Deutereulophus* Schulz, *Diglyphomorpha* Ashmead, *Euplectromorpha* Girault, *Notanisomorphella* Girault, *Platyplectrus* Ferrière, and *Xanthellum* Erdös & Nov. Thirty two new combinations are proposed and a lectotype is designated for *Cirrospiloideus playnotae.* A table of the genera of North American Eulophinae, with their current placement is given.

Key Words: Taxonomy, nomenclature, Eulophidae, Eulophinae, Euderinae, North America

There have been numerous changes in generic limits and placements in the family Eulophidae since the publication of the most recent catalog for North America (Burks 1979). Two subfamilies have been or are being revised (Entedoninae by Schauff 1991, Tetrastichinae by LaSalle, in press), and several genera have been moved from previously assigned subfamilies and tribes to new placements within the family. Joint work by the authors uncovered a number of new problems with generic limits and placements in the two remaining subfamilies. Eulophinae and Euderinae as well as several genera not previously recorded from North America. It is necessary to publish these changes so that an upcoming key to genera of North American Eulophidae reflects the most recent research findings on this group.

Classification of Eulophidae

The scheme of higher relationships followed here differs from that used by Burks (1979) (see Table 1). Burks recognized three subfamilies: Eulophinae, Entedoninae (as Entedontinae), and Elasminae. His overall concept of the subfamily Eulophinae is essentially the same as the one we are using. He included three tribes: Eulophini, Elachertini and Euplectrini; we include the Eulophini and Euplectrini, and consider the Elachertini is belonging in the Eulophini (see discussion below).

Burks also included three tribes in his subfamily Entedoninae: Euderini, Tetrastichini and Entedonini. These tribes have since all been regarded as deserving subfamily status (Graham 1987, Bouček 1988, Grissell and Schauff 1990), and we differ from Burks (1979) in treating these groups at this level.

Finally, Burks included the Elasmidae as a subfamily in the Eulophidae. Elasmids are believed to be very closely related to eulophids, and the relationship between the two groups is still under study. However, for the time being we are following the lead of recent authors (Bouček 1988, Grissell and Schauff 1990) and maintaining the Elasmidae as a distinct family.

Scope and Treatment

This paper attempts to clarify any nomenclatural problems concerning the Eulophinae and Euderinae which have arisen since Burks (1979). We thus include all genera: 1) that were treated as Eulophinae or Euderinae by Burks (1979), regardless of their current placement; 2) which were listed in other subfamilies by Burks, but which have subsequently been moved into the Eulophinae or Euderinae; 3) which have since been recorded from North America. Additionally, we treat two genera whose placement was considered uncertain by Schauff (1991), but which we now place in the Entedoninae.

As the present work is intended to complement the North American catalog (Burks 1979), we are not repeating synonymic information for genera treated in the catalog except where changes have been made (i.e. new generic synonymies). However, we do include this information for genera newly recorded for the region, and we make reference to any recent revisionary work not mentioned in the catalog. Genera are arranged alphabetically within each subfamily. Valid genera are numbered and in boldface. Acronyms for museums are: USNM, U.S. National Museum of Natural History, Washington, D.C.; BMNH, The Natural History Museum, London; CNC, Canadian National Collection, Ottawa.

Table 1. Difference in treatment of subfamilies and tribes of Eulophidae between the most recent North American catalog (Burks 1979) and the present treatment.

Burks 1979	Present Paper
Family Eulophidae	Family Eulophidae
Eulophinae	Eulophinae
Eulophini	Eulophini
Euplectrini	Euplectrini
Elachertini	
Entedoninae	Entedoninae
Tetrastichini	Tetrastichinae
Euderini	Euderinae
Entedonini	
Elsaminae	Family Elasmidae

Subfamily EULOPHINAE

Although the limits of the Eulophinae are now generally accepted, there is no consensus on relationships within the subfamily. Burks (1979) included three tribes: Eulophini, Elachertini and Euplectrini. Bouček (1988) included six tribes in the Eulophinae. Two of these (Anselmellini and Keryini) are based upon aberrant Australian forms, and are not relevant to this work. The remaining four tribes (Ophelimini, Eulophini, Elachertini, Euplectrini) are found in all regions of the world.

As discussed by Bouček (1988), the separation of these four tribes is not easy. Characters which have traditionally been used, such as the presence or absence of notauli, may vary within a single genus. Boucek was aware of these problems, and in a discussion of the tribal limits of the Eulophini (Bouček 1988: 691) said, "The similarities may constitute convergencies but it is also possible that they reflect genuine relationship, in which case it seems that the present tribes Ophelimini, Elachertini and Eulophini should be united. Because of these difficulties, the tribes are maintained but could not be keyed out."

Table 2. Generic names associated with North American Eulophinae, either in Burks 1979 or since. **Bold** indicates a currently valid eulophine genus which is found in North America. ENT, Entedoninae; Ela, Elachertini; Eul, Eulophini; Eup, Euplectrini; Oph, Ophelimini; TET, Tetrastichinae.

Generic Name	Burks 1979	Boucek 1988	Present Paper	
Apterolophus Gahan	Ela		TET	Removed to Tetrastichinae by LaSalle and Schauff (1990) and synonymized with *Tetrastichomyia.*
Ardalus Howard	Ela	Ela	Eul	Synonym of *Elachertus*
***Aulogymnus* Förster**	Ela	Oph	Eul	
Cirrospiloideus Ashmead	Ela		Eul	Synonym of *Elachertus*
***Cirrospilus* Westwood**	Ela	Oph	Eul	
***Colpoclypeus* Lucchese**			Eul	Newly recorded from North America in this paper.
***Cristelacher* gen. n.**			Eul	Newly described in this paper.
***Dahlbominus* Hincks**	Eul		Eul	
***Dasyeulophus* gen. n.**			Eul	Newly described in this paper.
***Deutereulophus* Schulz**		Ela	Eul	Newly recorded from North America in this paper.
***Diaulinopsis* Crawford**	Ela	Oph	Eul	
Diaulomorpha Thomson	Eul	Ela		Not known from North America, see discussion.
***Dicladocerus* Westwood**	Eul		Eul	
***Diglyphomorpha* Ashmead**			Eul	Newly recorded from North America in this paper.
***Diglyphus* Walker**	Eul	Oph	Eul	
***Dimmockia* Ashmead**	Eul		Eul	
***Elachertus* Spinola**	Ela	Ela	Eul	
***Eulophus* Geoffroy**	Eul		Eul	
***Euplectromorpha* Gir.**	Eup	Eup	Eul	Newly recorded from North America in this paper.
***Euplectrus* Westwood**	Eup	Eup	Eup	
Giraultia Gahan and Fagan	Ela	Oph	Eul	Synonym of *Cirrospilus*
***Grotiusomyia* Gir.**	Ela		Eul	
***Hemiptarsenus* Westwd.**	Eul	Eul	Eul	
***Hoplocrepis* Ashmead**	ENT		Eul	Transferred to Eulophinae from Entedoninae by Schauff (1991).
***Hyssopus* Gir.**	Ela	Ela	Eul	
***Miotropis* Thomson**	Ela	Ela	Eul	
Mirolynx Girault	Ela		Eul	Synonym of *Aulogymnus*
Mirzagrammosoma Gir.	Ela		Eul	Synonym of *Zagrammosoma*
***Necremnus* Thomson**	Eul		Eul	
Notanisomorpha Ashmead	Eul	Eul	Eul	Synonym of *Hemiptarsenus*
***Notanisomorphella* Gir.**		Eul	Eul	Newly recorded from North America in this paper.
***Paraolinx* Ashmead**	Ela		Eul	
Pardiaulomella Gir.	Eul	Eul	Eul	Synonym of *Sympiesis*
Peckelachertus Yoshimoto	Ela		TET	Removed to Tetrastichinae by Graham (1977).
***Platyplectrus* Ferrière**		Eup	Eup	Newly recorded in North America in this paper.
***Pnigalio* Schrank**	Eul	Eul	Eul	
Pseudolynx Gir.	Ela		Eul	Synonym of *Aulogymnus*
Scotolinx Ashmead	Ela	Oph	Eul	Synonym of *Aulogymnus*
Stenomesius Westwood	Ela	Ela	Eul	Not known from North America, see discussion

Table 2. Continued.

Generic Name	Burks 1979	Boucek 1988	Present Paper	
Sympiesis **Förster**	Eul	Eul	Eul	
Trichospilus **Ferrière**		Eul	Eul	Newly recorded in North America by Bennett et al. (1987).
Winnemana Crawford	TET	Oph	Eul	Transferred from Tetrastichinae to Eulophinae, and synonymized with *Cirrospilus*, by Graham (1975).
Xanthellum **Erdös & Nov.**			Eul	Newly recorded in North America in this paper.
Zagrammosoma **Ashmead**	Ela	Oph	Eul	

In this paper we recognize only two tribes in the Eulophinae: Eulophini and Euplectrini. The Euplectrini are demonstrably monophyletic on the basis of greatly lengthened hind tibial spurs. The separation of the Eulophini from the remaining tribes, as discussed above, is tentative at best. Since these latter tribes cannot be keyed, their limits are vague, and their monophyly has not been supported, we feel that it is not necessary to maintain them in this paper. Indeed, the Eulophini may be paraphyletic with respect to the Euplectrini, however we are retaining these two tribes in the absence of a more detailed study of relationships.

Table 2 lists all genera of Eulophinae treated in this paper, and shows their tribal placement according to Burks (1979), Bouček (1988), and the present paper.

GENERA REMOVED FROM EULOPHINAE SINCE BURKS, 1979

Apterolophus Gahan

Burks (1979: 982) treated *Apterolophus* in the Elachertini. It has since been moved to the Tetrastichinae and synonymized with *Tetrastichomyia* (LaSalle and Schauff 1990).

Peckelachertus Yoshimoto

Burks (1979: 983) treated *Peckelachertus* in the Elachertini. It ha since been moved to the Tetrastichinae (Graham 1977, 1991).

GENERA NEW TO NORTH AMERICAN EULOPHINAE SINCE BURKS, 1979

The following genera, (also included in the list of genera given below), were not included in the Eulophinae by Burks (1979) (see table 2): *Hoplocrepis* Ashmead, *Dasyeulophus* Schauff and LaSalle, **Gen. n.**, *Platyplectrus* Ferrière, *Trichospilus* Ferrière, *Winnemana* Crawford, *Colpoclypeus* Lucchese, *Xanthellum* Erdös and Novicky, *Diglyphomorpha* Ashmead, *Notanisomorphella* Girault, *Deutereulophus* Schulz, and *Cristelacher*, Schauff and LaSalle, **Gen. n.**

LIST OF NORTH AMERICAN EULOPHINAE GENERA

(Valid genera numbered and in bold face).

In those cases where there have been no changes since Burks (1979), we have only listed the generic name.

Ardalus Howard [see *Elachertus*]

1. *Aulogymnus* Förster

Aulogymnus Förster, 1851: 24. Type species *Aulogymnus aceris* Förster (monotypy).

Mirolynx Girault, 1916a: 131. Type species *Mirolynx flavitibiae* Girault. (orig. desig.) **Syn. n.**

Pseudolynx Girault, 1916b: 152. Type species *Pseudolynx io* Girault. (orig. desig.) **Syn. n.**

Scotolinx Ashmead, 1904: 354. Type species *Scotolinx gallicola* Ashmead (orig. desig.). Synonymized with *Aulogymnus* by Boucek (1988: 609).

Discussion: Study of the type species of European species of *Aulogymnus* convinced us that the two genera described from North America (*Mirolynx* and *Pseudolynx*) were synonymous with *Aulogymnus.* All species included in the genera *Mirolynx* and *Pseudolynx* are here transferred to *Aulogymnus. Scotolinx* was not listed in the North American catalogue (Burks, 1979), however, Gordh (1977) described a North American species, *S. californica,* which we are transferring to *Aulogymnus.*

New Combinations: From *Mirolynx*: *flavitibiae* (Girault 1916a); from *Pseudolynx*: *flavimaculata* (Girault 1916b), *io* (Girault 1916b), *marilandia* (Girault 1917e); from *Scotolinx*: *californica* (Gordh 1977).

Cirrospiloideus Ashmead [see *Elachertus, Miotropis*]

2. *Cirrospilus* Westwood

Cirrospilus Westwood, 1832: 128. Type species *Cirrospilus elegantissimus* Westwood (by monotypy).

Winnemana Crawford, 1911: 620. Type species *Winnemana argei* Crawford. (orig. desig.) Synonymized with *Cirrospilus* by Graham, 1975.

Cirrospilopsis Girault, 1915a: 263. Type species *Cirrospilopsis nigrivariegatus* Girault (orig. desig.). Preoccupied by *Cirrospilopsis* Brèthes, 1913.

Giraultia Gahan and Fagan, 1923: 66. Replacement name for *Cirrospilopsis* Girault, 1915a (not *Cirrospilopsis* Brèthes, 1913). Synonymized with *Cirrospilus* by Boucek, 1988.

Discussion: Giraultia Gahan and Fagan (a replacement name for *Cirrospilopsis* Girault), was treated as valid by Burks (1979), but has since been synonymized with *Cirrospilus* (Bouček, 1988). We are here transferring all North American species which had been in *Giraultia* to *Cirrospilus. Winnemana* was included in the Tetrastichinae by Burks (1979), however, it was transferred to the Eulophinae and synonymized with *Cirrospilus* by Graham (1975).

New Combinations: From *Giraultia*: *fuscipennis* (Girault 1916e), *metallicus* (Girault 1917g), *sapienta* (Girault 1917c).

3. *Colpoclypeus* Luccheses

Colpoclypeus Lucchese, 1941: 33. Type species *Eulophus florus* Walker: 1839 (= *silvestrii* Lucchese) (by monotypy).

Discussion: This genus has not been previously reported from North America. However, specimens in the USNM from Wenatchee, Washington reared from *Pandemis pyrusana* were recently determined by one of us (MES) as *C. florus.*

4. ***Cristelacher* Schauff and LaSalle, gen. n.**

Discussion: This genus is described to contain *Elachestus levana* (Walker) (the only included species). A full description of this genus is given at the end of this paper.

New Combinations: From *Stenomesius*: *levana* (Walker 1847).

5. *Dahlbominus* Hincks

6. ***Dasyeulophus* Schauff and LaSalle, gen. n.**

Discussion: This genus is described to contain *Grotiusomyia gelechiae* Miller (the only included species). A full description is given at the end of this paper.

New Combinations: From *Grotiusomyia*: *gelechiae* (Miller 1964).

7. *Deutereulophus* Schulz

Eulophopteryx Ashmead, 1904: 341, 342, 374. Type species *Eulophopteryx chapadae* Ashmead (original designation). Preoccupied by *Eulophopteryx* Möschler, 1878: 684.

Deutereulophus Schulz, 1906: 146. Replacement name for *Eulophopteryx* Ashmead, 1904 (not *Eulophopteryx* Möschler, 1878).

Entedonomorpha Girault, 1913: 261. Type species *Entedonomorpha tennysoni* Girault (original designation). Synonymy by LaSalle and Schauff, 1992: 17.

Discussion: The identity of this genus was discussed by LaSalle and Schauff (1992). It was included in a key to Australasian genera by Boucek (1988—as *Entedonomorpha*). There are at least three undescribed species in this genus from North America (USNM, CNC), which range from Texas to Florida, and as far north as Ontario.

8. *Diaulinopsis* Crawford

Note: Revision of New World species by Gordh and Hendrickson (1979).

Diaulomorpha Ashmead [see *Dicladocerus*]

Discussion: Diaulomorpha is not presently known from North America. The single species which was assigned to this genus, *D. borrowi* (Girault), is now placed in *Dicladocerus.*

9. *Dicladocerus* Westwood

Discussion: The single species assigned to the genus *Diaulomorpha* (*borrowi*) is now placed here.

New Combinations: From *Diaulomorpha*: *borrowi* (Girault 1917a).

10. *Diglyphomorpha* Ashmead

Diglyphomorpha Ashmead, 1904: 352. Type species *Diglyphus maculipennis* Ashmead [= *D. aurea* (Howard)] (orig. desig.).

Discussion: This genus has not been recorded previously from North America, although it is known from the Caribbean and has been discussed by LaSalle and Schauff (1992). We have seen a specimen of *D. aurea* (Howard, 1894) from Florida (Dade Co., Miami, 6.iii.1984, C. M. Yoshimoto, 1 female, CNC). For information on this species see LaSalle and Schauff, 1992: 18.

11. *Diglyphus* Walker

Note: Revision of New World species by Gordh and Hendrickson (1979).

12. *Dimmockia* Ashmead

13. *Elachertus* Spinola

Elachertus Spinola, 1811: 151. Type species *Diplolepis lateralis* Spinola (by monotypy; other included names were not available).

Ardalus Howard, 1897: 161. Type species *Ardalus aciculatus* Howard (= *scutellatus* (Howard), see Bouček 1988) (subs. desig. of Ashmead, 1904: 352). Synonymized with *Elachertus* by Bouček, 1988: 639.

Cirrospiloideus Ashmead, 1904: 354. Type species *Miotropis platynotae* Howard (orig. desig.). **Syn. n.**

Discussion: We are synonymizing *Cirrospiloideus* and *Elachertus.* Given the range of variation in these taxa, we can find no reliable characters which separate the two groups. Bouček (1988) mentioned that *Cirrospiloideus* was thought to be the same as *Miotropis.* We find that most of the North American species do belong in *Miotropis.* However the type of *Cirrospiloideus* (*platynotae*), is *Elachertus.*

Miotropis platynotae (type of *Cirrospiloideus*) was described from 6 specimens (Howard 1885). The lectotype female (**present designation**) is point mounted with three other specimens. The lectotype is the bottom specimen and the point has been marked with black ink. There are 5 paralectotypes on two pins (3 with lectotype and 2 on a separate pin). All in USNM.

We are transferring *harrisinae* Ashmead from *Stenomesius,* although it is quite distinct from most of the other species of *Elachertus* and from related genera such as *Alophomyia.* However, given the confusion about generic limits in this group of genera, we feel that it would be unwise to describe yet another genus for this single species and thereby further confuse the situation.

New Combinations: From *Cirrospiloideus*: *platynotae* (Howard 1885). From *Stenomesius*: *harrisinae* (Ashmead 1887).

Note: Revision of North American species by Schauff (1985a).

14. *Eulophus* Geoffroy

Eulophus Geoffroy, 1762. Type species *Ichneumon ramicornis* Fabricius (subseq. monotypy of Fabricius, 1781: 441).

Discussion: The authorship and type species of *Eulophus* is presently the matter of some controversy, and different combinations of author and type species have been used in Europe (Bouček and Askew 1968) and North America (Peck 1963, Burks 1979). An attempt to stabilize the name *Eulophus* is currently before the International Commission of Zoological Nomenclature (Kerzhner 1991), with a supporting comment which suggested a minor amendment by LaSalle (1992). We are using authorship and type species as recommended by Kerzhner and LaSalle.

15. *Euplectromorpha* Girault

Euplectromorpha Girault, 1913: 276. Type species *Euplectromorpha unifasciata* Girault (original designation).

Neoplectrus Ferrière, 1940: 134. Type species *Neoplectrus bicarinatus* Ferrière (subsequent designation of Bouček, 1988: 634).

Discussion: The identity of *Euplectromorpha* was discussed by Boucek (1988) who included it in a key to Australasian genera and made the above generic synonymy. The single North American species currently placed in this genus, *E. americana,* properly belongs in *Platyplectrus.* However, *Euplectromorpha* is represented in North America by an undescribed species from Florida (Monroe Co., Crane Key, 16/IV/1976, D. Simberloff, reared from *Alarodia slossoniae,* 4 females, USNM).

16. *Euplectrus* Westwood

Giraultia Gahan and Fagan [see *Cirrospilus*]

17. *Grotiusomyia* Girault

Note: see *Dasyeulophus* for discussion of *Grotiusomyia gelechiae* Miller.

18. *Hemiptarsenus* Westwood

Hemiptarsenus Westwood, 1833: 122–123. Type species *Hemiptarsenus fulvicollis* Westwood (subsequent designation of Westwood 1839).

Notanisomorpha Ashmead, 1904: 356. Type species *Notanisomorpha collaris* Ashmead (orig. desig.). **Syn. n.**

Discussion: Bouček (1988) suggested that *Notanisomorpha* might be nothing more than a species group of *Hemiptarsenus.* We agree with this interpretation and therefore propose the synonymy above. Miller (1970) separated the two genera based on the relative length to width of the propodeum and petiole. We find this character to be variable and do not believe that it can be used reliably to separate these species.

New Combinations: All from *Notanisomorpha*: *ainsliei* (Crawford 1912), *calavius* (Walker 1847); *collaris* (Ashmead 1904), *longifasciata* (Girault 1917a), *meromyzae* (Gahan 1917), *nevadensis* (Girault 1917a).

19. *Hoplocrepis* Ashmead

Discussion: This genus was treated in the Entedoninae by Burks (1979), however it has since been transferred to the Eulophinae (Schauff, 1991: 73).

20. *Hyssopus* Girault

Note: Revision of Nearctic species by Schauff (1985b).

21. *Miotropis* Thomson

Discussion: The genus *Cirrospiloideus* is synonymized with *Elachertus* (in this paper), however only the type species, *platynotae,* actually belongs to *Elachertus.* The majority of the North American species which had been placed in this genus properly belong in *Miotropis,* and are here transferred. See the also discussion of this genus under *Elachertus.*

New Combinations: All from *Cirrospiloideus*: *bicoloriceps* (Girault 1916e), *californicus* (Girault 1916c), *johnsoni* (Girault 1917a), *mediolineatus* (Girault 1917b), *nigriceps* (Girault 1916d), *nigriprothorax* (Girault 1916a), *seminigriventris* (Girault 1917c).

Mirolynx Girault [see *Aulogymnus*]

Mirzagrammosoma Girault [see *Zagrammosoma*]

22. *Necremnus* Thomson

Notanisomorpha Ashmead [see *Hemiptarsenus, Sympiesis*]

We are synonymizing *Notanisomorpha* with *Hemiptarsenus* in this paper. Most North American species currently assigned to *Notanisomorpha* belong to *Hemiptarsenus,* but two are properly assigned to *Sympiesis.*

23. *Notanisomorphella* Girault

Notanisomorphella Girault, 1913: 287. Type species *Notanisomorphella australiensis* Girault (original designation).
Crateulophus Masi, 1917: 206. Type species *Crateulophus niger* Masi (monotypy).
Raurua Risbec, 1952: 188. Type species *Raurua australis* Risbec (monotypy).
Sunha Delucchi, 1962: 53. Type species *Sunha bicolor* Delucchi (original designation).

Discussion: The identity of *Notanisomorphella* was discussed by Boucek (1988) who included it in a key to Australasian genera and made the above generic synonymies. We know this genus from North America from a single specimen of an undescribed species from West Virginia (Morgantown, summer 1929, E. Gould, par. of *Coleophora malivorella,* 1 female, USNM).

24. *Paraolinx* Ashmead

Pardiaulomella Girault [see *Sympiesis*]

25. *Platyplectrus* Ferrière

Platyplectrus Ferrière, 1941: 20. Type species *Platyplectrus natadea* Ferrière (orig. desig.).

Discussion: The genus *Platyplectrus* has not previously been recorded from North America. The genus *Euplectromorpha* was recorded in North America based on *E. americana* Girault. We find that this species is a member of the genus *Platyplectrus* and not *Euplectromorpha.*

New Combinations: From *Euplectromorpha*: *americana* (Girault 1916g).

26. *Pnigalio* Schrank

Pseudolynx Girault [see *Aulogymnus*]

Scotolinx Ashmead [see *Aulogymnus*]

Stenomesius Westwood

Two species were assigned to this genus by Burks (1979). Both are here transferred to other genera (*levana* to *Cristelacher,* n. gen., and *harrisinae* to *Elachertus*). At present, no species from North America can be assigned to *Stenomesius.* However, given that the genus does occur in several areas adjacent to the U.S., it is likely that some species of *Stenomesius* do occur in North America.

27. *Sympiesis* Förster

Sympiesis Förster, 1856: 74, 76. Type species *Eulophus sericeicornis* Nees (orig. desig.).
Pardiaulomella Girault, 1915b: 295. Type species *Pardiaulomella consonus* Girault. (orig. desig.). Synonymized by Boucek (1988: 620).

Discussion: The genus *Pardiaulomella* was listed by Burks (1979) as separate from *Sympiesis* with one included species. Boucek (1988) synonymized the two genera, but did not transfer the North American species. We formally make that transfer here along with two species from *Notanisomorpha.*

New Combinations: From *Notanisomorpha*: *noncarinata* (Girault 1917a), *particola* (Girault 1916f).; from *Pardiaulomella*: *ibseni* (Girault 1916d).

28. *Trichospilus* Ferrière

Trichospilus Ferrière, 1930: 358. Type species *Trichospilus pupivorus* Ferrière (monotypy).

Discussion: Trichospilus is native to tropical Africa and Asia. One species, *T. diatraeae* Cherian and Margabandhu (1942), has been established in the West Indies, and recorded from Florida (Bennett et al. 1987).

Winnemana Crawford [see *Cirrospilus*]

29. *Xanthellum* Erdös and Novicky

Xanthellum Erdös and Novicky, in Erdös 1951: 178. Type species *Xanthellum transsylvanicum* Erdös (orig. desig.).

Discussion: This genus has not been recorded previously from North America. We have seen specimens of *X. transsylvanicum* Erdös (1951) from Ontario (CNC) and Massachusetts (USNM). We have also examined specimens of an apparently undescribed species from Ohio (USNM).

30. *Zagrammosoma* Ashmead

Hippocephalus Ashmead, 1888: vii. Type species *Hippocephalus multilineatus* Ashmead (by monotypy). Preoccupied by *Hippocephalus* Swainson, 1839.

Zagrammosoma Ashmead, 1904: 354. Replacement name for *Hippocephalus* Ashmead 1888.

Mirzagrammosoma Girault, 1915a: 279. Type species *Mirzagrammosoma lineaticeps* Girault (by monotypy). Synonymized with *Zagrammosoma* by LaSalle (1989).

Discussion: The nearctic species were reviewed by Gordh (1978). LaSalle (1989) synonymized *Mirzagrammosoma* with *Zagrammosoma,* and transferred the single species, *M. lineaticeps* Girault, to *Zagrammosoma.*

Subfamily EUDERINAE

Burks (1979) considered the Euderinae as a tribe of the Entedoninae, however they have been considered to deserve subfamily status by other authors (Graham 1987, Bouček 1988, Grissell and Schauff 1990). We currently recognize 5 genera from North America.

Genera New to North American Euderinae since Burks, 1979

The following genera, which are here considered to belong to the Euderinae, were included in the Entedoninae by Burks (1979): *Carlyleia* Girault (transferred here), *Hubbardiella* Ashmead (transferred by Schauff 1991) and *Lophocomus* Haliday (the North American species = *Euderus*).

List of north american euderinae Genera

1. *Acrias* Walker

2. *Astichus* Förster

Bellerus Walker [see *Euderus, Lophocomus*]

Schauff (1991: 72) mentioned *Bellerus* as the proper senior synonym to *Lophocomus,* which had been placed in the Entedoninae in the North American catalogue (Burks 1979). This genus is not known from North America (see discussion under *Lophocomus, Euderus*).

3. *Carlyleia* Girault

Discussion: This genus was included in the Entedoninae by Burks (1979). Schauff (1991: 72), stated that it was clearly not an entedonine, and suggested that it might better belong to the Eulophinae. After further examination we feel that it belongs in the Euderinae.

4. *Euderus* Haliday

Discussion: This is the largest genus of Euderinae. The single North American species which had been placed in the genus *Lophocomus, L. verticillatus* Ashmead, properly belongs in *Euderus.* Schauff (1991) removed this species from the Entedoninae (Burks 1979) to the Euderinae, but did not reassign it to its proper genus.

New Combinations: From *Lophocomus: verticellatus* (Ashmead) (1888).

5. *Hubbardiella* Girault

Discussion: This genus had been included in the Entedoninae by Burks (1979). Schauff (1991) placed it in the Euderinae.

Lophocomus Haliday [see *Euderus*]

Lophocomus had been placed in the Entedoninae by Burks (1979), however it is a junior synonym of *Bellerus* and properly belongs in the Euderinae (Boucek 1963; Schauff 1991). *Bellerus* is known only from southern South America, and the single North American species which had been assigned to this genus, *verticellatus* Ashmead, properly belongs in *Euderus.*

Subfamily ENTEDONINAE

The Entedoninae has been treated recently (Schauff 1991). In the course of this study, a new synonymy has come to light, and further investigations have caused us to place *Euderomphale* back in the Entedoninae. However, we continue to regard this placement as provisional as these species do not share all the characters that define the subfamily. The authors are currently studying a group of taxa (all parasites of whiteflies) related to *Euderomphale* to better clarify the suprageneric classification of this group.

Eprhopalotus Girault

Eprhopalotus Girault, 1916d: 49. Type species *Eprhopalotus purpureithorax* Girault (orig. desig.).

Aabacharis Schauff, 1991: 32. Type species *Aabacharis hansoni* Schauff (orig. desig.). **Syn. n.**

Discussion: Schauff (1991) stated that he was unable to place the fragmented type of *E. purpureithorax.* Upon reexamination of this specimen, we conclude that it is the same genus as *Aabacharis* and have proposed the synonymy above. It remains uncertain whether *E. hansoni* (**Comb. n.**) is the same species as *E. purpureithorax.*

New Combinations: From *Aabacharis*: *hansoni* Schauff (1991).

Euderomphale Girault

Discussion: The placement of this genus is problematical. Schauff (1991) removed it from the Entedoninae because it lacked all the characters that defined the subfamily. However we are currently investigating the relationships of *Euderomphale* and several related genera (LaSalle and Schauff, in prep), and we now feel that it is better placed in the Entedoninae than in any other subfamily.

DESCRIPTION OF NEW TAXA

Cristelacher Schauff and LaSalle
Gen. n.

Type species: Elachestus levana Walker.

Discussion: This genus seems most closely allied to *Elachertus,* particularly in the following characters: mesoscutum with notauli complete (although fine), and with many, scattered setae; scutellum glabrate and with strong sublateral grooves which curve inward and meet in front of posterior margin; propodeum glabrous, with strong median carina which is expended anteriorly into a cup-shaped structure. The petiole is also generally quite long in species of *Elachertus.* The main characters which set this genus aside are the distinct carinae on the pronotum and head. The pronotum is quadrate, with a very strong transverse carina along the anterior margin. This form of pronotum is unknown in other North American Eulophini, although some Euplectrini may have a strong anterior carina on the pronotum. The only non-euplectrine Eulophinae which have a pronotum similar to *Cristelacher* are the extralimital *Euplectrophelinus* Girault and *Stenopetius* Bouček (see Bouček 1988 for a discussion of these genera). *Stenopetius* differs from *Cristelacher* in having an x-shaped median carina on the propodeum (as in *Stenomesius*). *Euplectro-*

phelinus differs in not having a distinct petiole, and having the axillae approaching each other medially (almost touching). Neither *Stenopetius* or *Euplectrophelinus* have two carinae on the back of the head as in *Cristelacher. Stenopetius* has a distinct carina behind the ocelli, which defines a large, concave occipital region (without another carina). *Euplectrophelinus* lacks carinae (or has the occipital carina very weakly represented).

Diagnosis: Pronotum large, quadrate with a strong transverse carina on anterior margin. Occipital region with two carinae; a transverse carina on the vertex just behind ocelli, and a strong, horseshoe-shaped occipital carina. Metasoma with distinct and long petiole. Otherwise similar to *Elachertus,* with many scattered setae on mesoscutum, and scutellum glabrate and with strong sublateral grooves which curve inward and meet in front of posterior margin.

Description: Female. Face and frons without sculpture, smooth and shiny; vertex with light, engraved sculpture. Scrobes shallow. Vertex behind ocelli with transverse carina, and back of head with strong, horseshoe-shaped occipital carina. Malar sulcus present and fine. Clypeal margin smooth, slightly convex. Antennal toruli placed at level of ventral eye margin. Mandibles with strong lower tooth, and several small upper teeth. Antenna with scape long and slender. Funicle with four segments, all of which are distinctly longer than wide, and short 3-segmented club. Pronotum large, quadrate; anterior margin with strong transverse carina. Notauli present and complete, although fine. Mesoscutum and axilla glabrous. Scutellum with deep sublateral grooves which curve inward and meet before posterior margin. Propodeum glabrous, with strong median carina which is set in a distinct furrow; median carina expanded anteriorly into a cup-shaped structure; propodeum with lateral groove between spiracle and raised median panel. Hind tibia with two spurs. Petiole distinct, as long as hind coxa and over half the length of the gaster, widest in basal half, tapering apically. Gaster short, ovate. Basal sternites extending forward to wrap around apex of petiole where it joins gaster. Cerci placed on small pegs. Wings typical for eulophines, with several setae on dorsal surface of submarginal vein, submarginal vein smoothly joining parastigma, postmarginal vein longer than stigmal vein.

Male. Unknown.

Etymology: A combination of *crista,* meaning crest or ridge, and *elacher,* a short form of *Elachertus.* Gender Masculine.

Included species: Cristelacher levana (Walker). (**Comb. n.**). There is presently only the single species, *C. levana* (Walker) included in this genus.

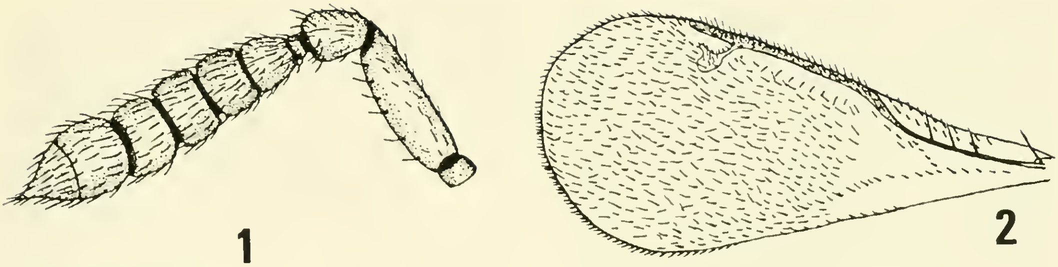
Note: Burks (1975: 145) designated a lectotype for this species and placed it in the genus *Stenomesius,* where it has remained since. The lectotype and paralectotype are in the BMNH.

Dasyeulophus **Schauff and LaSalle**
Gen. n.
(Figs. 1–5)

Type species: Grotiusomyia gelechiae Miller, 1964.

Discussion: Scutellum (and mesoscutum) covered with evenly scattered setae; those on the scutellum semi-erect. Notaulus not reaching posterior margin of mesoscutum. Clypeus bilobed. Antenna with a 4-segmented funicle and 2-segmented club; funicular segments all quadrate to wider than long. Propodeum medially short, not or only barely longer than dorsellum. Mandibles multidentate. Vertex without carina behind occiput. Female body yellow, male body yellow and brown or black, both without metallic coloration. Male antenna without branches.

Grotiusomyia was described by Girault (1917d) for his species *flavicornis.* Miller



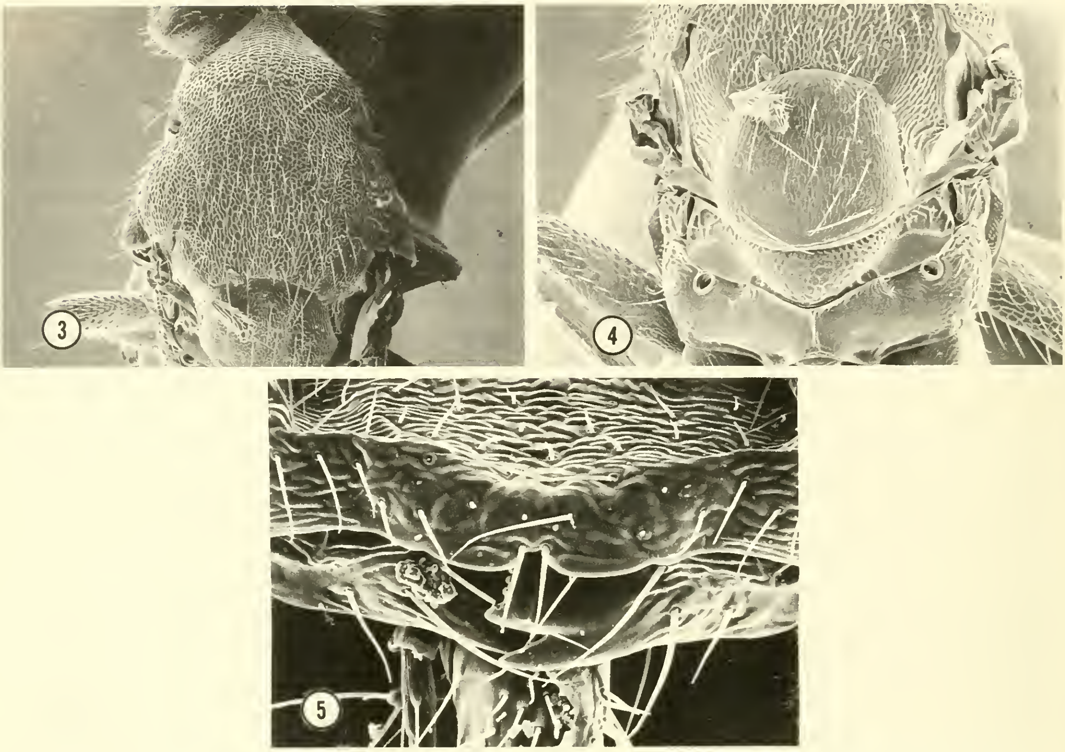
Figs. 1, 2. 1) Female antenna of *Dasyeulophus gelechiae.* 2) Forewing of *D. gelechiae.*

separated *gelechiae* from *flavicornis* based upon differences of the pronotum (campanulate rather than transverse quadrate), the propodeal spiracles (round rather than elliptical) and additional differences on the abdomen. Miller did not mention that the clypeal margin in *flavicornis* is produced, a condition not found in *gelechiae,* which has the clypeus bilobed, but not noticeably produced.

Diagnosis: Dasyeulophus is similar to the eulophine genera *Dimmockia, Grotiusomyia,* and *Sympiesis.* From *Dimmockia* it can be separated by the setose scutellum (scutellum with only 2 pairs of setae in *Dimmockia*). In addition, the known species of *Dimmockia* are black in color, not yellow as in *Dasyeulophus.* Species of *Grotiusomyia* can be separated by the shape of the notauli (weak, but continuing to the posterior margin of the mesoscutum); presence of an undivided clypeus; the presence of an occipital carina behind the occelli (rounded in *Dasyeulophus*); and the ovoid propodeal spiracle (spiracle round in *Dasyeulophus*). Species of *Sympiesis* have the funiculars quadrate to longer than wide (generally longer than wide) as opposed to wider than long in *Dasyeulophus,* have an undivided clypeus, and have only a few paired setae on the scutum and scutellum.

Description: Female. Head, mesosoma, and legs yellow. Funicle sometimes slightly darker, especially apically. Metasoma yellow with extensive brown markings on dorsal surface (some specimens with metasoma almost entirely brown dorsally except at base). Antennae (Fig. 1, from Miller 1964) nine-segmented with one annellus, four funicular segments, and a 2-segmented club; mandibles multi-dentate (9 or 10 toothed). Clypeus bilobed (Fig. 5). Pronotum campanulate (Fig. 3), about one third length of mesoscutum; mesoscutum with notauli incomplete, covered by numerous scattered setae; axillae advanced almost entirely beyond scuto-scutellar suture; scutellum with scattered setae (about 14–16), but less densely than mesoscutum, without longitudinal grooves. Propodeum medially only slightly longer than metanotum, (Fig. 4) with simple median carina, spiracular opening round, smooth; petiole reduced to narrow strip dorsally. Metasoma subsessile, slightly longer than head and thorax combined. Forewing hyaline (Fig. 2), submarginal vein with 7–8 setae, speculum closed; postmarginal shorter than marginal vein, about 1.5 × as long as stigmal; stigma enlarged, ovate, covered with several setae.

Male. Dark brown except scape, face below toruli and adjacent to eye margins, basal ⅓ to ½ of metasoma, fore and midlegs, including coxae; base of hindfemora, hindtibiae and tarsi yellow. Flagellar setae are longer, about equal to width of each funicle. Metasoma about equal in length to the thorax. Otherwise, similar to the female. In



Figs. 3–5. Scanning electron micrographs of *Dasyeulophus gelechiae.* 3) Dorsal thorax. 4) Propodeum. 5) Mandibles and clypeus.

some specimens, the midfemur and hindtibia are partly brownish.

Etymology: Generic name from dasy—meaning hairy, and eulophus. Gender masculine.

Included species: Dasyeulophus gelechiae (Miller). **(Comb. n.)**. There is presently only the single species, *D. gelechiae* (Miller) included in this genus.

Acknowledgments

We thank Steve Heydon, Lonny Coote, David Nickle, Douglas Ferguson and an anonymous reviewer for their reviews of the manuscript and their helpful comments. The Natural History Museum (London) (BMNH) and U.S. National Museum of Natural History (Washington, D.C.) (USNM) made their collections available to us for study. A Smithsonian Institution Short Term Visitor Fellowship allowed JL to visit the USNM. This work was partially funded through NSF grant no. BSR-9020206.

Literature Cited

Ashmead, W. H. 1887. Studies of the North American Chalcididae, with descriptions of new species, chiefly from Florida. Transactions of the American Entomological Society 14: 183–203.

———. 1888. Descriptions of some unknown parasitic Hymenoptera in the collection of the Kansas State Agricultural College, received from Prof. E. A. Popenoe. Bulletin of the Kansas State Agricultural College 3: I–VIII (Appendix).

———. 1904. A reclassification of the Chalcid Flies or the superfamily Chalcidoidea, with descriptions of new species in the Carnegie Museum, collected in South America by Herbert H. Smith. Memoirs of the Carnegie Museum 1: I–XI, 225–551.

Bennett, F. D., H. Glenn, M. Yaseen, and R. M. Baranowski. 1987. Records of *Trichospilus diatraeae,* an Asian parasite (Hymenoptera: Eulophidae) from the Caribbean and Florida. Florida Entomologist 70: 184–186.

Bouček, Z. 1963. Studien über europaischen Eulophidae, III: Euderinae (Hymenoptera: Chalcidoidea). Beitrage zur Entomologische 13: 257–281.

———. 1977. Descriptions of two new species of Neotropical Eulophidae (Hymenoptera) of economic interest, with taxonomic notes on related species and genera. Bulletin of Entomological Research 67: 1–15.

———. 1988. Australasian Chalcidoidea: A Biosystematic Revision of Genera of Fourteen Families, With a Reclassification of Species. CAB International Institute of Entomolology, Wallingford, UK. 832 pp.

Bouček, Z. and R. R. Askew. 1968. Index of Palearctic Eulophidae. Index of Entomophagous Insects, LeFrancois, Paris. 254 pp.

Brèthes, J. 1913. Himenópteros de la América Meridional. Annals del Museo Nacional de Historia Natural de Buenos Aires 24: 35–166.

Burks, B. D. 1975. The species of Chalcidoidea described from North American north of Mexico by Francis Walker (Hymenoptera). Bulletin of the British Museum (Natural History) Entomology 32: 139–170.

———. 1979. Family Eulophidae, pp. 967–1022. *In* Krombein, K. V. et al., eds., Catalog of Hymenoptera of America North of Mexico, Vol. 1. Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington, D.C. 1198 pp.

Cherian, M. C. and V. Margabandhu. 1942. A new species of *Trichospilus* (Hym: Chalcidoidea) from South India. Joural of Madras Agriculture 30: 44–49.

Crawford, J. C. 1911. Descriptions of new Hymenoptera 1. Proceedings of the U.S. National Museum 39: 617–623.

———. 1912. Descriptions of new Hymenoptera. No. 5. Proceedings of the U.S. National Museum 43: 185.

Delucchi, V. 1962. Hyménoptères chalcidiens du Maroc. III. Eulophidae. Al Awarnia 5: 53–66.

Erdös, J. 1951. Eulophidae novae. Acta Biologica Academiae Scientarium Hungaricae 2: 161–237.

Fabricius, J. C. 1781. Species Insectorum. Vol. 1. Hamburgi et Kilonii. 1: 552 pp.

Ferrière, C. 1930. Notes on Asiatic Chalcidoidea. Bulletin of Entomological Research 21: 353–360.

———. 1940. On some parasites and hyper parasites of *Artona catoxantha,* Hamps. Bulletin of Entomological Research 31: 131–139.

———. 1941. New species of Euplectrini (Hym. Chalcidoidea) from Europe, Africa, and Asia. Bulletin of Entomological Research 32: 17–48.

Förster, A. 1851. Eine Centurie neuer Hymenopteren. Vierte und fünfte Dekade. Verhandlug Naturhistorische Ver Preuss Rheinland 8: 1–42.

———. 1856. Hymenopterologische Studien. 2. Chalcidiae und Proctotrupii. Aachen. 152 pp.

Gahan, A. B. 1917. Descriptions of some new parasitic Hymenoptera. Proceedings of the U.S. National Museum 53: 195–217.

Gahan, A. B. and M. M. Fagan. 1923. The type species of the genera of Chalcidoidea or Chalcid-flies. Bulletin of the U.S. National Museum 124: 1–173.

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. Paris 2: 690 pp.

Girault, A. A. 1913. Australian Hymenoptera Chalcidoidea—IV. The family Eulophidae with descriptions of new genera and species. Memoirs of the Queensland Museum 2: 140–296.

———. 1915a. New chalcidoid Hymenoptera. Annals of the Entomological Society of America 8: 279–284.

———. 1915b. Australian Hymenoptera Chalcidoidea, IV. Memoirs of the Queensland Museum 3: 180–299.

———. 1916a. New North American Hymenoptera of the family Eulophidae. Proceedings of the U.S. National Museum 51: 125–133.

———. 1916b. A new genus of Eulophidae from the United States (Hym.). Entomological News 27: 152–154.

———. 1916c. Three new Chalcid Flies from California. Pomona Journal of Entomology and Zoology 8: 119–122.

———. 1916d. Descriptions of miscellaneous North American Chalcidoid Hymenoptera of the family Eulophidae. Proceedings of the U.S. National Museum 51: 39–52.

———. 1916e. New miscellaneous Chalcidoidea Hymenoptera with notes on described species. Annals of the Entomological Society of America 9: 291–308.

———. 1916f. Notes on described Chalcidoid Hymenoptera with new genera and species. Societas Entomologica 31: 42–44.

———. 1916g. Descriptions of miscellaneous chalcid-flies. Insecutor Inscititae Menstruus 4: 109–120.

———. 1917a. Descriptiones Hymenopterorum Chalcidoidicarum Variorum cum Observationibus III: 10 pp.

———. 1917b. Chalcidoidea nova Marilandensis II: 2 pp.

———. 1917c. Descriptiones Hymenopterorum Chalcidoidicarum Variorum cum Observationibus V: 16 pp.

———. 1917d. New miscellaneous chalcid-flies from North America. Psyche 24: 91–99.

———. 1917e. Chalcidoidea nova Marilandensis I: 2 pp.

———. 1917g. A metallic species of *Cirrospilopsis* from Maryland (Hymenoptera Eulophidae). Psyche 24: 100.

Gordh, G. 1977. A new species of North American *Scotolinx* with taxonomic notes on the genus (Hymenoptera: Eulophidae). Pan-Pacific Entomologist 53: 205–210.

———. 1978. Taxonomic notes on *Zagrammosoma*, a key to the Nearctic species and descriptions of new species from California (Hymenoptera: Eulophidae). Proceedings of the Entomological Society of Washington 80: 344–359.

Gordh, G. and R. Hendrickson. 1979. New species of *Diglyphus*, a world list of the species, taxonomic notes and a key to New World species of *Diglyphus* and *Diaulinopsis* (Hymenoptera: Eulophidae). Proceedings of the Entomological Society of Washington 81: 666–684.

Graham, M. W. R. de V. 1975. Relationships and synonymy of *Winnemana* Crawford (Hymenoptera Eulophidae). Journal of Entomology 44: 281–282.

———. 1977. Systematic position of *Peckelachertus* Yoshimoto (Hym., Eulophidae) and description of a new species from Britain. Systematic Entomology 2: 45–47.

———. 1987. A reclassification of the European Tetrastichinae (Hymenoptera: Eulophidae), with a revision of certain genera. Bulletin of the British Museum, Entomology series 55: 392 pp.

———. 1991. Reclassification of European Tetrastichinae. Memoirs of the American Entomological Institute 49: 322 pp.

Grissell, E. E. and M. E. Schauff. 1990. A handbook of the families of Nearctic Chalcidoidea (Hymenoptera). Handbook of the Entomological Society of Washington. No. 1. 85 pp.

Howard, L. O. 1885. *In* Hubbard, H. G. Insects affecting the Orange. U. S. Department of Agriculture, Division of Insects. Miscellaneous Document no. 4. p. 217.

———. 1894. Report on the Chalcididae of the subfamilies Chalcidinae, Eucharinae, Perilampinae, Encyrtinae, Aphelininae, Pireninae, and Elachistinae, pp. 79–108 *in* Riley, C. V., Ashmead, W. H., and Howard, L. O., Report on the Parasitic Hymenoptera of the Island of St. Vincent. Journal of the Linnean Society of London, Zoology 25: 56–254.

———. 1897 [1896]. On the Chalcididae of the Island of Grenada, B.W.I. Journal of the Linnean Society (Zoology) 26: 129–178.

Kerzhner, I. M. 1991. Historie abrégé des insectes qui se trouvent aux environs de Paris (Geoffroy, 1762): Proposed conservation of some generic names (Crustacea and Insecta). Bulletin of Zoological Nomenclature 48: 107–133.

LaSalle, J. 1989. Notes on the genus *Zagrammosoma* (Hymenoptera: Eulophidae) with description of a new species. Proceedings of the Entomological Society of Washington 91: 230–236.

———. 1992. Comments on the proposed conservation of some generic names first proposed in Histoire abrégé des insectes qui se trouvent aux environs de Paris (Geoffroy, 1762) (Crustacea and Insecta). Bulletin of Zoological Nomenclature 49: 71.

———. North American genera of Tetrastichinae (Hymenoptera: Eulophidae). Journal of Natural History. (In press).

LaSalle, J. and M. E. Schauff. 1990. New subfamily placement for some North American Eulophidae (Hymenoptera, Chalcidoidea). Proceedings of the Entomological Society of Washington 92: 282–285.

———. 1992. Preliminary studies on neotropical Eulophidae (Hymenoptera: Chalcidoidea): Ashmead, Cameron, Howard and Walker species. Contributions of the American Entomological Society 27: 47 pp.

Lucchese, E. 1941. Contributi alla conoscenza dei Lepidoptteri del melo. III. *Acrolita naevana* Hb. Bollettino del Laboratorio di Entomolgia Agraria "Filippo Silvestri" di Portici 5: 1–60.

Masi, L. 1917. Chalcididae of the Seychelles Islands. Novitates Zoologicae 24: 121–230.

Miller, C. D. F. 1964. A new species of *Grotiusomyia* Girault (Hymenoptera: Eulophidae). Canadian Entomologist 96: 1021–1023.

———. 1970. The Nearctic species of Pnigalio and Sympiesis (Hymenoptera: Eulophidae). Memoirs of the Entomological Society of Canada 68: 121 pp.

Möschler, H. B. 1878 [1877]. Beiträge sur Schmetterlings-Fauna von Surinam. II. Verhandlungen Zoologisch-botanischen Gesselschaft im Wien 27: 629–700.

Peck, O. 1963. A Catalogue of the Nearctic Chalcidoidea. Canadian Entomologist, Supp. 30. 1092 pp.

Risbec, J. 1952. Contribution a l'étude des chalcidoides de Madagascar. Mémoires de l'Institut Scientifique de Madagascar (Series E) 2: 1–449.

Schauff, M. E. 1985a. Taxonomic study of the Nearctic species of *Elachertus* Spinola (Hymenoptera: Eulophidae). Proceedings of the Entomological Society of Washington 87: 843–858.

———. 1985b. Revision of the Nearctic species of *Hyssopus* Girault (Hymenoptera: Eulophidae). Journal of the New York Entomological Society 93: 1096–1108.

———. 1991. The Holarctic genera of Entedoninae (Hymenoptera: Eulophidae). Contributions of the American Entomological Institute 26: 109 pp.

Schulz, W. A. 1906. Spolia Hymenopterologica. Paderborn. 355 pp.

Spinola, M. M. 1811. Essai d'une classification générale des Diplolépaires. Annales du Muséum d'Histoire Naturelle, Paris 17: 138–152.

Walker, F. 1839. Monographia Chalciditum. I. London. 333 pp.

———. 1847. Characters of undescribed Chalcidites collected in North America by E. Doubleday, Esq., and now in the British Museum. Annals and Magazine of Natural History 20: 19–29.

Westwood, J. 1832. Descriptions of several new British forms amongst the parasitic hymenopterous insects. Philosophical Magazine 1: 127–129.

———. 1833. On the probable number of species of insects in the creation: Together with descriptions of several minute Hymenoptera. Magazine of Natural History 6: 116–123.

———. 1839. Synopsis of the Genera of British Insects. London. 158 pp.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 504–510

PARASITOIDS ASSOCIATED WITH THE MACROLEPIDOPTERA COMMUNITY AT COOPER'S ROCK STATE FOREST, WEST VIRGINIA: A BASELINE STUDY[1]

Linda Butler

Division of Plant and Soil Sciences, P.O. Box 6108, West Virginia University, Morgantown, West Virginia 26506-6108.

Abstract.—During 1984 and 1985 macrolepidopterous larvae were collected by means of pole pruning from foliage of black birch, mixed oaks, black cherry, and red maple at Cooper's Rock State Forest in northern West Virginia. From 46 species of caterpillars, 74 species of parasitoids in eight families were reared. The most abundant parasitoids were Tachinidae (Diptera): *Hyphantrophaga virilis* (Aldrich and Webber) and *Compsilura concinnata* (Meigen); Braconidae (Hymenoptera): *Protapanteles paleacritae* (Riley), *Microplitis hyphantriae* (Ash.), and *Diolcogaster facetosa* (Weed); Eulophidae (Hymenoptera): *Euplectrus maculiventris* (Westwood), *Eulophus anomocerus* (Crawford), and *E. nebulosus* (Prov.); and Perilampidae (Hymenoptera): *Perilampus canadenis* (Crawford).

Key Words: Parasitoids, macrolepidoptera community, baseline study

In 1984 and 1985, Cooper's Rock State Forest in northern West Virginia was just west of the leading edge of the infestation of the gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae). During those two years, a study was conducted to obtain baseline data for native lepidopterous defoliators and their parasitoids before the buildup of gypsy moth and subsequent defoliation and suppression efforts.

Previous reports have summarized hymenopterous and dipterous parasitoids associated with macrolepidopterous larvae (Muesebeck et al. 1951, Krombein and Burks 1967, Krombein 1958, Krombein et al. 1979, Viereck 1916, Arnaud 1978, Raizenne 1952, Schaffner and Griswold 1934, Townes and Townes 1959, 1960, 1962). Butler (1990) recorded 28 species of parasitoids associated with a "looper" complex in eastern West Virginia.

During the baseline study at Cooper's Rock State Forest, 400 species of adult macrolepidoptera were collected by blacklight trap (Butler and Kondo 1991) and 100 species of macrolepidopterous larvae were collected from the most abundant host trees (Butler 1992). Here I report results of the associated study of parasitoids reared from macrolepidoptera larvae.

METHODS AND MATERIALS

The West Virginia University Forest at Cooper's Rock State Forest is located at 561 m in Preston and Monongalia counties about 32 km east of Morgantown, West Virginia. The area consists of a 50- to 60-year-old mixed mesophytic forest (Carvell 1983). The most abundant tree species in the study area are red maple (*Acer rubrum* L., Aceraceae), white and red oak (*Quercus alba* L., *Q. rubra* L., Fagaceae), black cherry (*Prunus serotina*

---

[1] Published with the approval of the West Virginia Agricultural and Forestry Experiment Station as Scientific Article #2312.

Ehrh., Rosaceae), and black birch (*Betula lenta* L., Betulaceae).

Macrolepidopterous larvae were sampled from the mid- and lower canopies of red maple, mixed oaks, black cherry and black birch using pole pruners with large plastic catch bags. Samples were taken once each week from 16 May to 11 October 1984 and from 2 May to 3 October 1985.

In the laboratory, macrolepidopterous larvae were removed from the foliage, identified and placed for rearing in 150 × 25 ml plastic Petri dishes on bouquets of fresh foliage of the appropriate host plant. At pupation, Lepidoptera were placed in jars of moist vermiculite and held at 24° C or, for those species requiring a cold period, jars were held at 4° C for a minimum of 90 days. As parasitoid larvae emerged and pupated, they were placed in 4 dram vials of moist vermiculite plugged with cotton. Adults emerging from pupation vials or directly from macrolepidopterous larvae or pupae were killed, pinned, labeled and sent to specialists for identification. Voucher specimens are located in the West Virginia University Arthropod Collection.

RESULTS

Parasitoids were reared from 46 Macrolepidoptera species (Table 1). A total of 74 parasitoid species in eight families was recorded. The number of parasitoid species in each family is as follows: 11 Tachinidae, 29 Ichneumonidae, 16 Braconidae, 1 Trigonalidae, 1 Chalcididae, 13 Eulophidae, 1 Pteromalidae and 2 Perilampidae.

Species reared most frequently from four or more different host species include Tachinidae *Hyphantrophaga virilis* (8 hosts) and *Compsilura concinnata* (7 hosts); Braconidae *Protapanteles paleacritae* (7 hosts), *Diolcogaster facetosa* (4 hosts), and *Microplitis hypantriae* (4 hosts); Eulophidae *Eulophus anomocerus* (5 hosts), *E. nebulosus* (5 hosts), and *Euplectrus maculiventris* (4 hosts); and Perilampidae *Perilampus canadensis* (4 hosts). No attempt was made to determine percentage parasitism contributed by each parasitoid species.

DISCUSSION

The liklihood of rearing multiple species of parasitoids from a given lepidopterous larval species increases as abundance of the larva increases. The two most abundant species of caterpillars collected at Cooper's Rock State Forest in 1984 and 1985 were the noctuids *Polia latex* (Gn.) and *Morrisonia confusa* (Hbn.) (Butler 1992); 16 and 14 species of parasitoids were reared from these two species, respectively. Other abundant species of caterpillars were the geometrids *Itame pustularia* (Gn.) (9 species of parasitoids), *Lomographa vestaliata* (Gn.) (7), *Campaea perlata* (Gn.) (7); the arctiids *Hyphantria cunea* (Drury) (7), and *Halysidota tesselaris* (J. E. Smith) (6); and *Acronicta fragilis* (Gn.) (5) and *A. ovata* (Grt.) (5). The geometrids *Melanolophia canadaria* (Gn.) and *Probole amicaria* (H.-S.) were among the most numerous caterpillars, but only four and three species of parasitoids were reared from them, respectively.

During a study of parasitoids associated with an outbreak of a looper complex (Geometridae) in eastern West Virginia in 1983 and 1984, Butler (1990) reared 21 species of parasitoids from *Phigalia titea* (Cram.), the most abundant of the looper species.

Twenty-one of the 136 primary parasitoid/host relationships listed in Table 1, reconfirm records published by Arnaud (1978) for Tachinidae and by Krombein et al. (1979) for hymenopterous taxa. These previous records are, as expected, for lepidopterous hosts which are generally more abundant and/or considered more economically important: *Alsophila pometaria, Erannis tiliaria, Hydria prunivorata, Malacosoma americanum, Dryocampa rubicunda, Anisota virginiensis, Nadata gibbosa, Hyphantria cunea,* and *Orygia leucostigma.* New primary parasitoid/host records presented here total 115 or 85% of those generated during this study.

Table 1. Parasitoid taxa reared from Macrolepidoptera larvae collected at Cooper's Rock State Forest 1984 and 1985. Secondary parasitoids indicated by "2°."

Macrolepidoptera Species N[1]	Parasitoids	
	Family[2]	Genus/Species[3]
Drepanidae		
Drepana arcuata Wlk. 2	Brac.	*Rogas* sp. R
Geometridae		
Alsophila pometaria (Harr.) 9	Brac.	*Protapanteles paleacritae* (Riley) R
Itame pustularia (Gn.) 234	Tach.	*Hyphantrophaga virilis* (Aldrich & Webber) U
		Xanthophyto sp. U
		Blepharomyia sp. U
	Ichn.	*Drusonia deceptor* (Walley) U
		Casinaria forcipata Walley U
	Brac.	*Meteorus* sp. U
		Rogas sp. U
	Chal.	*Brachymeria aeca* Burks (2°)
	Eulo.	*Euplectrus maculiventris* Westwood U
Glena cribrataria (Gn.) 5	Brac.	*Rogas* sp. U
Epimecis hortaria (F.) 2	Brac.	*Cotesia* sp. U
Melanolophia canadaria (Gn.) 228	Tach.	*Xanthophyto* sp. U
	Ichn.	*Aphanistes* sp. U
	Brac.	*Protapanteles paleacritae* (Riley) U
		Cotesia sp. U
Hypagyrtis unipunctata (Haw.) 11	Pter.	*Hypopteromalus tabacum* (Fitch) U
Erannis tiliaria (Harr.) 40	Ichn.	*Hyposoter fuscitarsis* (Vier.) R
		Phobocampe geometrae (Ash.) R
Lomographa vestaliata (Gn.) 123	Tach.	*Compsilura concinnata* (Meigen) U
		Hyphantrophaga virilis (Aldrich & Webber) U
	Ichn.	*Aphanistes heinrichi* Hopper U
		Mesochorus pictilis Holmgren (2°)
	Brac.	*Protapanteles paleacritae* (Riley) U
		Meteorus sp. U
		Rogas sp. U
Lomographa glomeraria (Grt.) 183	Tach.	*Compsilura concinnata* (Meigen) U
		Hyphantrophaga virilis (Aldrich & Webber) U
	Brac.	*Diolcogaster facetosa* (Weed) U
		Meteorus sp. U
Campaea perlata (Gn.) 59	Brac.	*Protapanteles paleacritae* (Riley) U
		Diolcogaster facetosa (Weed) U
		Microgaster sp. U
	Eulo.	*Euplectrus maculiventris* Westwood U
		Cirrospilus cinctithorax (Girault) U
		C. sp. 2 U
	Peri.	*Perilampus canadensis* Crawford (2°)
Probole amicaria (H.-S.) 237	Ichn.	*Mesochorus discitergus* (Say) U
	Brac.	*Protapanteles paleacritae* (Riley) U
		Cotesia sp. U
Plagodis serinaria (H.-S.) 10	Tach.	*Hyphantrophaga virilis* (Aldrich & Webber) U
		Xanthophyto sp. U
	Ichn.	*Platylabus hyperetis* Heinr. U
Besma endropiaria (G. & R.) 18	Tach.	*Hyphantrophaga virilis* Aldrich & Webber) U
Nemoria mimosaria (Gn.) 4	Brac.	*Protapanteles paleacritae* (Riley) U
Hydria prunivorata (Fgn.) 139	Ichn.	*Sinophorus hydriae* Sanborne U
	Brac.	*Cotesia acauda* (Prov.) R

Table 1. Continued.

Macrolepidoptera Species N[1]	Parasitoids	
	Family[2]	Genus/Species[3]
Lasiocampidae		
Malacosoma americanum (F.) 6	Tach.	*Compsilura concinnata* (Meigen) R
		Lespesia sp. R
	Ichn.	*Bathythrix triangularis* (Cresson) (2°)
Saturniidae		
Dryocampa rubicunda (F.) 42	Tach.	*Eumasicera sternalis* (Coquillett) R
		Lespesia anisotae (Webber) U
	Ichn.	*Hyposoter fugitivus* (Say) R
Anisota virginiensis (Drury) 71	Ichn.	*Hyposoter fugitivus* (Say) R
	Trig.	*Poecilogonalos costalis* (Cresson) U
Notodontidae		
Nadata gibbosa (J.E. Smith) 37	Tach.	*Compsilura concinnata* (Meigen) R
Symmerista leucitys Franc. 46	Ichn.	*Ophion flavidus* Brullé U
Macrurocampa marthesia (Cram.) 46	Tach.	*Lespesia stonei* Sabrosky U
	Trig.	*Poecilogonalos costalis* (Cresson) U
Heterocampa guttivitta (Wlk.) 23	Eulo.	*Eulophus* sp. near *koebelei* (Crawford) U
Lochmaeus manteo Doubleday 21	Tach.	*Lespesia stonei* Sabrosky U
	Brac.	*Diolcogaster schizurae* (Mues.) U
Schizura unicornis (J.E. Smith) 4	Brac.	*Diolcogaster schizurae* (Mues.) U
Arctiidae		
Hyphantria cunea (Drury) 73	Tach.	*Compsilura concinnata* (Meigen) R
		Hyphantrophaga blanda (Osten Sacken) U
		Blondelia hyphantriae (Tothill) R
	Ichn.	*Therion sassacus* (Vier.) R
	Brac.	*Cotesia hyphantriae* (Riley) R
		Meteorus hyphantriae (Riley) R
	Eulo.	*Elachertus cidariae* (Ash.) U
Halysidota tessellaris (J.E. Smith) 63	Tach.	*Blondelia hyphantriae* (Tothill) R
	Ichn.	*Therion morio* (F.) U
		Bathythrix triangularis (Cresson) (2°)
		Mesochorus discitergus (Say) (2°)
	Brac.	*Cotesia phoberti* (Rohwer) R
	Peri.	*Perilampus canadensis* (Crawford) U
Lymantriidae		
Orygia leucostigma (J.E. Smith) 38	Ichn.	*Phobocampe pallipes* (Prov.) R
		Iseropus stercorator orygiae (Ash.) R
	Brac.	*Meteorus tersus* (Mues.) U
	Peri.	*Perilampus hyalinus* (Say) (2°)
Noctuidae		
Bomolocha baltimoralis (Gn.) 35	Tach.	*Oswaldia assimilis* (Townsend) U
	Ichn.	*Hyposoter annulipes* (Cresson) U
	Brac.	*Protapanteles paleacritae* (Riley) U
Zale minerea (Gn.) 19	Tach.	*Xanthophyto* sp. Townsend U
	Brac.	*Distatrix* sp. U
Parallelia bistriaris Hbn. 46	Ichn.	*Netelia palpalis* (Cush.) U
		Netelia sp. U
	Brac.	*Rogas* sp. U
Cerma cerintha (Tr.) 7	Tach.	*Compsilura concinnata* (Meigen) U
Colocasia propinquilinea (Grt.) 13	Brac.	*Microplitis* sp. U

Table 1. Continued.

Macrolepidoptera Species N[1]	Parasitoids	
	Family[2]	Genus/Species[3]
Acronicta americana (Harr.) 19	Brac.	*Diolcogaster* (poss. *facetosa*) (Weed) U
Acronicta hasta (Gn.) 14	Tach.	*Hyphantrophaga virilis* (Aldrich & Webber) U
	Brac.	*Rogas* sp. U
Acronicta fragilis (Gn.) 124	Tach.	*Compsilura concinnata* (Meigen) R
	Brac.	*Meteorus hyphantriae* (Riley) U
		Meteorus communis (Cresson) U
		Meteorus sp. U
		Rogas sp. U
Acronicta ovata (Grt.) 106	Ichn.	*Phobocampe* n. sp. U
	Brac.	*Meteorus hyphantriae* (Riley) U
		Meteorus sp. U
	Eulo.	*Eulophus anomocerus* (Crawford) U
		Eulophus sp. U
Amphipyra pyramidoides (Gn.) 6	Brac.	*Microplitis hyphantriae* Ash. U
Lithophane hemina (Grt.) 23	Ichn.	*Diphyus comes* (Cresson) U
	Eulo.	*Eulophus anomocerus* (Crawford) U
		Eulophus nebulosus (Prov.) U
Eupsila morrisoni (Grt.) 9	Brac.	*Microplitis hyphantriae* Ash. U
Polia latex (Gn.) 276	Tach.	*Hyphantrophaga virilis* (Aldrich & Webber) U
		Blondelia hyphantriae (Tothill) U
		Lespesia stonei Sabrosky U
	Ichn.	*Hyposoter fugitivus* ((Say) U
		Alloplasta superba (Prov.) U
		Eutanyacra improvisa (Cresson)
		Mesochorus pictilis Holmgren (2°)
	Brac.	*Diolcogaster facetosa* (Weed) U
		Microplitis hyphantriae Ash.
		Microplitis sp. U
		Meteorus bakeri C. & D. U
	Eulo.	*Euplectrus maculiventris* Westwood U
		Euplectrus sp. U
		Eulophus nebulosus (Prov.) U
		Eulophus sp. U
	Peri.	*Perilampus canadensis* Crawford (2°)
Orthosia rubescens (Wlk.) 6	Eulo.	*Eulophus nebulosus* (Prov.) U
		Eulophus smerinthi (Ash.) U
		Eulophus anomocerus (Crawford) U
Orthosia hibisci (Gn.) 14	Eulo.	*Eulophus nebulosus* (Prov.) U
		Eulophus anomocerus (Crawford) U
Crocigrapha normani (Grt.) 6	Eulo.	*Eulophus nebulosus* (Prov.) U
		Eulophus anomocerus (Crawford) U
Morrisonia confusa (Hbn.) 263	Tach.	*Hyphantrophaga virilis* (Aldrich & Webber) U
	Ichn.	*Hyposoter annulipes* (Cresson) U
		Drusonia wyomingensis (Vier.) U
		Enicospilus merdarius (Grav.) U
		Isodromas lycaenae How. U
		Mesochorus vittator (Zett.) U
		Itoplectis conquisitor (Say) (2°)
	Brac.	*Microplitis hyphantriae* Ash. U
		Microplitis sp. U
		Cotesia sp. U

Table 1. Continued.

Macrolepidoptera Species N[1]	Parasitoids Family[2]	Genus/Species[3]
	Eulo.	*Euplectrus maculiventris* Westwood U
		Euplectrus bicolor (Swederus) U
		Pediobius crassicornis (Thomson) U
	Peri.	*Perilampus canadensis* Crawford (2°)
Abagrotis alternata (Grt.) 15	Eulo.	*Euplectrus bicolor* (Swederus) U

[1] Number of specimens reared of each macrolepidoptera species.

[2] Tach. = Tachinidae; Ichn. = Ichneumonidae; Brac. = Braconidae; Trig. = Trigonalidae; Chal. = Chalcididae; Eulo. = Eulophidae; Pter. = Pteromalidae; Peri. = Perilampidae.

[3] R = parasitoid/host relationships recorded by Arnaud (1978) for Tachinidae (Diptera) and Krombein et al. (1979) for hymenopterous species. U = those parasitoid host relationships not recorded in above publications. Secondary parasitoids not considered.

At Cooper's Rock in 1984 and 1985 little defoliation was evident from the 100 species of macrolepidopterous larvae collected on black cherry, black birch, red maple, and mixed oaks. Caterpillar populations were generally low. Among the factors responsible for the low populations were the 74 species of parasitoids obtained in this study. Our knowledge of parasitoid/host relationships for most of our native forest defoliating macrolepidoptera is apparently very limited as evidenced by the large number of new records in this study.

ACKNOWLEDGMENTS

I thank the U.S.D.A. Forest Service for partial support of this research; Peter S. Wood and Vicki Kondo for field and laboratory assistance; James W. Amrine, John F. Baniecki, and Joseph E. Weaver for comments on the manuscript; R. W. Carlson, E. E. Grissell, P. M. Marsh, M. E. Schauff, D. R. Smith, N. E. Woodley (U.S.D.A. Systematic Entomology Laboratory, Washington, D.C.), D. M. Wood, J. E. O'Hara (Biosystematics Research Centre, Ottawa, Ont.), and D. C. Darling (Royal Ontario Museum, Toronto, Ont.) for parasitoid identifications.

LITERATURE CITED

Arnaud, P. H., Jr. 1978. A host-parasite catalog of North American Tachinidae (Diptera). United States Department of Agriculture Miscellaneous Publication No. 1319. 860 pp.

Butler, L. 1990. Parasitoids of a looper complex (Lepidoptera: Geometridae) in West Virginia. Canadian Entomologist 122: 1041–1043.

———. 1992. The community of macrolepidopterous larvae at Cooper's Rock State Forest, West Virginia: A baseline study. Canadian Entomologist. (In press.)

Butler, L. and V. Kondo. 1991. Macrolepidoptera moths collected by blacklight trap at Cooper's Rock State Forest, West Virginia: A baseline study. West Virginia Agriculture and Forestry Experiment Station Bulletin 705. 25 pp.

Carvell, K. L. 1983. A summary of 1973–1982 weather data from the West Virginia University Forest. West Virginia University Forestry Notes 10: 13–16.

Krombein, K. V. 1958. Hymenoptera of America North of Mexico, Synoptic Catalog, First Supplement. United States Department of Agriculture Monograph 2. 305 pp.

Krombein, K. V. and B. D. Burks. 1967. Hymenoptera of America North of Mexico, Synoptic Catalog, Second Supplement. United States Department of Agriculture Monograph 2. 584 pp.

Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks. 1979. Catalog of Hymenoptera in America North of Mexico. Vol. 1, Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington, D.C. 1198 pp.

Muesebeck, C. F. W., K. V. Krombein, and H. K. Townes. 1951. Hymenoptera of America North of Mexico, Synoptic Catalog. United States Department of Agriculture Monograph 2. 1420 pp.

Raizenne, H. 1952. Forest Lepidoptera of Southern Ontario and Their Parasites Received and Reared at the Ottawa Forest Insect Survey Laboratory from 1937 to 1948. Canada Department of Agricultural

Science Service, Division of Forest Biology. 277 pp.

Schaffner, J. V., Jr. and C. L. Griswold. 1934. Macrolepidoptera and their parasites reared from field collections in the northeastern part of the United States. United States Department of Agriculture Miscellaneous Publication 188: 1–160.

Townes, H. and M. Townes. 1959. Ichneumon-Flies of America North of Mexico: 1. Subfamily Metopiinae. United States Natural History Museum Bulletin 216. 318 pp.

———. 1960. Ichneumon-Flies of America North of Mexico: 2. Subfamilies Ephialtinae, Xoridinae, Acaenitinae. United States Natural History Museum Bulletin 216, Part 2. 676 pp.

———. 1962. Ichneumon-Flies of America North of Mexico: Subfamily Gelinae, Tribe Mesostenini. United States Natural History Museum Bulletin 216, Part 3. 601 pp.

Viereck, H. L. 1916. Guide to the Insects of Connecticut, Part III, The Hymenoptera, or Wasp-like Insects, of Connecticut. Bulletin No. 22, State Geology and Natural History Survey. 824 pp.

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 511–512

NOTE

A New Method for Determining the Sex of Living Weevils

As part of the USDA-ARS biological control of weeds program, the biology of the host specificity of several weevil species have been studied. Since reliable morphological differences for sexing the adults are not known, copulating pairs have been collected and then males and females separated (Clement et al. 1988, Proceedings of the Entomological Society of Washington 90: 501–507). This procedure is very time consuming and often it is difficult or impossible to obtain large numbers of sexed adults.

Working with *Larinus minutus* Gyl., distinct morphological differences between males and females were observed. Examination of adults of *Bangasternus orientalis* Capiomont, *B. fausti* Reit., *Larinus curtus* Hochhut, *L. onopordi* Fabricius, and *Eustenopus villosus* (Boheman) showed that the same differences exist in males and females of these species. Similar dimorphism may also exist in other species of Curculionidae.

Differences in shape, size, and vesture of the pygidium are the main differences between the sexes. In females the pygidium consists of one part, bears none or few setae, and is normally brown (Fig. 1). In males, the pygidium is composed of two parts, and is covered with dense setae that are turned toward the center (Fig. 2).

If it is difficult to observe the pygidium under the stereomicroscope (it might be hidden under the elytra), the sternite of the weevil may be pulled down gently with a pinning needle. In many cases the female's anal opening will be visible. Contrary to the female, the male's pygidium comes down and therefore its anal opening is not visible (Fig. 3).

Acknowledgments.—I thank J. Pakaluk (SEL, ARS-USDA, Washington, D.C.), R. Sobhian, L. Knutson, A. Kirk, and L. Fornasari (USDA-ARS, Montpellier, France) for their continuous support during the study and for reviewing the manuscript.

Javid Kashefi, *European Biological Control Laboratory, ARS-USDA, P.O. Box 1637. GR-54006 Thessaloniki, Greece.*

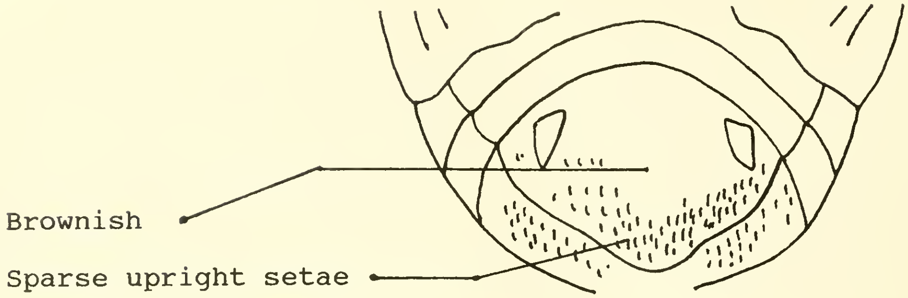


Figure 1: Dorsal view of pygidium of *Larinus minutus* female

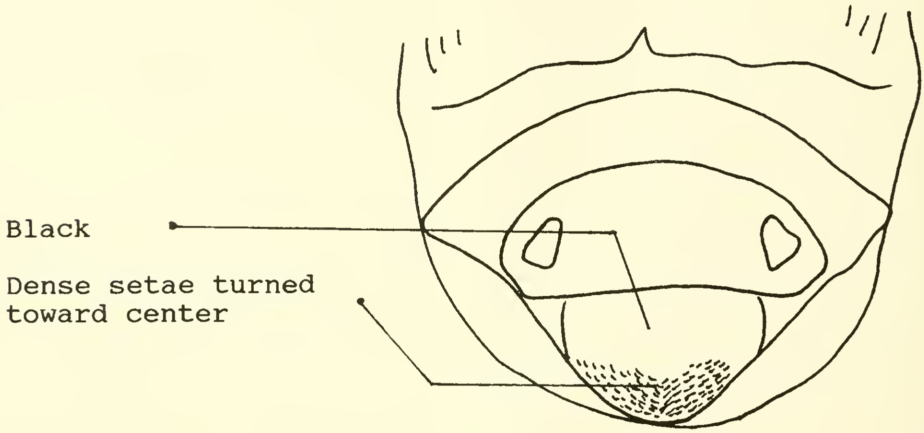


Figure 2: Dorsal view of pygidium of *Larinus minutus* male

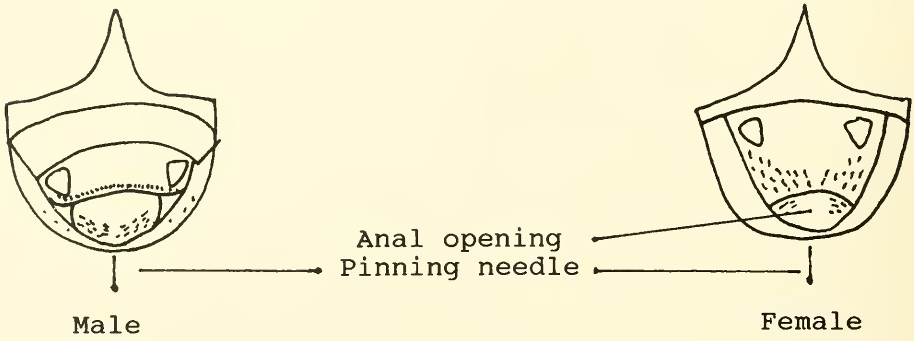


Figure 3: Visible anal opening of *Larinus minutus* female and invisible anal opening of male

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 513–516

Book Review

A Synthesis of the Holarctic Miridae (Heteroptera): Distribution, Biology and Origin, with Emphasis on North America. A. G. Wheeler, Jr. and T. J. Henry. Entomological Society of America, Lanham, MD (Thomas Say Foundation vol. XV). 1992. v + 282 pp. ISNB 0-938522-39-6. Hardback. $30.00 (ESA members), $50.00 (non-members).

This is an ambitious study of all of the Miridae at present known to occur both in North America and Eurasia. The authors are eminently qualified to have undertaken this work, as for many years they have been the leading field collectors of plant bugs in the eastern United States. As the text demonstrates, they are responsible for the reports of many species that were thought to be European but are now established in North America.

The experience of both authors in agricultural entomology, as well as in the systematics of Miridae, has added significantly to the organization and maximum utility of the text.

The Miridae or plant bugs are not only by far the largest family of Heteroptera with 1930 species from North America north of Mexico (Henry and Wheeler 1988. *In* Henry, T. J. & R. C. Froeschner, eds., *Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States.* Brill, New York), but many of them are of economic importance, and several of these are not native to the Western Hemisphere.

The book begins with a short introduction that discusses why such a study is desirable and the few groups of insects where such studies have been accomplished. This section is followed by a review of previous work on the Heteroptera and a defense of terminology used.

The major portion of the book treats each species known to occur, or thought to have occurred, in the Holarctic. It includes a superb survey of the literature, a synopsis of the range in the Old World, a thorough summary of the host plants and habits, a North American distribution map, and a "Zoogeographic summary" of the status of each species—i.e. whether it was brought here by man, occurred naturally on both continents, arrived by its own dispersal powers, and what is known of its dispersal if "introduced." For many species a full view illustration is included.

The organization is by subfamily and by genus and species alphabetically within each subfamily.

The book concludes with two valuable chapters, one called "Summary and Conclusions," in which the authors present their evidence and criteria for assessing the status of each species in North America. A second chapter segregates the "Holarctic" species into a series of subgroups: those considered to be "indigenous" or "adventive" in eastern North America; those "adventive" in northwestern North America; those "adventive" in North America by multiple introductions; and those that are thought to be tropicopolitan.

There is an exhaustive list of references (44 pages), including many references certainly unfamiliar to most students of either zoogeography or hemipteran biology.

The authors conclude (correctly in this reviewer's opinion) that most "adventive" species have been brought in with plant material and that dispersal by ballast, or by the insects' own powers of flight, or by wind is relatively unimportant for members of this family.

There is one unfortunate feature of this basically outstanding work. This is the authors' decision to use a terminology at variance with that of most biogeographers. Most unfortunate, in my opinion, is their decision to include as "Holarctic species" all species that now occur in North America and Eurasia, regardless of whether they natually so occur or have been brought to North America (or the reverse) by man. The authors argue that this definition agrees with that of the second edition of the Oxford English Dictionary, which they quote as saying "In the Geographical Distribution of animals; of or pertaining to the entire northern or Arctic region, as the Holarctic Region, or Holarctic family of Birds." This definition is certainly ambiguous enough to be interpreted any way one wishes to use it! But it most certainly is not what biogeographers, whether plant or animal, have used for the most part since the days of Alfred Russell Wallace. I find this unfortunate, for this is an important work and likely to influence other insect zoogeographers. If such a definition of "Holarctic" is adopted widely, we will in the future be forced to ask, "Does he/she mean Holarctic 'old sense' or Holarctic 'Wheeler & Henry sense'?" In fairness to the authors, they are not the first to use the term in this catch-all manner. They note Benson has done so for Sawflies in 1962 (Bulletin British Museum (Natural History) Entomology 12: 379–409). Nevertheless, it forces the authors to talk constantly about "naturally Holarctic," "indigenous" (meaning in the book "naturally occurring in North America" and presumably Eurasia). Thus, indigenous appears to be synonymous with "naturally Holarctic" although one wonders about what species that occur in North America but not in the Palearctic will be called, because "endemic" is said to be too ambiguous. Furthermore, "naturally Holarctic" is not necessarily synonymous with "a natural Holarctic origin" (see page 67). For species not "naturally Holarctic" a plethora of terms appear, such as the restriction of "introduced" to species intentionally brought in by man, and "immigrant" to include both those brought in accidentally and those that arrived under their own powers of dispersal. This reviewer thus kept finding himself constantly thinking, "Let's see now, is this one 'natural' or 'introduced', or did they really mean 'immigrant' when they said 'introduced'?" For example, the discussion of *Pinalitus rubricatus* Fallén (p. 61) is said to have been introduced with imported conifer nursery stock. One finally says, "Oh well, that wasn't really a Holarctic species (traditional sense) but was 'adventive', I guess."

This redefinition of "Holarctic" to include everything that is found in North America and Eurasia becomes particularly misleading when it includes species that are essentially tropicolitan and reach only the southern limits of the United States or Europe. There are 5 species that have an essentially tropicopolitan distribution and reach only Florida and a few other areas in the southern states. Only by their unfortunate definition of "Holarctic" can these species, which reach only the southern limits of both the Nearctic and Palearctic, be really considered to be Holarctic Miridae, and their distributions would be more appropriately dealt with in a discussion of other Heteroptera that show similar tropicolitan distributions.

One of the important conclusions of the book is that most of the adventive species that have reached North America have come from western Europe. There are interesting exceptions, such as the predatory *Stethoconus japonicus* Schumacher which was probably introduced on nursery stock from Japan and which has a distribution that includes Japan, China, Korea and eastern Russia. *Dicyphus rhododendri* Dolling appears to have been imported into Great Britain from the United States, even though it was originally described from Britain. *Irbisia sericans* (Stål) has apparently "moved" westward from western North America into eastern Siberia, either by way of Beringia, or by later island hopping (or is it adventive there, or vicariant?). An interesting term is developed for such distributions which are called "incomplete Holarctic."

For the most part Wheeler & Henry have

been cautious yet thorough in presenting possible alternative explanations for particular distributions, as in their discussion of *Agnocoris rubicundus* (Fallen). Amusingly, they quote Moore in 1956 (Journal Kansas Entomological Society 29: 37–39) as considering it "truly Holarctic"—a term very useful, but impossible under the Wheeler-Henry definition. In evaluating this species and its Nearctic sister species, they (correctly in my opinion) dismiss out of hand Schaefer and Calabrese's belief that this is an "amphi-atlantic pair" merely by saying "such a conclusion is incorrect." However, their alternative seems to fumble a bit. Fortunately, they do recognize that an Alaskan unglaciated refugium was present during the Pleistocene, but their statement that "speciation may have occurred during the Pleistocene following the last glacial retreat" seems very limiting. One wonders why some speciation could not have been earlier since there were four major ice advances and retreats and a number of lesser ones. Strangely, they quote Coope (1979. Annual Review Ecology Systematics 10: 247–267) "and others" in pointing out that range disjunction rather than speciation is the more common result of range fragmentation. Taken out of context, (perhaps the inference is to the Wisconsin only), this is indeed a strange statement. It is hardly possible to imagine range fragmentation that does not result in range disjunction, and if range disjunction is not a major cause of speciation then the whole model of allopatric speciation would seem to come crashing to the ground.

There are tantalizing problems raised for future taxonomists. For example, the authors note that eastern populations of *Lygocoris pabulinus* (L.) breed almost entirely on *Impatiens*; whereas western populations feed on a wide variety of hosts and "behave more like *L. pabulinus* in the old world." This suggests either separate introductions, or the presence of more than one species. Probably the authors really do not mean their previous restriction of the word "introduction" but a more general use of the word—i.e. "introductions" to mean either two "invasions" by the insects' own powers of dispersal, or two separate adventive events by man and his produce or a combination of the two.

Despite the mass of records it is obvious (and the authors stress this) that much field work is still needed. *Phytocoris dimidiatus* Kirshbaum, apparently "immigrant" on both coasts, is known in the east only from a male reported from Nova Scotia by Knight in 1923. Is this species actually established in eastern North America? *Phytocoris ulmi* (L.) is known only from a Nova Scotia specimen taken in 1914.

A review cannot hope to comment on all of the fine details of this book. There are many. The problem of whether *Leptopterna dolobrata* (L.) was "adventive" or "naturally occurring" was one which puzzled this reviewer a number of years ago. The insect appears to have all of the characteristics of an adventive species. However, the statement by H. M. Harris (1928. Entomologica Americana 9: 1–97) that the myrmecomorphic damsel bug *Nabicula subcoleoptrata* (Kirby) (which does not occur in Eurasia) was completely tied to this species in its life history seemed to militate against an adventive status for *Leptopterna*. Wheeler and Henry point out that Harris was in error and that the nabid feeds on a variety of hosts, thus removing the difficulty of reconciling the status of the mirid bug.

For economic entomologists this book will have great value for many years to come. Some of the "adventive" species are likely to become serious pests, as has *Adelphocoris lineolatus* (Goeze), and their increase and dispersal now has a basis with which future studies can be compared.

The book is amazingly free of typographical errors thanks to Dr. Wheeler's noted intense scrutiny for such mishaps. I am sure that Dr. Wheeler looked with misgivings upon the vagaries of computer typesetting that in the bibliography sometimes drew words together so as almost to make single Germanic combinations (see Kavanaugh & Erwin 1985 (Pan-Pacific Entomologist 61: 170–179) p. 235 for example).

Finally, it must be said that this book is a beautiful example of the best of scientific reporting. It is thorough, strongly documented, the conclusions cautiously and carefully thought out, and perhaps of greatest importance, all of the information is there for anyone who wishes to consider alternate hypotheses. It avoids the too frequent statements of vast and ready movement of populations and also, the desire to invoke vicariance patterns by not allowing plant bugs to move except under unusual circumstances. There is thus a delicate balance achieved (and recognized) between the "spread potential" of Miridae by Leston, which considered the family to be among the most mobile of all Heteropterans, and the vicariance ideas of Schuh and Stonedahl, which allowed them only the most grudging dispersal and colonizing ability.

Perhaps the best tribute that can be paid to this fine work is the recognition that if other groups, not only of Heteropterans but most other insects, had anything comparable, future insect biogeographers and students of the dynamics of introduced species would be able to work with a confidence that their conclusions were founded upon accurate and thorough information.

James A. Slater, *Department of Ecology & Evolutionary Biology, University of Connecticut, Storrs, Connecticut 06269.*

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 517–519

BOOK REVIEW

The Insects and Arachnids of Canada. Part 19. The Ground Spiders of Canada and Alaska (Araneae: Gnaphosidae). Norman I. Platnick and Charles D. Dondale. Agriculture Canada Publication No. 1875. 1992. 297 pp. Paperback ($25.95 in Canada, $31.15 elsewhere). Available from Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, Canada K1A 0S9.

The present volume is the nineteenth in a series devoted to the insects and arachnids of Canada and Alaska, and published by Agriculture Canada. Parts 5, 9, and 17 of this series have treated the spider families Philodromidae and Thomisidae, Clubionidae and Anyphaenidae, and the lycosoids, respectively. This identification manual deals with the family Gnaphosidae, the only Canadian representatives of the dionychan superfamily Gnaphosoidea. As currently delimited, Gnaphosoidea includes a total of seven families and about 150 genera (Platnick. 1990. American Museum Novitates 2978: 1–42).

The general format of this book follows that of its predecessors in the series. A short "Introduction" provides some general comments on the natural history of this group, and on some of the recent advances in its systematics. The section entitled "Behavior" summarizes the relatively little information available about the life history of gnaphosids. The "Anatomy" section gives a general description of the external morphology of ground spiders and illustrates some of their morphological features. The methods of study are presented at the end of this section. The rest of the book is devoted to the taxonomic part, which conforms closely to the standard format adopted by the earlier spider manuals of this series. The description and diagnosis of the family is followed by a bilingual key (all the keys in the book are provided in French as well) to the Canadian and Alaskan genera of Gnaphosidae. Keys for the species are also provided. The keys are clear and explicit, with numerous references to the many illustrations (over 430 drawings and 71 maps) that accompany the descriptions. The book treats a total of 16 genera and 100 species which occur, or are assumed to occur, in Canada and Alaska. The species descriptions are illustrated with line drawings of the male (ventral and retrolateral view of the palp) and female genitalia (dorsal and ventral view of the epigynum) and a map of the collecting localities within the area treated in the book. Readers not familiar with spider morphology will benefit from the rather extensive (116 entries) glossary that follows the taxonomic section. The bibliography contains more than 140 entries. An exhaustive index, which includes synonyms, closes this carefully edited manual, which has been printed on recycled paper.

This volume partially synthesizes Platnick's work (very frequently in collaboration with Mohammad Shadab) on the systematics of North American gnaphosoids, a task that has been accomplished in about 25 publications spanning a period of more than twelve years. Unfortunately this has been done only for the Canadian fauna. Good taxonomic keys and accurate, clear, and well labelled illustrations are perhaps the most critical "ingredients" of an identification manual, in part because, as the senior author of this book has put it, "a page of illustrations often provides more useful taxonomic information than could a dozen pages of text" (Platnick. 1985. Journal of the New York Entomological Society 93(4): 1279–1280). In both aspects, keys and illustrations, this book has to be praised. The bulk of the taxonomic illustrations are the same as those used in the original revisionary papers, and have been drawn by Mohammad Shadab. James Redner has added some additional drawings matching Shadab's graphic style, avoiding therefore the distracting effect caused by putting together a disparity of illustration styles, which in my opinion is one of the main defects (together with the extremely poor quality of some of the illustrations) of the recently published "Spinnen Mitteleuropas" (S. Heimer and W. Nentwig. 1991. Paul Parey. Berlin and Hamburg). A large portion of the taxonomic section of this book is redundant with the original revisionary papers, although descriptions and diagnoses have been slightly modified, and additional locality records have been added to the new maps (after the unfortunate deletion of the records that fall out of the Canadian-Alaskan area). Despite the limited scope of Platnick and Dondale's book there are some improvements over the original taxonomic revisionary papers that are worth mentioning. Some of the original generic revisions lacked keys for the species (e.g. *Zelotes*), and have been published here, although unfortunately only for the Canadian representatives. Some of the original illustrations have been modified to correct former errors (e.g. the epigynum of *Zelotes fratis*, Fig. 106). In other instances new illustrations have replaced some inaccurate figures from the original revisions (e.g. the epigyna of *Herpyllus ecclesiasticus*, Fig. 435 and of *Gnaphosa microps*, Figs. 274 and 275). While in some of the original revisions the figures lacked any labels other than the figure numbers (e.g. the revisions of *Cesonia* or *Nodocion*), in the present book there is at least one species per genus in which the palpal sclerites and the epigynal components have been labelled. In addition, arrows have been used in the illustrations to point diagnostic features. Other improvements include corrections of earlier taxonomic descriptions (e.g. the female described as *Gnaphosa orites* in the 1975 revision turned out to belong to *G. borea*) or of locality records (e.g. for *Haplodrassus hiemalis*, p. 218), which are given for the first time in this book. So it seems that despite the redundancies this manual complements some of the original taxonomic work on which the book is based.

While Platnick and Dondale's book shares with other manuals of this series some of its virtues, it also shares two of the major criticisms: the narrow scope imposed by being limited to arbitrary political boundaries and the almost absolute lack of phylogenetic insight. I have already discussed some of the problems of regional faunal studies (Hormiga. 1992. Proceedings of the Entomological Society of Washington 94: 602–604), and Griswold (1991. Journal of Arachnology 19: 233–234) has summarized the pros and cons of this kind of study.

Part 1 of "The Insects and Arachnids of Canada" does not detail the aims of this series of identification manuals, but some of the editorial policies of the series can be inferred from the standards to which these manuals conform. It seems that to provide some biological information on the organism in question is the right thing to do. So from these books, we might learn details on the phenology, on the habitats in which these animals have been collected, on the kind of collecting methods that have been successfully used, on their mating behavior, or on the altitudinal range they occupy, just to mention a few. Obviously there are a good number of things that one would like to know and that will not be found in the pages of these manuals, simply because they still remain unknown. There are some other things that have been studied and published, but nevertheless will not be found in this series, because apparently they are not the right thing to include. Most of the explicit phylogenetic information found in the primary literature has been effectively targeted and "eradicated" from the pages in this series. Some might argue that these are identification manuals, aimed to a more general audience, and therefore the specialized subjects (like phylogenetics) should be left for the more specialized publications. This is a weak argument. While it seems logical (and might even be considered as "non-specialized" data) to mention that a given species has been collected in clover fields, using such technique and at such altitude, it seems that to mention which its closest relatives might be or why the genus is hypothesized to be monophyletic is not considered appropriate. To include some of the available phylogenetic information is not incompatible with the nature of these books, despite their narrow geographical scope, particularly when the phylogenetic work has already been done. The reader should be allowed to decide whether she or he wants to skip or ignore any particular information. Species are related to each other in a hierarchical fashion, and to ignore that a phylogeny underlies such diversity is simply wrong. In some cases little if any phylogenetic information is available. But in others, and gnaphosoid spiders are a good example, well corroborated phylogenetic hypotheses exist in the literature, although they are ignored in the book. For example, the authors diagnose gnaphosids as having well-sclerotized anterior lateral spinnerets, with an oblique depression of the palp-coxal lobe, and irregularly shaped posterior median eyes (p. 16). Because all the diagnoses are only regional in scope, the authors do not mention that all of these three characters are synapomorphic for the superfamily Gnaphosoidea, and therefore are symplesiomorphies for Gnaphosidae. It certainly does not take much printed space to point this out, and failure to mention it that might be, in a sense, misleading for the reader. While it is surprising that the book fails to mention this point, it is not surprising at all to learn that Platnick himself (1990. American Museum Novitates 2978: 1–42) is the author of this hypothesis. It is paradoxical to find a book by Norman Platnick, one of the foremost architects of cladistics, in which most of the phylogenetic content of his work has been deleted or concealed. In view of works like Platnick and Dondale's manual, one cannot help but question what impact, if any, phylogenetic systematics has had on taxonomy.

Nonetheless, Platnick and Dondale have succeeded in producing an excellent identification manual, which will be welcomed by anyone interested in identifying and studying spiders from this region of the world, as well as by all spider systematists.

Jonathan Coddington provided valuable comments on a draft of this review.

Gustavo Hormiga, *Department of Entomology, NHB-105, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560; and Maryland Center for Systematic Entomology, Department of Entomology, University of Maryland, College Park, Maryland 20742.*

PROC. ENTOMOL. SOC. WASH.
95(3), 1993, pp. 520–525

MEMBERSHIP LIST OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

The previous list was published in April 1989 with 547 members; the present list contains 473 members from every state in the union except Alaska, Maine, and Oregon. The largest representation is in Maryland (69), followed by the District of Columbia (51), California (31), Florida (31), and Virginia (22). The figures for the Washington, D.C. area are slightly skewed since some members receive their Proceedings at office addresses. Eighteen other countries in every continent except Africa and Antarctica are represented.

The format used in this list follows that of the 1989 list. Names of Honorary Members are capitalized, those of Emeritus Members are italicized, and Life Members are distinguished by an Asterisk (29) following the date they joined the Society. Dates of election to Honorary or Emeritus status are entered in parentheses. In 1988, Dr. Curtis W. Sabrosky was elected to Honorary President, and Dr. Louise M. Russell and Dr. Alan Stone were elected to Honorary membership. In 1992 Dr. Karl V. Krombein was elected to Honorary membership.

I thank Mrs. Dianne Mathis and Drs. Ralph Ekerlin and Norman Woodley for their assistance in the preparation of this list. Any corrections to the list can be sent to the Corresponding Secretary at the address on the inside front cover of this issue. Corrections will be read at the next meeting of the Society, and will be published in the Proceedings by the Recording Secretary.

Holly B. Williams,
Corresponding Secretary

Abe, M. 1988 JAPAN
Adams, J. R. 1963 Maryland
Adams, M. S. 1983 New York
Adamski, D. 1984 District of Columbia
Adler, P. H. 1986 South Carolina
Ahlstrom, K. R. 1992 North Carolina
Aitken, T. G. H. 1957 (1984) Connecticut
Anderson, D. M. 1954 District of Columbia
Anderson, L. D. 1944 (1989) California
Anderson, R. S. 1991 CANADA
Anderson, W. H. 1937 Maryland
Appel, A. G. 1983 Alabama
Apsey, R. P. 1992 Michigan
Arduser, M. S. 1985 Missouri
Armitage, B. J. 1983 Ohio
Arnaud, P. H., Jr. 1955 California
Austin, D. F. 1977 Florida
Babin, M. J. 1992 District of Columbia
Baker, G. T. 1987 Mississippi
Baker, R. H. 1992 Florida
Ball, G. E. 1948 CANADA
Barber, K. N. 1985 CANADA
Barnes, J. K. 1979 New York
Barr, W. F. 1948 Idaho
Barrows, E. M. 1976 District of Columbia
Batra, S. W. T. 1985 Maryland
Baumann, R. W. 1973 Utah
Baumgardner, D. 1992 Texas
Beal, R. S., Jr. 1958 Colorado
Bechtel, R. C. 1960 Nevada
Becker, E. C. 1951 CANADA
Becker, V. O. 1987* BRAZIL
Bell, R. T. 1955 Vermont
Bellinger, R. G. 1972 South Carolina
Berry, R. L. 1972 Ohio
Bezark, L. G. 1974 California
Bicha, W. 1981 Tennessee
Bickley, W. E. 1949* Maryland
Bilby, P. J. 1993 New Jersey
Blom, P. E. 1986 Idaho
Boettcher, R. A. 1955 District of Columbia
Bohart, R. M. 1944 California
Boldt, P. E. 1987 Texas
Borkent, A. 1988 CANADA
Bowles, D. E. 1993 Texas
Broda-Hydorn, S. 1991 Florida
Brodel, C. F. 1991 Florida
Brodie, E. H. 1991 Virginia
Brou, V. A. 1985 Louisiana
Brown, B. V. 1993 California
Brown, F. M. 1975 Colorado

Brown, H. P. 1977 Oklahoma
Brown, R. L. 1979 Mississippi
Brushwein, J. R. 1987 Florida
Bueno-Soria, J. 1977 MEXICO
Burger, J. F. 1975 New Hampshire
Burke, H. R. 1981 Texas
Burns, J. M. 1975* District of Columbia
Burrows, W. L. 1983 West Virginia
Butler, L. 1966 West Virginia
Byers, G. W. 1984 Kansas
Calabrese, D. M. 1981 Missouri
Carapia Ruiz, V. E. 1992 MEXICO
Carlow, T. 1992 District of Columbia
Carlson, R. W. 1970* Maryland
Carpenter, J. M. 1984 New York
Carroll, J. F. 1977 Maryland
Cave, R. D. 1977 HONDURAS
Chapin, J. B. 1973 Louisiana
Clark, W. E. 1975 Alabama
Cochran, D. G. 1981 Virginia
Cohen, N. Y. 1983 Maryland
Connor, E. F. 1990 Virginia
Contreras-Ramos, A. 1986 Minnesota
Cooper, K. W. 1955 California
Corpus, L. D. 1985 Mississippi
Coulson, J. R. 1961 Maryland
Couri, M. S. 1987 BRAZIL
Courneya, P. 1986 Florida
Courtney, G. W. 1985 District of Columbia
Covell, C. V., Jr. 1986 Kentucky
Craig, G. B. 1954 Indiana
Cross, H. F. 1954 Georgia
Currado, I. 1978 ITALY
Darling, D. C. 1981 CANADA
Darsie, R. F. 1949 South Carolina
Daussin, F. J., III 1993 Virginia
Davidson, J. A. 1957 Maryland
Davis, D. R. 1961 District of Columbia
Davis, L. G. 1952 California
Davis, L. R. 1992 Florida
Deeming, J. C. 1974* WALES
Deitz, L. L. 1982 North Carolina
Dennis, S. 1979 Colorado
Dewalt, R. E. 1992 Louisiana
Deyrup, M. A. 1979 Florida
Dietrich, C. H. 1988 District of Columbia
Dimock, M. B. 1989 Maryland
Dobbs, T. T. 1992 Florida
Donahue, S. A. 1992 District of Columbia
Donnelly, T. W. 1962 New York
Downes, W. L. 1985 Michigan
Doyen, J. T. 1983 California
Dozier, H. L. 1952* South Carolina
Drea, J. J. 1984 Maryland
Drummond, R. O. 1954 (1987) Texas
Eckerlin, R. P. 1990 Virginia
Eisenberg, R. M. 1988 Delaware
Elias, M. K. 1972 Maryland
Enns, W. R. 1960 Missouri
Erwin, T. L. 1972 District of Columbia
Evans, H. E. 1948 Colorado
Evans, W. G. 1957 CANADA
Evenhuis, N. L. 1980 Hawaii
Fairchild, G. B. 1939 Florida
Fales, J. H. 1944 Maryland
Fee, F. D. 1983 Pennsylvania
Feller, C. 1989 District of Columbia
Ferguson, D. C. 1969 District of Columbia
Fisher, E. M. 1977 California
Fisk, F. W. 1968 (1988) Florida
Fitzgibbon, B. 1990 Louisiana
Flint, O. S., Jr. 1961 District of Columbia
Floyd, M. A. 1991 South Carolina
Fluno, J. A. 1957 Florida
Foote, B. A. 1958 Ohio
Foote, R. H. 1950 Virginia
Forattini, O. P. 1956 BRAZIL
Fox, I. 1936 Puerto Rico
Franclemont, J. G. 1947 New York
Frania, H. 1991 CANADA
Frazer, K. S. 1989 Michigan
Freidberg, A. 1979 ISRAEL
Freytag, P. H. 1979 Kentucky
Gagné, R. J. 1966* District of Columbia
Gelhaus, J. K. 1989 Pennsylvania
Gentry, J. W. 1958 Florida
Gerberg, E. J. 1953 Florida
Gibson, L. P. 1981 Ohio
Giles, F. E. 1981 Maryland
Glaser, J. D. 1988 Maryland
Goeden, R. D. 1982 California
Gomes, P. 1991 Maryland
Gomez-Arias, L. M. 1992 Florida
Gordon, R. D. 1968 District of Columbia
Gorham, J. R. 1974 District of Columbia
Grace, J. K. 1987 Hawaii

Grimaldi, D. A. 1992 New York
Grissell, E. E. 1979 District of Columbia
Grogan, W. L., Jr. 1974 Maryland
Guirey, B. N. 1991 New York
Gunther, R. G. 1981 Illinois
Habeck, D. H. 1957 Florida
Hagen, K. G. 1949 California
Haines, K. A. 1952 Virginia
Halbert, S. 1989 Idaho
Halstead, J. A. 1983 California
Hamilton, S. W. 1982 Tennessee
Hanks, L. M. 1993 California
Hanson, P. 1985 COSTA RICA
Hansson, C. 1985 SWEDEN
Harbach, R. E. 1990 District of Columbia
Harlan, H. J. 1988 Maryland
Harman, D. M. 1966 Maryland
Harrington, D. 1989 Texas
Harris, S. C. 1979 Alabama
Harrison, B. A. 1976 District of Columbia
Haskins, C. P. 1945 District of Columbia
Headrick, D. H. 1992 California
Hendricks, H. J. 1987 Virginia
Henry, C. S. 1975 Connecticut
Henry, T. J. 1975 District of Columbia
Heppner, J. B. 1974 Florida
Heraty, J. M. 1986 CANADA
Hernandez, V. 1992 MEXICO
Hespenheide, H. A., III 1981 California
Hevel, G. F. 1970 District of Columbia
Heydon, S. L. 1986 California
Hight, S. 1990 Maryland
Hilton, D. F. J. 1990* CANADA
Hodges, R. W. 1960* District of Columbia
Hoebeke, E. R. 1980 New York
Hoffman, K. M. 1986 South Carolina
Hoffmann, C. H. 1945 Maryland
Holzbach, J. E. 1983 Ohio
Hopla, C. E. 1961 Oklahoma
Hopper, H. P. 1978 District of Columbia
Howden, H. F. 1948 CANADA
Huang, Y.-M. 1968 District of Columbia
Hung, A. C. F. 1981 Maryland
Hurd, L. E. 1988 Delaware
Husband, R. W. 1973 Michigan
Imai, E. M. 1983 Maryland
Irwin, M. E. 1976 Illinois
Ivie, M. A. 1984 Montana
Jackson, D. L. 1966 Ohio
Jenkins, J. 1987 Michigan
Johnson, J. B. 1987 Idaho
Johnson, N. F. 1980 Ohio
Johnson, P. J. 1984 Wisconsin
Joseph, S. R. 1957 Maryland
Kaster, C. H. 1979 Michigan
Keffer, S. L. 1993 Virginia
Keirans, J. E. 1984 Georgia
Kethley, J. B. 1974 Illinois
Kim, K. C. 1983 Pennsylvania
Kingsolver, J. 1963 (1992) Florida
Kirchner, R. F. 1981 West Virginia
Kitayama, C. 1974 California
Kittle, P. 1975 Alabama
Kliewer, J. W. 1983 Virginia
Knipling, E. E. 1946 (1985) Maryland
Knisley, C. B. 1981 Virginia
Knutson, L. V. 1963* FRANCE
Kondratieff, B. C. 1992 Colorado
Kosztarab, M. 1978 Virginia
KROMBEIN, K. V. 1941* (1992) District of Columbia
Labandeira, C. C. 1993 District of Columbia
Lago, P. K. 1984* Mississippi
Lambdin, P. L. 1974 Tennessee
LaSalle, J. 1993 ENGLAND
Latorre, L. T. 1984 West Virginia
Lavigne, R. 1972 Wyoming
Lee, C. E. 1989 SOUTH KOREA
Levesque, C. 1985 CANADA
Lewis, P. A. 1974 Ohio
Lewis, R. E. 1958 Iowa
Lien, J. C. 1967 TAIWAN REPUBLIC OF CHINA
Linley, J. R. 1990 Florida
Lisowski, E. A. 1988 Illinois
Loechelt, H. K. 1988 Washington
Loeffler, C. C. 1992 Pennsylvania
Lozada, P. 1991 PERU
Lubbert, R. T. 1988 Maryland
Lyon, R. J. 1961 California
MacDonald, J. F. 1984 Indiana
MacKay, W. P. 1982 Texas
Magner, J. M. 1953 Missouri
Maier, C. T. 1976 Connecticut
Main, A. J., Jr. 1965 Connecticut

Maldonado-Capriles J. 1947 Puerto Rico
Mallampalli, V. 1993 Maryland
Mangan, R. L. 1977 Texas
Manglitz, G. R. 1956 (1989) Nebraska
Manley, D. G. 1984 South Carolina
Manuel, K. L. 1983 North Carolina
Marinoni, L. 1992 BRAZIL
Marsh, P. M. 1960 District of Columbia
Marshall, S. 1982 CANADA
Mason, H. C. 1949 (1973) Maryland
Mason, W. R. M. 1970 CANADA
Mathis, W. N. 1976* District of Columbia
Mawdsley, J. 1986 Virginia
May, E. 1990 Kansas
McCabe, T. L. 1977 New York
McCafferty, W. P. 1968 Indiana
McComb, C. W. 1956 Virginia
McDaniel, B. 1964 Arizona
McDonald, F. J. D. 1983 AUSTRALIA
McGovran, E. R. 1937 (1973) Maryland
McGuire, J. U., Jr. 1954 (1987) Puerto Rico
McKainey, S. H. 1989 Connecticut
McKeever, S. 1990 Georgia
McPherson, J. E. 1985 Illinois
Mead, F. W. 1976 Florida
Menke, A. S. 1969 District of Columbia
Meikle, T. 1991 California
Miller, D. D. 1987 Maryland
Miller, G. L. 1981 Maryland
Miller, R. S. 1981 Montana
Miller, S. E. 1980* Hawaii
Miller, T. D. 1988 Idaho
Ming, Y. 1992 Michigan
Mitchell, R. T. 1949 (1978) Maryland
Mockford, E. L. 1955 Illinois
Molineaux, M. J. 1986 Maryland
Moore, T. E. 1950 Michigan
Moron, M. A. 1985 MEXICO
Morse, J. C. 1976 South Carolina
Moulton, S. R., II 1988 Texas
Muegge, M. A. 1989 Louisiana
Munroe, E. 1986 CANADA
Munson, S. C. 1938 (1975) District of Columbia
Myles, T. G. 1990 CANADA
Nakahara, S. 1968 Maryland
Neal, J. W., Jr. 1982* Maryland
Neff, S. E. 1969 Pennsylvania
Nelson, C. H. 1969 Tennessee
Nelson, G. H. 1949 California
Neunzig, H. H. 1956 North Carolina
Nielsen, G. R. 1983 Vermont
Nordlander, G. 1992 SWEDEN
Norrbom, A. L. 1989 District of Columbia
Nuhn, T. P. 1981 Virginia
Oatman, E. R. 1980 California
O'Brien, M. F. 1979 Michigan
Oliver, D. R. 1993 CANADA
Olsen, A. R. 1989 California
Oman, P. W. 1930 (1993) Oregon
Orr, R. L. 1990 Maryland
Osbrink, W. L. A. 1984 Wisconsin
Oswald, J. D. 1987 Virginia
Ott, J. R. 1991 Maryland
Pagac, B. P., Jr. 1984 Maryland
Painter, H. F. 1990 Virginia
Pakaluk, J. 1992* Maryland
Palmer, W. A. 1985 Texas
Parker, C. R. 1977 Tennessee
Parrish, D. W. 1963 (1987) Maryland
Parsons, M. A. 1963 Ohio
Patterson, J. L. 1991 Maryland
Pemberton, R. W. 1989 California
Perry, S. 1991 West Virginia
Peters, T. M. 1990 Massachusetts
Petersen, J. L. 1981 Florida
Peterson, R. V. 1952 District of Columbia
Pinto, J. D. 1982 California
Plakidas, J. D. 1986 Pennsylvania
Platt, A. P. 1985 Maryland
Polhemus, D. A. 1993 Hawaii
Polhemus, J. T. 1964 Colorado
Pollock, D. M. 1990 Mississippi
Porter, C. H. 1984 Georgia
Pratt, G. F. 1992 Delaware
Pratt, G. K. 1974 New Mexico
Pratt, H. D. 1943 Georgia
Price, R. D. 1963 Arkansas
Pulawski, W. J. 1975 California
Purrington, F. F. 1987 Ohio
Quintero Arias, D. 1990 Florida
Rack, G. 1975 GERMANY
Rainwater, C. F. 1954 (1975) Maryland
Rainwater, H. I. 1964 (1983) Maryland
Ramos, J. A. 1947 Puerto Rico

Ramsay, M. J. 1968 Maryland
Raupp, M. J. 1982 Maryland
Rawlins, J. 1974 Pennsylvania
Reed, W. D. 1931 District of Columbia
Reichart, C. V. 1946 Rhode Island
Ribeiro-Costa, C. S. 1992 BRAZIL
Richardson, H. H. 1939 (1976) New Jersey
Riddick, E. W. 1988 California
Rider, D. A. 1991 North Dakota
Riegel, G. T. 1952 Illinois
Riley, D. R. 1984 Texas
Robbins, R. G. 1979* Maryland
Robbins, R. K. 1986 District of Columbia
Robbins, T. O. 1989 Texas
Robinson, H. 1963 District of Columbia
Rolston, L. 1973 Louisiana
Root, R. B. 1984 New York
Rosenthal, S. S. 1988 Montana
Ross, M. H. 1981 Virginia
Roth, L. M. 1944 Massachusetts
Rothschild, M. J. 1989 Maryland
Roughley, R. E. 1992 CANADA
Rozen, J. G., Jr. 1956 New York
Ruiter, D. 1976 Colorado
Ruiz, V. E. C. 1992 MEXICO
RUSSELL, L. M. 1930 (1988) Maryland
SABROSKY, C. W. 1946 (1988) New Jersey
Sands, D. P. A. 1984 AUSTRALIA
Santana, F. J. 1966 Florida
Saugstad, E. S. 1979 Maryland
Scarbrough, A. G. 1971 Maryland
Schaefer, C. W. 1985 Connecticut
Scharf, W. C. 1981 Nebraska
Schauff, M. E. 1980 District of Columbia
Schiff, N. 1992 Maryland
Schmidt, C. H. 1969 North Dakota
Schmude, K. L. 1990 Wisconsin
Scudder, G. G. E. 1984 CANADA
Sedlacek, J. D. 1988 Kentucky
Sedman, Y. S. 1951 Illinois
Selander, R. B. 1954 Florida
Shaffer, J. C. 1974 Virginia
Shands, W. A. 1940 (1991) South Carolina
Shaw, S. R. 1991 Wyoming
Shepard, W. D. 1992 California
Sheppard, W. S. Maryland
Shewell, G. E. 1949 CANADA
Shinohara, A. 1981 JAPAN
Sholes, O. D. V. 1979 Massachusetts
Shorthouse, J. D. 1986 CANADA
Sites, R. W. 1989 Missouri
Skelley, P. E. 1992 Florida
Slater, J. A. 1949 Connecticut
Slater, J. A., II 1992 Kansas
Sleeper, E. L. 1976 California
Smiley, R. L. 1964 Maryland
Smith, C. F. 1967 (1986) North Carolina
Smith, D. R. 1965* District of Columbia
Snelling, R. 1972 California
Solis, M. A. 1985 District of Columbia
Sollers-Riedel, H. 1938* District of Columbia
Spangler, P. J. 1958* District of Columbia
Spence, J. R. 1986 CANADA
Spilman, R. E. 1950 (1977) Maryland
Spilman, T. J. 1950 District of Columbia
Spinelli, G. R. 1983 ARGENTINA
Starr, C. K. 1987 Georgia
Steck, G. J. 1988 Florida
Stegmaier, C. E., Jr. 1965 Florida
Steiner, W. E., Jr. 1979 District of Columbia
Steinly, B. A. 1983 Illinois
Stewart, K. W. 1989 Texas
Stewart, R. D. 1985 Maryland
Steyskal, G. C. 1947 Florida
Stibick, J. N. L. 1992* Maryland
Stoetzel, M. B. 1971 Maryland
STONE, A. 1931* (1988) Maryland
Stonedahl, G. M. 1982 ENGLAND
Stribling, J. B. 1983 Maryland
Strickman, D. 1987 District of Columbia
Surdick, R. F. 1979 Virginia
Sutherland, C. M. 1974 New Mexico
Sutherland, D. W. S. 1973* Maryland
Swearingen, J. M. 1990 Maryland
Taft, S. J. 1979 Wisconsin
Tennessen, K. J. 1982 Alabama
Thomas, D. B., Jr. 1983 Texas
Thompson, F. C. 1968* District of Columbia
Thompson, J. V. 1953 (1985) New Jersey
Tidwell, M. A. 1991 South Carolina
Togashi, I. 1983* JAPAN
Townes, G. F. 1956 South Carolina

Traub, R. 1947 (1990) Maryland
Triplehorn, C. A. 1972 Ohio
Turner, W. J. 1982 Washington
Ulrich, H. 1978* GERMANY
Utmar, J. 1974* Maryland
Valley, K. 1976 Pennsylvania
Vandenberg, N. J. 1991 District of Columbia
Vazquez, A. 1957 Virginia
Villegas, B. 1977 California
Voegtlin, D. 1981 Illinois
Wagner, M. R. 1986 Arizona
Wahl, D. B. 1987 Florida
Wallenmaier, T. E. 1979 Maryland
Waller, D. A. 1984 Virginia
Walton, M. 1937 Maryland
Waltz, R. D. 1988 Indiana
Ward, R. A. 1975 District of Columbia
Webb, D. W. 1981 Illinois
Webb, R. E. 1967 Maryland
Weber, N. A. 1941 (1981) Florida
Weller, S. J. 1991 Louisiana
Wendleton, D. S. 1965 Connecticut
Wenzel, R. L. 1984 Illinois
Wharton, B. 1981 Texas
Wheeler, A. G., Jr. 1974 Pennsylvania
Wheeler, T. A. 1990 CANADA
Whitcomb, R. F. 1966 Maryland
White, G. B. 1977 Maryland
White, R. E. 1966 District of Columbia
Whitsel, R. H. 1967 California
Williams, G. L. 1984 Maryland
Williams, H. B. 1977* District of Columbia
Williams, M. L. 1971 Alabama
Wilson, N. 1957 Iowa
Wirth, W. W. 1945 Florida
Wojtowicz, J. A. 1981 Tennessee
Woke, P. A. 1936 (1976) Maryland
Wood, D. M. 1987 CANADA
Wood, T. K. 1974 Delaware
Woodley, N. E. 1984* District of Columbia
Wooley, J. B. 1986 Texas
Young, A. M. 1983 Wisconsin
Young, D. K. 1981 Wisconsin
Zack, R. 1983 Washington
Zenner-Polania, I. 1977 COLOMBIA
Zimmerman, E. C. 1965 AUSTRALIA
Zolnerowich, G. 1987 Texas
Zuccaro, A. E., Jr. 1986 Mississippi
Zungoli, P. 1978 South Carolina
Zuparko, R. L. 1992 California

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld. 124 pp. 1959	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld. 35 pp. 1960	3.00
Both papers on cynipid galls	6.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver. 25 pp. 1951	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney. 15 pp. 1976	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal. 35 pp. 1977	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal. 61 pp. 1979	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff. 85 pp. 1990	10.00

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
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00

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.

CONTENTS

(*Continued from front cover*)

MARINONI, LUCIANE and CLAUDIO J. B. DE CARVALHO—A cladistic analysis of *Protodictya* Malloch (Diptera, Sciomyzidae) 412

PURRINGTON, FOSTER FORBES and DAVID J. HORN—Canada moonseed vine (Menispermaceae): Host of four roundheaded wood borers in central Ohio (Coleoptera: Cerambycidae) 313

ROBINSON, W. H. and B. V. BROWN—Life history and immature stages of two species of *Megaselia* (Diptera: Phoridae) predatory on gall-inhabiting insects 404

RUSSELL, LOUISE M.—Description of *Disiphon*, new genus, and its type species, *Asterochiton dubienus* Bondar (Homoptera, Aleyrodidae) 463

SCHAEFER, CARL W.—Notes on the morphology and family relationships of Lestoniidae (Hemiptera: Heteroptera) 453

SCHAUFF, MICHAEL E. and JOHN LASALLE—Nomenclatural notes on genera of North American Eulophidae (Hymenoptera: Chalcidoidea) 488

SPINELLI, GUSTAVO R. and WILLIAM L. GROGAN, JR.—*Borkenthelea*, a new predaceous midge genus from subantarctic Argentina and Chile (Diptera: Ceratopogonidae) 321

NOTES

KASHEFI, JAVID—A new method for determining the sex of living weevils 511

BOOK REVIEWS

HORMIGA, GUSTAVO—*The Insects and Arachnids of Canada. Part 19. The Ground Spiders of Canada and Alaska (Araneae: Gnaphosidae)* 517

SLATER, JAMES A.—*A Synthesis of the Holarctic Miridae (Heteroptera): Distribution, Biology and Origin, with Emphasis on North America* 513

MEMBERSHIP LIST 520

VOL. 95 OCTOBER 1993 NO. 4
(ISSN 0013-8797)

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY of WASHINGTON

PUBLISHED
QUARTERLY

CONTENTS

AHLSTROM, KENNETH R. and RICHARD C. McDONALD—A new species of *Pediobius* Walker (Hymenoptera: Eulophidae), associated with tettigoniid eggs 527

COOPER, KENNETH W.—Description of *Osmia cahuilla*, n. sp., recognition of the male of *O. gabrielis* Sandhouse and the likely female of *O. bridwelli* Sandhouse (Apoidea, Megachilidae) 532

GAGNÉ, RAYMOND J. and DONALD R. STRONG—A new species of *Dasineura* (Diptera: Cecidomyiidae) galling leaves of *Lupinus* spp. (Fabaceae) in California 541

GARCIA, MARCOS V. B. and JOACHIM ADIS—On the biology of *Penepodium goryanum* (Lepeletier) in wooden trap-nests (Hymenoptera, Sphecidae) 547

KONDRATIEFF, BORIS C. and SCOTT J. FITZGERALD—A new species of *Sphecomyiella* (Diptera: Pyrgotidae) from North America 554

MALDONADO CAPRILES, J.—A new species of *Ghilianella* and the female of *Ghinallelia claviventris* (Bergroth) (Heteroptera: Reduviidae: Emesinae) 558

MALDONADO CAPRILES, J.—Redescription of *Nesocastolus nigrocoris* (Fracker and Bruner) and notes on the genus (Heteroptera: Reduviidae: Harpactorinae) 562

MUÑOZ Q., FERNANDO and RALPH W. HOLZENTHAL—New species and records of Costa Rican *Austrotinodes* (Trichoptera: Ecnomidae) 564

PRATT, GORDON and THOMAS K. WOOD—Genitalic analysis of males and females in the *Enchenopa binotata* (Say) complex (Membracidae: Homoptera) 574

RUSSELL, LOUISE M.—A new species of *Trialeurodes* (Homoptera: Aleyrodidae) from *Phlox* 583

SCHAUFF, M. E. and A. SALVO—Taxonomic and biological notes on the genus *Phytomyzophaga* (Hymenoptera: Eulophidae) 587

SLATER, JAMES A., MERRILL H. SWEET, and HARRY BRAILOVSKY—Two new species of *Slaterobius* Harrington with comments on the ecology and distribution of the genus (Hemiptera: Lygaeidae) 590

(*Continued on back cover*)

THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

ORGANIZED MARCH 12, 1884

OFFICERS FOR 1993

RUSSELL D. STEWART, *President*
PAUL J. SPANGLER, *President-Elect*
M. ALMA SOLIS, *Recording Secretary*
HOLLIS B. WILLIAMS, *Corresponding Secretary*
NATALIA J. VANDENBERG, *Custodian*
NORMAN E. WOODLEY, *Treasurer*
CHRISTOPHER H. DIETRICH, *Program Chairman*
RALPH P. ECKERLIN, *Membership Chairman*
WAYNE N. MATHIS, *Past President*

THOMAS J. HENRY, *Editor*
GARY L. MILLER, *Book Review Editor*

Publications Committee
DONALD R. DAVIS
TERRY L. ERWIN
F. CHRISTIAN THOMPSON
A. G. WHEELER, JR., *Special Publications Editor*

Honorary President
CURTIS W. SABROSKY

Honorary Members
LOUISE M. RUSSELL
ALAN STONE
KARL V. KROMBEIN

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, % 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 $25.00 (U.S. currency).

PROCEEDINGS.—The *Proceedings of the Entomological Society of Washington* (ISSN 0013-8797) are published quarterly beginning in January by The Entomological Society of Washington. POSTMASTER: Send address changes to the Entomological Society of Washington, % Department of Entomology, NHB-168, Smithsonian Institution, Washington, D.C. 20560. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember U.S. subscriptions are $60.00 per year and foreign subscriptions are $70.00 per year, payable (U.S. currency) 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. 218 OF THE JANUARY, 1991 ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Editor: Thomas J. Henry, Systematic Entomology Laboratory, ARS, USDA, % Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Books for Review: Gary L. Miller, Systematic Entomology Laboratory, ARS, USDA, Building 046, BARC-West, Beltsville, MD 20705.

Special Publications: A. G. Wheeler, Jr., Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, PA 17110-9408

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 7 October 1993
Second Class Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 527–531

A NEW SPECIES OF *PEDIOBIUS* WALKER (HYMENOPTERA: EULOPHIDAE), ASSOCIATED WITH TETTIGONIID EGGS

Kenneth R. Ahlstrom and Richard C. McDonald

North Carolina Department of Agriculture, Plant Industry Division, P.O. Box 27647, Raleigh, North Carolina 27611.

Abstract.—*Pediobius smithi* Ahlstrom, n. sp., is described from *Scudderia* eggs (Orthoptera: Tettigoniidae) on grapefruit leaves from Merritt Island, Florida. This is believed to be the first record of *Pediobius* parasitizing tettigoniids.

Key Words: Insecta, *Pediobius,* Eulophidae, tettigoniid eggs, *Scudderia*

The genus *Pediobius* was first proposed by Walker (1846). Graham (1959, 1963) reviewed and furnished a key to British material; Thomson (1878) treated species from Scandinavia. Bouček (1965) made an extensive revision of the Palearctic species and included a key to 32 species. This information was supplemented by Bouček and Askew (1968) and Bouček (1974). Early study of Japanese species was performed by Crawford (1910); Kamijo (1977, 1979, 1986) has studied and keyed species from Japan and Korea. Species from the Australasian Region have recently been evaluated by Bouček (1988). Kahn and Shafee (1982) recorded the species from India and furnished a key to the Indian species. Species from tropical and subtropical areas have been reviewed by Kerrich (1973). North American species of *Pediobius* have been reviewed by Burks (1966), and a comprehensive study of Nearctic species has recently been completed by Peck (1985). Both Burks (1966) and Peck (1985) included keys to species. This article describes a new species and compares it with related species. The senior author (K.R.A.) is solely responsible for the description.

On 19 February, 1991, a "White March" grapefruit tree sapling was collected at Merritt Island, Brevard County, Florida, and delivered to James W. Smith, Senior Entomologist at Rhône-Poulenc Ag Company in Research Triangle Park, North Carolina. Shortly after arrival, some tettigoniid nymphs were observed on the foliage of the tree. Closer examination revealed a series of eggs on the margin of two leaves, which were removed and placed in a fine mesh cage. Quite soon after placement in the cage, J.W.S. noticed several small, gregarious, hymenopterous parasites emerging from some of the unhatched eggs. Approximately fifteen minutes after the onset of parasite emergence, a total of 31 specimens had emerged from eight eggs. The parasites, along with the tettigoniid nymphs and the leaves were collected, and placed in 80% ethanol and given to K.R.A., who identified the first instar nymphs as belonging to the genus *Scudderia* Stål 1873 (Orthoptera: Tettigoniidae). Because the parasites did not appear like others recovered from *Scudderia* or from other tettigoniid eggs, a few were sent to Michael E. Schauff at the Systematic Entomology Laboratory in Washington, D.C., who determined them to be specimens of an undescribed species of the entedontine genus *Pediobius* Walker.

Pediobius smithi Ahlstrom, New Species

Diagnosis.—This species is recognizable by the unique sculpturing on the scutellum, the reticulate vertex, the submedian carinae of propodeum parallel to slightly divergent posteriorly, and the coloration of the tarsi.

Female: Length 1.8 mm. Head and thorax (including scutellum) shining metallic green with brassy overtones; propodeum and basal 0.67 of gastral tergum I metallic green and blue-green; petiole faintly metallic green; remainder of gaster shiny black; antennae and legs (except tarsi) black with green metallic sheen visible on coxae, femora, and tibiae; basal 3 segments of the tarsi white, apical segment dark brown; wings hyaline, veins brown.

Frons sculptured above and below transverse groove, sculpturing above groove and on vertex equally strong; ocellocular line 0.5 × the length of lateral ocellus; distance between lateral ocellus and occipital ridge equal to length of lateral ocellus (Fig. 1); dorsal width of compound eye 0.75 × interocular width at anterior ocellus. Relative lengths (*sensu* Burks 1966) of antennomeres—scape, 20; pedicel, 8; funicular segment I, 11; II, 9; III, 7; club, 13.

Pronotum with 6 dorsal bristles; mesoscutum, including foveae, with strong, reticulate sculpturing (Fig. 2). Scutellum flattened, with reticulate sculpturing which gradually diverges apically, median area of apex glabrous (Fig. 3). Postnotum depressed with a pair of deep, transverse pits on propodeum just behind postnotum. Propodeum glabrous except extreme apex somewhat rugulose; median carinae of propodeum slightly divergent from base to apex, lateral carinae straight, divergent (Fig. 4). Forewing with marginal vein 8 × as long as stigmal vein, postmarginal vein and stigmal vein equal in length (Fig. 5).

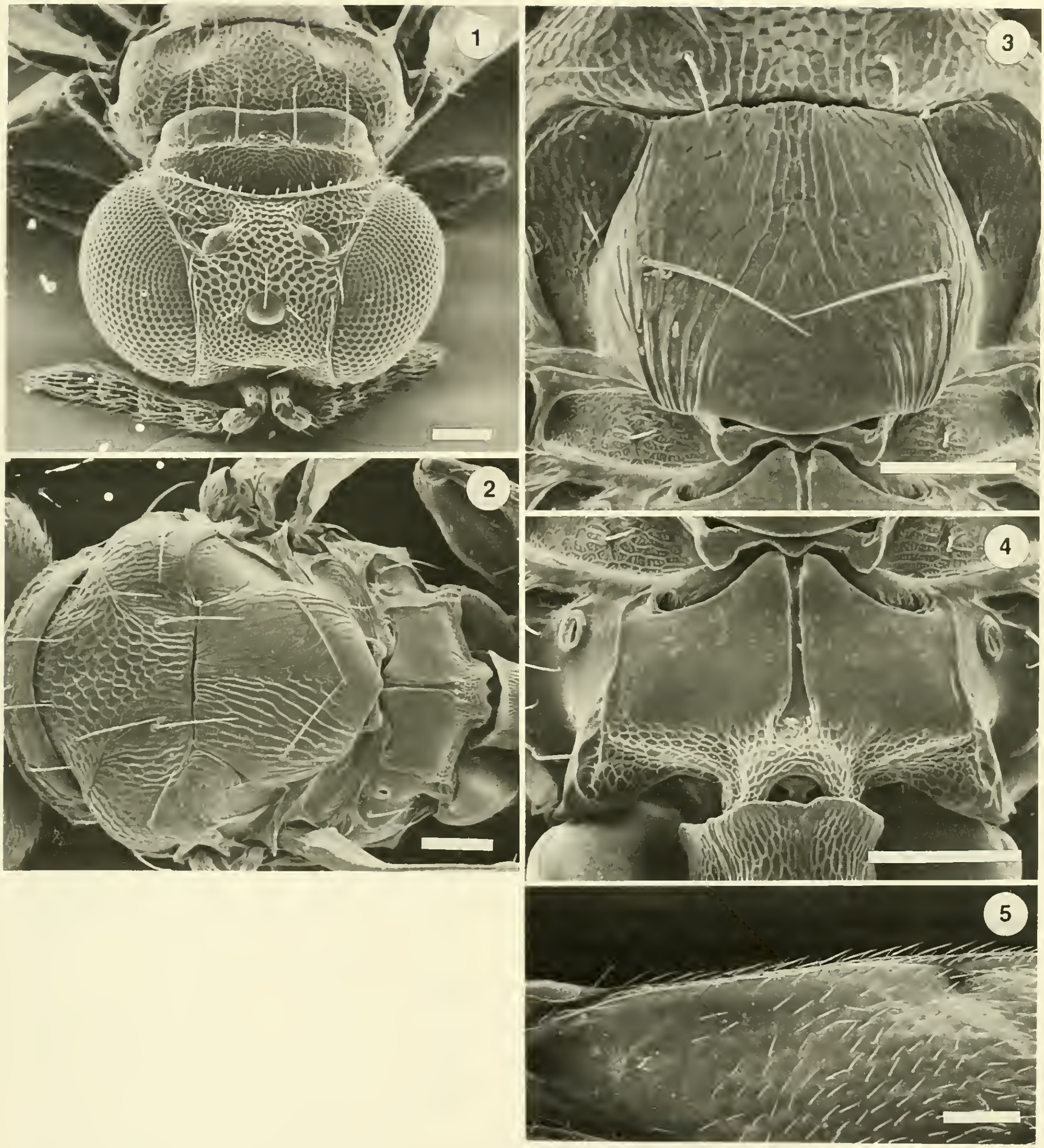
Petiole slightly longer than broad. Gaster 1.125 × longer than thorax and propodeum; tergum I is >0.5 × the length of the gaster, anterior 0.67 glabrous, posterior 0.33 and remaining 6 terga slightly scabriculous.

Male: Length 1.4 mm. Frons bright metallic green, vertex brassy; entire thorax including propodeum, antennae and legs (except tarsi) brassy green; tarsi as in female; basal 0.5 of gastral tergum I bright metallic green, apical 0.5 black, remaining terga brassy.

Antenna with 3 funicular segments; relative lengths of antennomeres—scape, 15; pedicel, 8; funicular segment I, 10; II, 9; III, 10; club, 12. Structure and sculpturing as in female; gaster shorter than thorax and propodeum (posterior terga slightly telescoped beneath tergum I).

The descriptions above are based on one female which has been designated as the holotype, and one representative male. All of the female specimens varied slightly in overall length, ranging from 1.7 to 1.9 mm. Coloration and sculpturing of the specimens was fairly uniform, differing only in slight variations in intensity of the base color and clarity of the reticulate sculpturing on the scutellum. Tarsal coloration was as described except that the basal segment of the hind tarsi on two females was more of a dirty white rather than the bright white seen in all other specimens. Males ranged in length from 1.4 to 1.5 mm and tarsal coloration was uniform among all specimens. Otherwise, slight differences were similar to those found in the females.

Material examined.—Holotype ♀, and 25 ♀ and 5 ♂ paratypes, Merritt Island, Florida, Brevard Co., Florida, 1 March 1991, reared from eggs of *Scudderia* sp. by J. W. Smith. Holotype ♀ to be deposited in the National Museum of Natural History (NMNH), Washington, D.C. Paratypes: 10 ♀♀ and 2 ♂♂ to be deposited in the (NMNH); 10 ♀♀ and 2 ♂♂ to be deposited in the North Carolina Department of Agriculture C. S. Brimley Memorial Insect Collection, Raleigh; and 5 ♀♀ and 1 ♂ to be deposited in the North



Figs. 1–5. *Pediobius smithi* Ahlstrom, n. sp. 1, Head (dorsal view). 2, Mesothorax (dorsal view). 3, Scutellum. 4, Propodeum. 5, Forewing. Scale line = 0.1 mm.

Carolina State University Insect Collection, Raleigh.

Discussion.—This species runs to *pseudotsugatae* in couplet 17 of Peck's (1985) key based on similarity of sculpturing on the scutellum, but differs from *pseudotsugatae* because of the coloration of the tarsi which appear like those of *williamsoni* (Girault 1911). In Burks' (1966) key, this species runs to *lonchaeae* Burks 1966 in couplet 6 where it differs by having a sculptured vertex and slightly diverging submedian carinae on the propodeum. Using Peck's (1985) key, *smithi* would key out as follows:

16(15). Vertex laterally smooth. Propodeum with submedian carinae strongly divergent posteriorly ...... *lonchaeae* Burks (p. 669)
Vertex entirely, densely reticulate. Pro-

podeum with submedian carinae parallel or slightly divergent 17
17(16). Scutellum anterolaterally with parallel striae forming 2 convergent stripes; medially and posteriorly smooth (Fig. 20) 17a
Scutellum with basal two-thirds longitudinally striate; apex smooth (Fig. 18). Tarsi pale, apical segment dark . . . . *williamsoni* (Girault) (p. 670)
17a(17). Tarsi brown . . *pseudotsugatae* Peck (p. 669)
Tarsi pale, apical segment dark . . . . *smithi*, n. sp.

Biological relationships.—The genus *Pediobius* contains species which are primary or secondary parasites of Arachnida, Coleoptera, Diptera, Hymenoptera, Lepidoptera, and very rarely Orthoptera. Most species are solitary; a few, however, exhibit a gregarious behavior. Host-parasite relationships outside of the Nearctic Region have been cataloged by several authors (Bouček 1965, 1988, Bouček and Askew 1968, Kahn and Shafee 1982, Kamijo 1977, Kerrich 1973). Of all the hosts identified by the authors above, only Kerrich (1973) records two species of *Pediobius* parasitizing egg masses of mantids. Host-parasite relationships for the Nearctic Region have been cataloged by Burks (1966, 1979) and Peck (1963, 1985). This is the first reported occurrence of a species of *Pediobius* being reared from tettigoniid eggs.

Etymology.—The species is named in honor of Dr. James W. Smith, who collected the species.

ACKNOWLEDGMENTS

We would like to thank M. E. Schauff, Systematic Entomology Laboratory, Washington, D.C., who determined this to be an undescribed species of *Pediobius*. Thanks also are extended to C. S. Richter and V. Knowlton of the Center for Electron Microscopy at North Carolina State University for assistance in preparing the SEM photographs. We would also like to thank L. L. Deitz and H. H. Neunzig, both of the Entomology Department at North Carolina State University, Raleigh, for reviewing the manuscript.

LITERATURE CITED

Bouček, Z. 1965. Studies of European Eulophidae, IV: *Pediobius* Walk., and two allied genera (Hymenoptera). Acta Entomologica Musei Nationalis Pragae 36: 5–90.

———. 1974. On the Chalcidoidea (Hymenoptera) described by C. Rondani. Redia 55: 241–285.

———. 1988. Australasian Chalcidoidea (Hymenoptera). A Biosystematic Revision of Genera of Fourteen Families, with a Reclassification of Species. CAB International, Wallingford, UK. 832 pp.

Bouček, Z. and R. R. Askew. 1968. Index of Palearctic Eulophidae (excl. Tetrastichinae). *In* Delucchi, V. and G. Remaudière, eds., Index of Entomophagous Insects 3. Le François, Paris. 254 pp.

Burks, B. D. 1966. The North American species of *Pediobius* Walker. Proceedings of the Entomological Society of Washington 68: 33–43.

———. 1979. Family Eulophidae, pp. 967–1022. *In* Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, Catalog of Hymenoptera in America North of Mexico. Vol. I. Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington, D.C. 1198 pp.

Crawford, J. C. 1910. Technical results from the gipsy moth parasite laboratory. II. Descriptions of certain chalcidoid parasites. Technical Series, United States Department of Agriculture, Bureau of Entomology, 19, part II. 24 pp.

Girault, A. A. 1911. Notes on the Hymenoptera Chalcidoidea, with descriptions of several new genera and species. Journal of the New York Entomological Society 19: 179–181.

Graham, M. W. R. de V. 1959. Keys to the British genera and species of Elachertinae, Eulophinae, Entedontinae and Euderinae (Hym., Chalcidoidea). Transactions of the Society for British Entomology 13: 169–204.

———. 1963. Additions and corrections to the British list of Eulophidae (Hym., Chalcidoidea), with descriptions of some new species. Transactions of the Society for British Entomology 15: 167–275.

Kahn, M. and S. Shafee. 1982. Species of the genus *Pediobius* Walker (Eulophidae: Entedontinae) from India. Journal of the Bombay Natural History Society 79: 370–374.

Kamijo, K. 1977. Notes on Ashmead's and Crawford's types of *Pediobius* Walker (Hymenoptera, Eulophidae) from Japan, with descriptions of a new species. Kontyu 45: 12–22.

———. 1979. Eulophidae (Hymenoptera) from Korea, with descriptions of two new species. Annales

Historico-Naturales Musei Nationalis Hungarici 71: 252–264.

———. 1986. A key to the Japanese species of *Pediobius* (Hymenoptera, Eulophidae). Kontyu 54: 395–404.

Kerrich, G. J. 1973. A revision of the tropical and subtropical species of the eulophid genus *Pediobius* Walker (Hymenoptera: Chalcidoidea). Bulletin of the British Museum of Natural History (Entomology) 29: 115–200.

Peck, O. 1963. A catalogue of the Nearctic Chalcidoidea (Insecta: Hymenoptera). Canadian Entomologist, Supplement 30: 1–1092.

———. 1985. The taxonomy of the Nearctic species of *Pediobius* (Hymenoptera: Eulophidae), especially Canadian and Alaskan forms. Canadian Entomologist 117: 647–704.

Stål, C. 1873. Orthoptera nova. Öfversigt af K. Vetenskaps Akademiens Förhandlinger 30: 39–53.

Thomson, C. G. 1878. Hymenoptera Scandinaviae. V. Ohlssen, Lund, Sweden. 307 pp.

Walker, F. 1846. The characters of some undescribed species of Chalcidites. Annals and Magazine of Natural History 17: 177–185.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 532–540

DESCRIPTION OF *OSMIA CAHUILLA*, N. SP., RECOGNITION OF THE MALE OF *O. GABRIELIS* SANDHOUSE AND THE LIKELY FEMALE OF *O. BRIDWELLI* SANDHOUSE (APOIDEA, MEGACHILIDAE)

Kenneth W. Cooper

Professor of Biology, University of California, Riverside, California 92521-0472.

Abstract.—*Osmia* (*Monilosmia*) *cahuilla*, n. sp. is described from the offspring of a typical female of *O.* (*M.*) *bridwelli*. Her sons are distinct from the holotype and paratype males of *O. bridwelli*. The probable male of *O.* (*M.*) *gabrielis* is briefly diagnosed; reasons are provided for considering *O. bridwelli* to be the male of *O.* (*M.*) *cara* Cockerell. Features separating male *O. cahuilla* from each of the known or tentatively assigned males of other large, montane *Monilosmia* females are listed.

Key Words: *Osmia, Monilosmia,* correlation of sexes, synonymy

On Mt. San Jacinto, Riverside Co., CA, from time to time in the spring of 1990, a very large, very dark female *Osmia* was seen to fly to a rift in the shaded junction between bark and wood of an old insect-ravaged pine stump. The bee would disappear in an instant between the slightly loosened bark and wood, remaining within for considerable periods of time. I did not capture the *Osmia* later in spring, nor did I disturb the nesting site, but marked that portion of the crevice used by the bee as entrance to the stump.

I removed the completed nest in October of that year. It proved not only of unusual structure, unlike any so far described for other species of *Osmia*, but contained male and female offspring of the easily recognized female of the infrequent bee known as *Osmia* (*Monilosmia*) *bridwelli* Sandhouse (1939). However, the sibling males from the nest are entirely distinct from the male holotype and male paratype of *O. bridwelli*, despite their sisters' identity with the allotype and the three other female paratypes of *Osmia bridwelli*. The male occupants of the nest and their sisters therefore represent an unnamed species.

Here described are the two sexes of *Osmia cahuilla*, n. sp. and their taxonomic differentiation from other large, so-called *Monilosmia*. The strong likelihood is discussed that the true *O. bridwelli* (the male) is a junior synonym of *O. cara* Cockerell (1910), known only from females.

Conventions

The numerical data presented are the observed range ($\overline{\text{or}}$) within the sample, the sample mean (= $\bar{\text{m}}$), and Haldane's (1955) unbiased estimate (V*) of the coefficient of variation (V) of the sample; namely, $V^* = V(1 + 1/4n)$.

Twenty female specimens of *O. cahuilla* were available (the 4 female paratypes of Sandhouse's *O. bridwelli*, + 5 from the nest and 11 field-collected). The sample size for female measurements is 20 if no other number (n) is given; when less than 20, a subscript to n indicates the number of Sandhouse's paratypes in that sample. Males available for measurement were 16 (13 from the nest, 3 field-collected).[1] If the sample includes less than 16, n is given. Males or females omitted from samples were those in which the particular character could not be measured.

Because many specimens of both sexes caught in the field had lost the apices of their wings, or the distal region was bent, the measure of wing length (L*) used is that of Shinn (1967), namely: the distance along the costal margin from the apex of the costal sclerite to the discontinuity between prestigma and stigma—almost always a length measurable on at least one side with reasonable accuracy and good precision.

The measure of body length in females is the sum of the lengths of head (anterior to posterior surface at level of antennal insertions), meso- and metasoma; at best it is only a possible size of the living bee. That of males is a derived estimate. Because 15 of the males had the metasoma maximally stretched to permit study of the sternites without dissection, only one unstretched male could be measured. Its body length was 2.53 × L*. Multiplication of each individual measure of L* by 2.53 gave the figures for which the statistics of male "body length" are provided. Necessarily, V* is the same for both L* and "body length." The resulting dimensions of males are minimal, and certainly less reliable than those for females. However, they are not out of line with published sizes of large *O.* (*Monilosmia*) species having females of similar size to that of *O. cahuilla*, n. sp.

Head length was measured medially from the apical margin of the clypeus to the vertex. The external limit of a compound eye was taken as the outermost row of ommatidea; that of an ocellus is the outer rim of its lens. The intertegular width was measured between the anterior ends of the tegulae.

The width of the fimbriate emargination at the apex of sternite-III, after several trial methods, proved best given as the distance between the outermost base of the left- and right-most tuft of distal fimbria at the level of the rim of the emargination. The depth of the emargination was obtained by placing a short, straight length of fine hair (20 μ in diameter) tangent to the apices of sternite-III immediately to each side of the emargination, then measuring the shortest distance from the proximal mid-point of the emargination to the bounding margin of the hair. The "width" of a sternite proved best represented by the easily measured distance between the distal ends of its gradulus.

Michener's and Fraser's (1978) terminology is used for description of the mandibles. Puncta are said to be large when of greater size than those medially on the anterior third of the mesonotum.

Finally, I follow Riek (1970) and Naumann in the two editions of the Insects of Australia (see Naumann 1991, pp. 923–924), in their use of "terminalia" for the sclerotized copulatory organs of Hymenoptera (or their homologs), rather than "genitalia." The male terminalia are in effect the median, unpaired intromittent organ, in *Osmia* consisting of not less than five sclerotized elements. Accordingly, I use the plural form.

Osmia cahuilla **Cooper, New Species**

(Figs. 1–8)

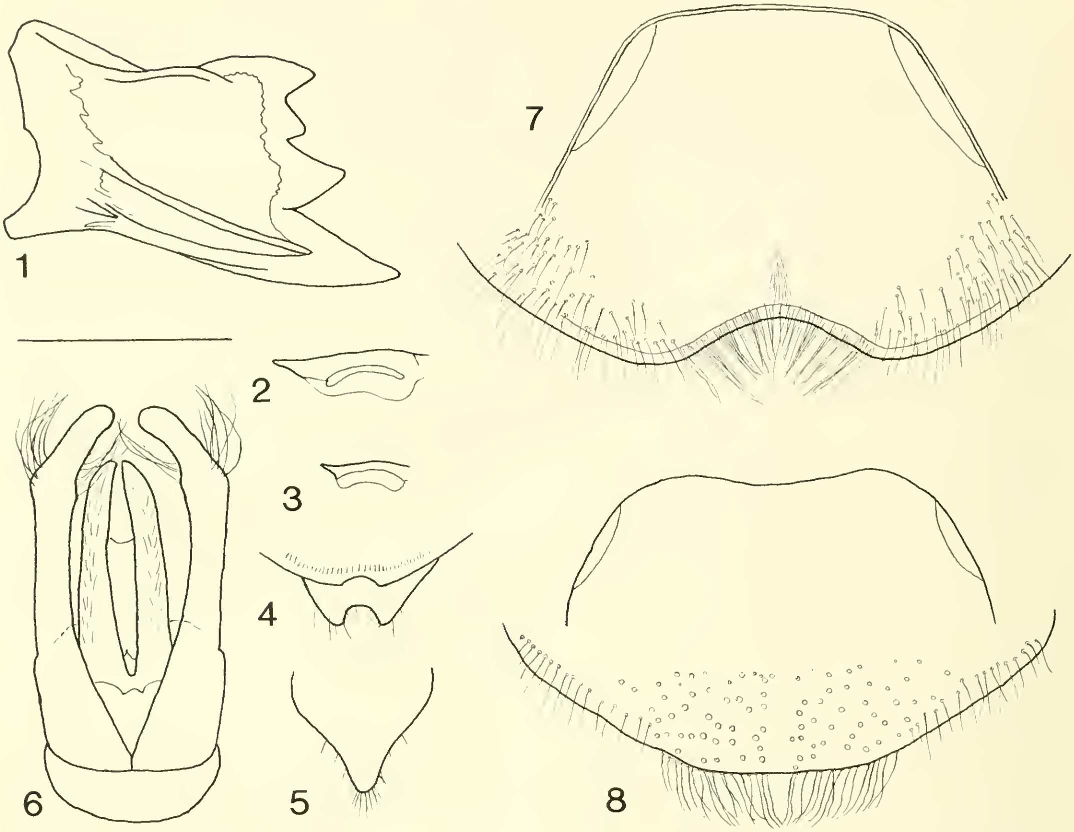
In part, females only, *O. bridwelli* Sandhouse 1939, p. 100.

Male (n = 16).—Length (L) (see conventions), observed range (= $\overline{\text{or}}$) = 7.7–10.6 mm, $\bar{\text{m}}$ = 9.6 mm, V* = 7.4. Forewing L*, $\overline{\text{or}}$ = 3.0–4.2 mm, $\bar{\text{m}}$ = 3.8 mm, V* = 7.4. Intertegular width (W), $\overline{\text{or}}$ = 2.1–2.8 mm, $\bar{\text{m}}$ = 2.5 mm, V* = 6.6.

Integument dorsally and laterally dark

---

[1] Thirteen males were pinned at the time the nest was opened. When preparing a fragment of the nest for display in the spring of 1991, an additional three males were discovered dead within their cocoons. The three cells with their enclosed occupants have each been mounted on a pin. These three males are included among the paratypes, but not in the measured series.



Figs. 1–8. *Osmia cahuilla* n. sp. 1, Female mandible. 2, Female strigilis. 3, Male strigilis. 4, Distal ends of male tergites VI and VII. 5, Male sternite VIII. 6, Male terminalia. 7, Male sternite III. 8, Male sternite IV. Bar = 1 mm. (Note: Setal patterns and sculpture of more proximal regions are not indicated in Figs. 7, 8; drawings semi-diagrammatic, made from camera lucida sketches.)

blue; sternites(st)-I, II blue, III and IV blue on apical thirds. Anterior margin of clypeus black; mandible black, greenish-blue reflection at base; antennal scape, pedicel black, flagellum piceous to black. Tegula with metallic luster; forewing light brown, hind wing less so, veins black to brown; legs black, coxae, femora, tibiae with a bluish sheen.

Pubescence of clypeus and face long, dense, white, some black hairs; on vertex and gena long, largely or entirely black; on posterior gena long, dense, white. Mesonotal and scutellar hairs long, whitish, some black, on flanks dark sooty. Femora-I with dense, very long white hair, few black; on femora-II, III and tibiae-I, II, long hairs sparser, black or blackish, some *bicolorous* (namely, whether light or dark depends on angle of incident light); tibiae-III long hairs black; plantar setae of basitarsi mostly ferruginous. On propodeum and tergite-I long white hairs, few black; remainder of metasomal dorsum with suberect black hairs, those along proximal margins of impunctate bands bicolorous. On sternites mixed, hairs overlain by preceding sternite and fimbria of st-III emargination bicolorous, apical fringe of st-IV black.

Head (W) : (L), $\overline{or}$ = 1.14–1.21, $\bar{m}$ = 1.17, V* = 1.8. Maximum W(gena) : max W(eye), $\overline{or}$ = 0.75–0.92, $\bar{m}$ = 0.87, V* = 4.6. Least distance (D) (eye to lateral ocellus) : D(lat ocel–occiput), $\overline{\mathrm{or}} = 1.25$–$1.61$, $\bar{\mathrm{m}} = 1.42$, $V^* = 7.0$.

Clypeus convex, closely, finely punctate, apical margin polished, arcuate, not thickened, widest medially (*ca.* 6–8 puncta diameters), variably crenulate, a low median papilla (lacking in 1). Labrum closely punctate apically and laterally, bounding medial polished area. Eyes convergent below. Punctation of upper face, vertex, gena, postgena, dense, larger than clypeal puncta.

Hypostomal carina: Height ~ 0.5 W(antennal pedicel), gradually reducing to <0.5 from highest point to distal end, obtusely reduced before angle by ~ 0.5.

Mandible: Distal angle between apex and pollex clearly less to nearly 90°, acetabular carina weak, condylar ridge somewhat to moderately wider than outer ridge (but condylar ridge much wider in 1).

Maxillary palpi 5-segmented, 3rd article subequal to 4 + 5. Labial palpi L(article-1) : L(art-2), $\overline{\mathrm{or}} = 0.69$–$0.83$, $\bar{\mathrm{m}} = 0.73$, $V^* = 5.0$, $n = 15$.

Mesonotum dull, discal puncta small, closer than on vertex; scutellum with larger, well-spaced puncta medially; mesopleural puncta close-set. Metanotal puncta widely spaced, interspaces strongly microsculptured. Propodeal triangle dull, with tortuous rugosities above, minute strigosities below.

Wing papillae separated *ca.* 2+ diameters. Inner margin of malar spine oblique to apical margin of velum, shorter than W(malus) at apex of velum (Fig. 3). Hind coxae subcarinate in 12 individuals. Calcars fairly stout (the posterior more so), narrowing toward tip, slightly bent near apex. Hind basitarsi widest near apical fifth ($\overline{\mathrm{or}} = 0.17$–$0.29$, $\bar{\mathrm{m}} = 0.22$, $V^* = 15.0$), a weak semblance of a low, elongate tooth may be present at widest region (in 4 individuals only; on both sides in 2, on one side only in 2).

Metasoma: At 50× magnification shape of main puncta of tergites (t) depends on angle of incident light—may appear to have an anterior raised rim, a widening furrow behind, or be granular; the large puncta spaced 1 to 2 diameters, closest on t-IV, largest before concavity on t-VI; interspaces shining, with sparsely scattered micropuncta. Impunctate bands (IB)-I 0.5 W(antennal pedicel), IB-II through V subequal to W(pedicel); all IBs metallic, microsculptured. T-VI, VII concave in profile; t-VI shallowly emarginate in 13 males; t-VII (Fig. 4) with a deep emargination (shallow in one), apical angles acute.

Distal margin of st-II arcuate, rim translucent brown. St-III, median emargination very variable, W(between outermost fimbrial tufts) : D(between ends of gradulus), $\overline{\mathrm{or}} = 0.36$–$0.47$, $\bar{\mathrm{m}} = 0.42$, $V^* = 8.0$. Depth of emargination : (W), $\overline{\mathrm{or}} = 0.21$–$0.31$, $\bar{\mathrm{m}} = 0.25$, $V^* = 12.8$. Fimbrial hair axes normal to emarginate rim, converge apically as tufts, extend medially beyond apices of st-III (Fig. 7). St-IV (Fig. 8), posterior third of disc coarsely, sparsely granulate, strongly microsculptured, apically subtruncate (convexly arcuate in 3 males) with apical fringe of erect, subparallel, long setae, tips bent mesad, bases normal to subtruncation, axes parallel to surface of st-IV; fringe interrupted medially by a bare, broad, medial band extending from apical margin to proximal limit of blue integument, band defined by granular bases of suberect setae. Distal margin of st-VI with a subhemicircular apical lobe, lobe with sparse, short, stout, erect piceous setae, some hamate. St-VIII (Fig. 5), apical third very variable, often somewhat inwardly sinuate to each side before tip.

Terminalia (= "genitalia" of authors), (Fig. 6): Similar to some other large *Monilosmia* (see Sandhouse 1939, figs. 234, 235); subapical flexure of gonoforceps angularly bent on lateral margin not markedly expanded subdistally, setae of lateral cluster always more numerous than inner cluster (both vary greatly); lateral dorsal surfaces of parapenial lobes with numerous semi-erect to recumbent, apically directed golden hairs.

Female (n = 20).—Length (= L), $\overline{or}$ = 11.0–14.0 mm, $\bar{m}$ = 12.8 mm, V* = 8.5. Forewing L*, $\overline{or}$ = 4.3–5.0 mm, $\bar{m}$ = 4.8 mm, V* = 5.9. Intertegular W, $\overline{or}$ = 3.11–3.9 mm, $\bar{m}$ = 3.6 mm, V* = 6.5.

Integument: Almost black to dark purplish-blue, or blue. Clypeal margin, mandible, scape, pedicel, flagellum as in male, wings and veins darker. Legs black. Setal tufts below clypeal margin from orange to black. Pubescence black, smoky black to black on sides of mesosoma, on propodeum, and metasomal tergite-I. Setae of wings black to brown, of legs black, rusty-brown to black beneath foretarsi. Scopa black.

Head(W) : (L), $\overline{or}$ = 1.13–1.19, $\bar{m}$ = 1.16, V* = 1.6. W(gena) : W(eye), $\overline{or}$ = 1.32–1.60, $\bar{m}$ = 1.43, V* = 5.2. Least distance (D) (lateral ocellus–eye) : D(lat ocell–occiput) subequal, $\overline{or}$ = 0.89–1.05, $\bar{m}$ = 1.00, V* = 4.5.

Clypeus convex, truncate, or slightly incurved apically, densely punctate, apical margin subequal to D from lateral angle of truncation to end of epistomal suture, $\overline{or}$ = 0.86–1.16, $\bar{m}$ = 1.00, V* = 7.5, impunctate margin 2–4 puncta wide, setae proclinate; fronto-clypeal suture marks boundary above which facial setae are erect or bent posteriorly; puncta below each side of clypeus large, well-separated, contrast with smaller, closer-set puncta of clypeus and paraocular area and frons above. A narrow, shiny, impunctate medial strip extends between lateral ocelli to vertex. Eyes slightly convergent below. Postgenal setae long, tips curl mesad over hypostomal carina. Carina high, abruptly reduced to 25–60% at angle, very variable; tooth ≤90° in 14 of 19_3 females.

Mouthparts: Mandible 4-dentate (Fig. 1), D(apex to inner tooth P_3) subequal to L of base, narrowest at about 0.33 L from condylar insertion, measured along ventral edge in ventral view; P_3 stouter, larger than P_2 below, L(P_1) $\sim$1.5 × P_2, L apical tooth $\sim$2 × P_1; angle between P_3 and P_2 obtuse, others acute. Condylar ridge $\sim$2× as wide as outer ridge, convergent. Maxillary palp with 5 articles, L(article-3) : L(4 + 5), $\overline{or}$ = 0.64–0.85, $\bar{m}$ = 0.75, V* = 9.1, med = 0.77, n = 17_3. Labial palp, L(article-1) : L(art-2), $\overline{or}$ = 0.71–0.81, $\bar{m}$ = 0.75, V* = 3.9, n = 17_2. Dorsal, lateral and outer margin of galea with stout, erect, setae angularly bent to $\sim$90° at apical third (at length subequal to article-3 of maxillary palp); except at base, setae are of very similar lengths for 0.5 L(galea), then increasingly smaller, most apical not bent.

Mesosoma: Punctation resembles that of females of *O. cara* Cockerell, *O. densa* Cresson, and *O. gabrielis* Cockerell; lower 0.5–0.33 of propodeal triangle polished, or dull with microrugae. Tegulae coarsely, irregularly punctate. Wing papillae separated 2 or 2+ diameters. Malar spine long, acute (Fig. 2).

Metasoma: Puncta of tergites-I to IV small near gradulus, enlarging distally and appearing shallowly furrowed in oblique light; interspaces polished, sparsely micropunctate, those of t-V appearing granulate; t-VI densely punctate, slope nearly straight in profile, a narrow sulcus before apical flange. Inner margins of impunctate bands (IB) of t-I to V (of all females) widen medially (t-III least so) forming an angle; to one side of widening, W(IB-I) < W of antennal pedicel (= wp), others <2 wp (n = 20). IB-I polished, IB-II and III shiny, with sculpture or not, IB-IV and V always microsculptured; all IBs behind first microsculptured one are increasingly sculptured.

Etymology: "Cahuilla" is the name of the Indians of southern California known to have hunted acorns, berries and game on the slopes of Mt. San Jacinto. That very appropriate name is given in gratitude for the courtesies granted my endeavors by the Agua Caliente Band of Cahuilla, especially by Tony Andreas.

Types.—Holotype, male; paratypes: female allotype plus 4 sisters and 16 male siblings. All 21 bees from a single nest within the bark of a yellow pine stump (taken on 21 October 1990) at the type locality, 1500 m, near Azalea Creek, Vista Grande road (3S08), Mt. San Jacinto, Riverside, California (Banning Quadrangle, Sec. 9, T4S, R2E). The holotype and allotype siblings are deposited in the U.S. National Museum of Natural History (USNM).

Field collected (my label dates record the month by a single letter, with the months in alphabetic sequence; thus A or a = January, E or e = May, etc.; 82 G 7 accordingly is 7 July '82): 82 G 7, 2 ♀♀, Coon Creek, 2300 m, Mt. San Gorgonio, San Bernardino Co., CA; 84 F 28, 1 ♀, Rattlesnake Trail, N of Eagle's Roost, 1900 m, Los Angeles Crest Hwy, Los Angeles Co., CA; 86 F 10, 1 ♀, Sta Rosa Mtn, 2300 m, Riverside Co., CA; 86 F 21, 1 ♀, Dawson Saddle, 2400 m, Los Angeles Crest Hwy, Los Angeles Co., CA; 90 D 17, 1 ♂, Vista Grande, 1500 m, Mt. San Jacinto, Riverside Co., CA; 90 D 26, 1 ♂, same locality as preceding; 90 E 9, 1 ♀, 1 ♂, vicinity of Azalea Creek, Mt. San Jacinto, Riverside Co., CA; 90 F 19, 1 ♀, Mountain Rd 50, 2000 m, Sequoia National Forest, Tulare Co., CA; 91 F 4, 2 ♀♀, Vista Grande, 1500 m, Mt. San Jacinto, Riverside Co., CA; 91 F 6, 2 ♀♀, same locality as preceding.

I have found *O. cahuilla* in the mountains not far from a seep, spring, or stream, at the shrubby margins of moderately open woodland, less frequently amid chaparral, and at best in small numbers only.

The following are additional records of *O. cahuilla*: V.29.11, 2 ♀♀ (paratypes of *O. bridwelli*), Siskiyou Co., CA—F. W. Nunnemacher collector; July – 1912, 1 ♀ (allotype of *O. bridwelli*), San Jacinto Mts., Riverside Co., CA—J. C. Bridwell; no date, 1 ♀ (paratype of *O. bridwelli*), Nevada—collector ? (Sandhouse 1939).

Moldenke and Neff (1974)[2] list only the California county of origin of the bees they examined when searching for records of floral visitations by *O. cahuilla* (as "*O. bridwelli*"), thus: 18 ♀♀, Mariposa Co., 9 ♀♀, Sacramento Co.; 2 ♀♀, Riverside Co. From my flower records the following are to be added: *Lotus grandiflorus* (Benth.) Greene (2 ♀♀), *Lupinus excubitus* Jones (3 ♀♀), *Phacelia imbricata* Greene (1 ♀), and *Ribes nevadensis* Kell. (1 ♀, 1 ♂), giving a total species-list of 22 flowers, representing 16 genera among 10 families. Whether any of these nectariferous flowers provide *O. cahuilla* with pollen is not known, though likely. Such seeming polytropy awakens the question as to whether the unusual, strongly bent, galeal setae are now functionally significant or merely a relic from earlier times. Certainly they are not necessary for taking nectar, and the strange orientations of the setae on the galea (see below) do not suggest that they are efficient pollen-scoops.

DIFFERENTIATION OF *O. CAHUILLA*, N. SP. FROM OTHER LARGE *MONILOSMIA*

Among other, less well-defined attributes, the male holotype and paratype of *O. bridwelli* Sandhouse differ from *O. cahuilla* by having: antennal articles 3 through 11 brown; the polished surface of the anterior rim of the clypeus somewhat thickened and weakly, outwardly curved in cross-section; labrum very coarsely punctate, impunctate basally only; a scattering of long black hairs anteriorly on genae, remainder white; no vestige of a lengthwise carina on posterior coxae; at most a very faint metallic sheen to tibiae; hind basitarsi with a very strong subapical tooth on ventral margin; rim of tergite-VI translucent; sternite-IV arcuate apically, dull, with small, closely-set granulations (= setal bases) over apical third, apical fimbria pale, tips of setae not bent near tips, fimbria not interrupted medially by a broad, lengthwise asetose band (*cf.* Fig. 8).

Attributes which readily distinguish males of other large species of *Monilosmia* from *O. cahuilla* include: (1) for *O. atrocyanea* Cockerell, the white pubescence of its mesosomal flanks anteriorly, becoming sooty-

---

[2] A very useful work not cited in the Catalog of the Hymenoptera of America North of Mexico, Vol. 2, 1979. The list of flowers in the catalog (Hurd 1979, p. 2047) is identical with that of Moldenke and Neff.

black posteriorly and on sides of the propodeum; the sub-triangular emargination of st-III; and above all, its striking male terminalia (*cf.* Sandhouse 1939, fig. 238 with fig. 4); (2) for *O. densa* Cockerell, its very low, nearly uniform hypostomal carina; pubescence of mesosomal flanks and propodeum white (a few dark hairs in some); hind basitarsal tooth strong; st-IV truncate on apical third, surface dull; (3) for *O. gabrielis* Cockerell, its posterior projection of the mandible at the condylar insertion similar to but less pronounced than that of female *O. gabrielis*; pubescence of mesosomal flanks white anteriorly, sooty-black hairs behind continuing onto the lower propodeum; hind basitarsal tooth strong; emargination of st-III deep, subtriangular; (4) for the more northern *O. juxta* Cresson (with male ? = *O. theta* Sandhouse 1924, 1925, 1939) its femora and tibiae black; pubescence of mesosomal and propodeal flanks white; hind basitarsal tooth large; st-IV very broadly truncate (*ca.* 0.5 its width). (5) Should *O. enena* Cockerell prove to be the actual male of *O. juxta* Cresson[3], then it would strikingly differ from *O. cahuilla* males by its black legs (Cockerell 1907), its well defined triangular patch of coarse setae on st-IV, and by the two widely separated clusters of setae on the medial, subapical aspects of the gonostyli, as well as by the much larger brushes of subapical setae on their lateral aspects (*cf.* fig. 256 in Sandhouse 1939 with fig. 6; in her text Sandhouse states that the ". . . genitalia are very similar to those of *collinsiae.*").

The female of *O. cahuilla* is easily separated from all other "*Monilosmia*" females, large and small, by the distinctive bristles occurring *only* on its galea. Very stiff, erect, smoothly but abruptly bent at their distal thirds, tapering thereafter to their tips, these bristles are well-spaced, but irregularly so, with their tips oriented nearly haphazardly (pointing posteriorly, medially, obliquely and anteriorly in no obvious pattern). One of Sandhouse's (1939) paratypes of *O. bridwelli* from Siskiyou Co. shows this very well, the Nevada specimen does so fairly well (mouthparts not extended); the remaining two paratypes are in poor condition, retaining but few bent bristles.

The much smaller, more slender females of *O. sculleni* Sandhouse and *O. rostrata* Sandhouse, currently placed in "*Monilosmia,*" and *O.* (*Chenosmia*) *illinoiensis* Robertson, also have characteristic bent hairs or bristles on their maxillae, but in addition such bent bristles or hairs occur on articles-1 and 2 of the labial palps, and a few on the maxillary palps as well. Females of *O.* (*Nothosmia*) *mixta* Michener (1936, 1949) resemble *O. cahuilla* by having bent bristles on the galea only; it is, however, a smaller, white-pubescent bee having tridentate mandibles.

A remotely related Palaearctic *Osmia* (*Melanosmia*) *pilicornis* Smith has hooked hairs on the maxillary palps similar to those of *O. cahuilla,* but evidently more regular in arrangement (see Tkalcú 1983, fig. 11). According to Michener's (1941, 1943, 1947) widely accepted concepts of the Osmiinae, the five Palaearctic species of "*Osmia*" having hooked hairs on their mouthparts, discussed by Parker and Tepedino (1982), in fact belong in *Anthocopa* (subg. *Haetosmia,* 3 spp., see Popov 1952a, b) and *Hoplitis* (subg. *Tridentosmia,* 2 spp., see Popov 1952b) and are now so catalogued (van der Zanden 1988).

THE STATUS OF *OSMIA* (*MONILOSMIA*) *BRIDWELLI* SANDHOUSE 1939

The previously undescribed male of *O. gabrielis* Cockerell (1910) is sufficiently

---

[3] *O* (*M.*) *albolateralis* Cresson, with smaller females than *O. cara,* was held by Sandhouse (1939) to have *O. enena* Cockerell as its possible male. However, in his letter of 11 November 1939 to P. H. Timberlake, Cockerell states "Grace Sandhouse, when here, went over my collection, and now holds to the following synonymy, different from that of her book . . . *enena* Ckll = *juxta* Cr. . . ." That is but one of eleven changes in her decisions which Cockerell lists in that letter. Sandhouse (1939) held *O. theta* Sandhouse (1925) to be the male of *O. juxta.*

characterized above to allow recognition. There now remains but one among the largest montane *Monilosmia* for which no male has been described, *O. cara* (Cockerell 1910), locally frequent in montane California (from Siskiyou Co. where the male paratype of *O. bridwelli* was collected, to San Diego Co.).[4]

The type locality for *O. bridwelli* is Strawberry Valley (~1650 m alt.) on Mt. San Jacinto, Riverside Co., California. It is well within the altitudinal range of *O. cara* on Mt. San Jacinto, Santa Rosa Peak, Mt. San Gorgonio, and the San Gabriel mountains (1200–2450 m), each of which provides similar habitats of chaparral and shrubby areas adjoining open woodlands of a sort in which *O. cara* females are to be found. *O. bridwelli* is of appropriate size, coloration, habitus, and similar habitat to be the male of *O. cara.* Just as male *O. gabrielis* have a small but distinct posterior projection of the mandible at the condylar insertions, less pronounced than that unique attribute of its female, so the holotype and paratype of *O. bridwelli* have a somewhat swollen anterior clypeal margin, unlike those of the males discussed earlier. It is notable that a strong thickening of the clypeal apex is a distinctive feature of female *O. cara,* though not mentioned by Cockerell (1910).

P. H. Timberlake's collection, at the University of California, Riverside, includes a series of 43 specimens identified by him as *O. cara.* Remarkably, 10 of these are males (4 *ex* Madera Co., 3—Tulare Co., and 3—San Bernardino Co.), all of which run directly to *O. bridwelli* in Sandhouse's (1939) key, agreeing reasonably well with her description of that species. Comparison of the ten males with the holotype and male paratype of *O. bridwelli* show all 12 specimens to be morphologically alike. *O. bridwelli* Sandhouse, 1939, as Timberlake evidently earlier concluded, is therefore the likely missing male, and junior synonym, of *O. cara* Cockerell 1910, and it may be distinguished from the males of other large, montane "*Monilosmia*" by the differentiating attributes listed above. However, apart from DNA testing, certainty of that synonymy depends upon discovery of either a nest of *O. cara* containing both male and female offspring, or of a bilateral gynandromorph of *O. cara.* The finding of one or two mated pairs of which the female is *O. cara* would not prove the specific identity of the two sexes involved, for cross matings do occur among bees (Shinn 1967). For example, I have captured and preserved three copulating pairs in each of which the female is *O.* (*Osmia*) *ribifloris biedermanii* Michener and the male is *O.* (*Monilosmia*) *densa pogonigera* Cockerell.

ACKNOWLEDGMENTS

I am grateful to R. J. McGinley, M. J. Molineaux, and M. Mello, of the U.S. National Museum of Natural History, and to D. Azuma of the Academy of Natural Sciences, Philadelphia, for loans of the type and paratypes of *Osmia bridwelli* in their care, and to S. Frommer, of the University of California, Riverside, for frequent access to, and loans from, the Timberlake collection. N. Penny, of the California Academy of Sciences, J. Chemsak of the University of California at Berkeley, and T. Griswold, of the Bee Biology and Systematics Laboratory, Logan, Utah, very kindly provided me with locality records for specimens of *O. cara* females in their care. To all of these, many thanks.

Reviews of the text by C. D. Michener of the University of Kansas, E. G. Linsley of the University of California, B. B. Norden of the U.S. National Museum of Natural History, and especially by K. V. Krombein,

---

[4] According to Dr. Norman Penny, specimens of *O. cara* in the collection of the California Academy of Sciences are from Walla Walla Co., Washington; Washoe Co., Nevada, and California counties of Siskiyou, Trinity, Butte, Plumas, Nevada, Napa, Contra Costa, Tuolomne, Santa Clara, Stanislaus, Fresno, and Tulare; to these may be added: Inyo (Timberlake Collection), Sacramento, Marin, Mariposa, Madera, Kern, Los Angeles, San Bernardino, Riverside, and San Diego counties (Moldenke and Neff 1974). It has also been taken in Emery, Wayne, Garfield and Kane counties, Utah (Dr. Terry Griswold).

also of the U.S.N.M., have been very helpful. It is a pleasure to express my warm gratitude for their kindness.

LITERATURE CITED

Cockerell, T. D. A. 1907. Description and records of bees.—XVII. The Annals and Magazine of Natural History (Series 7) 20: 445–451.

———. 1910. New and little known western bees. Entomological News 21: 270–273.

Haldane, J. B. S. 1955. The measurement of variation. Evolution 9: 484.

Hurd, P. D., Jr. 1979. Superfamily Apoidea, pp. 1741–2209. *In* Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, Catalog of Hymenoptera in America North of Mexico. Volume 2. Smithsonian Institution Press, Washington, District of Columbia.

Michener, C. D. 1936. New California Osmiinae (Hymen., Megachilidae). Bulletin of the Southern California Academy of Sciences 35: 84–93.

———. 1941. A generic revision of the American Osmilnae with descriptive notes on Old World genera (Hymenoptera, Megachilidae). The American Midland Naturalist 26: 147–157.

———. 1943. The American bees of the genus *Anthocopa* with notes on Old World genera. The Annals of the Entomological Society of America 36: 49–86.

———. 1947. A revision of the American species of *Hoplitis* (Hymenoptera, Megachilidae). Bulletin of the American Museum of Natural History 89: 257–318.

———. 1949. Records and descriptions of American megachilid bees (Hymenoptera). Journal of the Kansas Entomological Society 22: 41–59.

Michener, C. D. and A. Fraser. 1978. A comparative anatomical study of mandibular structure in bees. The University of Kansas Science Bulletin 51: 463–482.

Moldenke, A. R. and J. L. Neff. 1974. The bees of California: A catalogue with special relevance to pollination and ecological research. Origin and structure of ecosystems: Technical Report 74-3 (Part III of 3). Santa Cruz: Board of Studies in Biology, University of California, Santa Cruz, California. 292 pp.

Naumann, I. D. 1991. Hymenoptera, chapter 42, volume 2: The insects of Australia, Chief Editor: I. D. Naumann. Division of Entomology, Commonwealth Scientific and Industrial Research Organization. 2nd edition. Carlton, Victoria, Melbourne University Press. 601 pp.

Parker, F. D. and V. J. Tepedino. 1982. A nest and pollen-collection records of *Osmia sculleni* Sandhouse, a bee with hooked hairs on its mouthparts (Hymenoptera: Megachilidae). Journal of the Kansas Entomological Society 55: 329–334.

Popov, V. V. 1952a. Hymenoptera, Apoidea of southwestern Turkmenistan and their ecological distribution. (Russian text). Trudy Zoologicheskii Institut Akademia Nauk SSSR 10: 61–117.

———. 1952b. On related species of *Tridentosmia* Schmied, (Hymenoptera, Megachilidae)—Pollinators of Chenopodiaceae. (Russian text). Zoologicheskii Zhurnal 31: 183–190.

Sandhouse, G. A. 1924. Bees of the genus *Osmia* in the collection of the California Academy of Sciences. Proceedings of the California Academy of Sciences (series 4) 13: 341–372.

———. 1925. Canadian bees of the genus *Osmia*. The Canadian Entomologist 57: 33–41, 60–65.

———. 1939. The North American bees of the genus *Osmia* (Hymenoptera: Apoidea). Memoirs of the Entomological Society of Washington 1. 171 pp.

Shinn, A. F. 1967. A revision of the bee genus *Calliopsis* and the biology and ecology of *C. andreniformis* (Hymenoptera, Andrenidae). The University of Kansas Science Bulletin 46: 753–936.

Tkalcú, B. 1983. Die Europäischen Osmia-Arten der Untergattung Melanosmia (Hymenoptera, Apoidea, Megachilidae). Vestnik Ceskoslovenske Spolecnosti Zoologicke 47: 140–159.

van der Zanden, G. 1988. Beitrag zur Systematik und Nomenklatur der Paläarktischen Osmiini, mit Angaben über ihre Verbreitung. Zoologische Mededelingen 62: 113–133.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 541–546

A NEW SPECIES OF *DASINEURA* (DIPTERA: CECIDOMYIIDAE) GALLING LEAVES OF *LUPINUS* SPP. (FABACEAE) IN CALIFORNIA

Raymond J. Gagné and Donald R. Strong

(SJG) Systematic Entomology Laboratory, PSI, Agricultural Research Service, USDA, % U.S. National Museum NHB 168, Washington, D.C. 20560; (DRS) Bodega Marine Laboratory, University of California, Box 247, Bodega Bay, California 94923.

Abstract.—A new species of gall midge, *Dasineura lupinorum* (Diptera: Cecidomyiidae), is described and illustrated. Larvae cause leaflet galls on *Lupinus* spp. (Fabaceae) in California and Oregon. The new species is distinguished from similar species of *Dasineura*, which also form leaflet galls on legumes, and from *Dasineura lupini* Felt, which forms a bud gall on lupines.

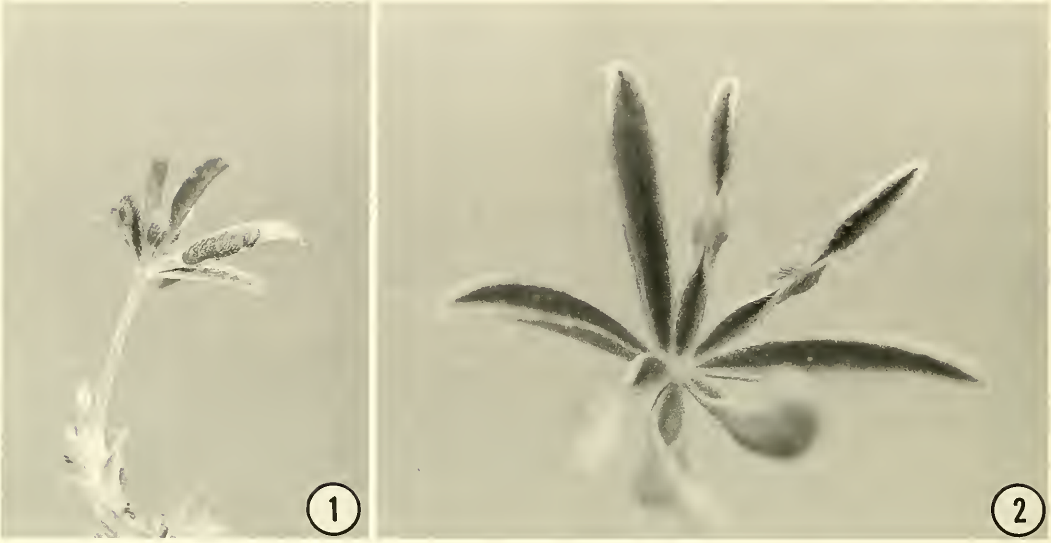
Key Words: Gall midges, lupines, Nearctic

Three kinds of lupine galls formed by cecidomyiids are commonly found along the Pacific coast of the United States (Gagné 1989). One is an enlarged, hairy bud formed by *Dasineura lupini* Felt and another is a stem swelling formed by *Neolasioptera lupini* (Felt). The third kind of gall is a swelling that develops on still folded, elongating leaflets (Figs. 1, 2), but the gall midge has not been described. Osten Sacken (1877) was first to publish a notice of this gall and recognized it as being formed by a cecidomyiid. Felt (1918, 1940) attributed the damage to *Dasineura trifolii* (Loew), which makes a similar leaf fold gall on clovers, *Trifolium* spp. Gagné (1989) assigned the damage to *Dasineura* sp.

During 1991–1992, one of us (DRS) found the leaf galls in Bodega Bay, California on several lupines, *Lupinus arboreus* Sims., *L. chamissonis* Eschs., and *L. variicolor* Steud. Galls were much more abundant on *L. arboreus* than other species. The gall midge is multivoltine on *L. arboreus,* and galls can be found throughout the year. The galls appear to be more abundant in summer, when densities vary upwards to about 80% of leaflets, giving the leaf the appearance of a hand of bananas. Eggs are laid on unopened leaflets of developing buds, when the buds are less than 1 cm in length. Upon hatching, the larvae crawl between the closed halves of the unfolded leaflets in a way similar to larvae of the northern European *Dasineura marginemtorquens* (Bremi) on willow leaves (Larsson and Strong 1992, Strong et al. in press). A gall may contain one to several gregarious larvae. Pupation occurs in the gall. Most galls remain green with succulent, wet interiors while the larvae are feeding. Some galls turn reddish and sclerotic, but the larvae in these are always dead (S. Wainwright, personal communication).

The National Museum of Natural History (USNM) has additional specimens of the galls and gall midges taken in California from San Francisco to Los Angeles. These specimens are from the three hosts listed above and also from *L. albifrons* Benth. and *L. albicaulis* Dougl. ex Hook. RJG has seen the gall on *L. albicaulis* in the vicinity of Corvallis, Oregon.

Dasineura is a large, cosmopolitan genus of some 400 described species, 110 of them



Figs. 1, 2. Leaves of *Lupinus arboreus* infested with *Dasineura lupinorum*. 1, Leaf with galls. 2, Detail of same, showing partially swollen, unfolded leaflets.

from North America. The genus is an artificial, catchall category and contains species of the tribe Oligotrophini that have four palpal segments, toothed tarsal claws, a shortened R_5 wing vein that meets the costa anterior to the wing apex, and the full basic complement of larval papillae for the tribe. The only derived character in that list is the short R5 vein, which may not be unique in this genus, as a short R_5 occurs also in other tribes of Cecidomyiinae. The new species differs from all other Nearctic *Dasineura* spp. known to us by its bilaterally flattened, fused female cerci. Similarities between the male genitalia of *D. lupinorum* to those of other leaf fold gall makers on papilionaceous Fabaceae, such as *D. trifolii*, show that these species form a natural group within *Dasineura*.

Methods

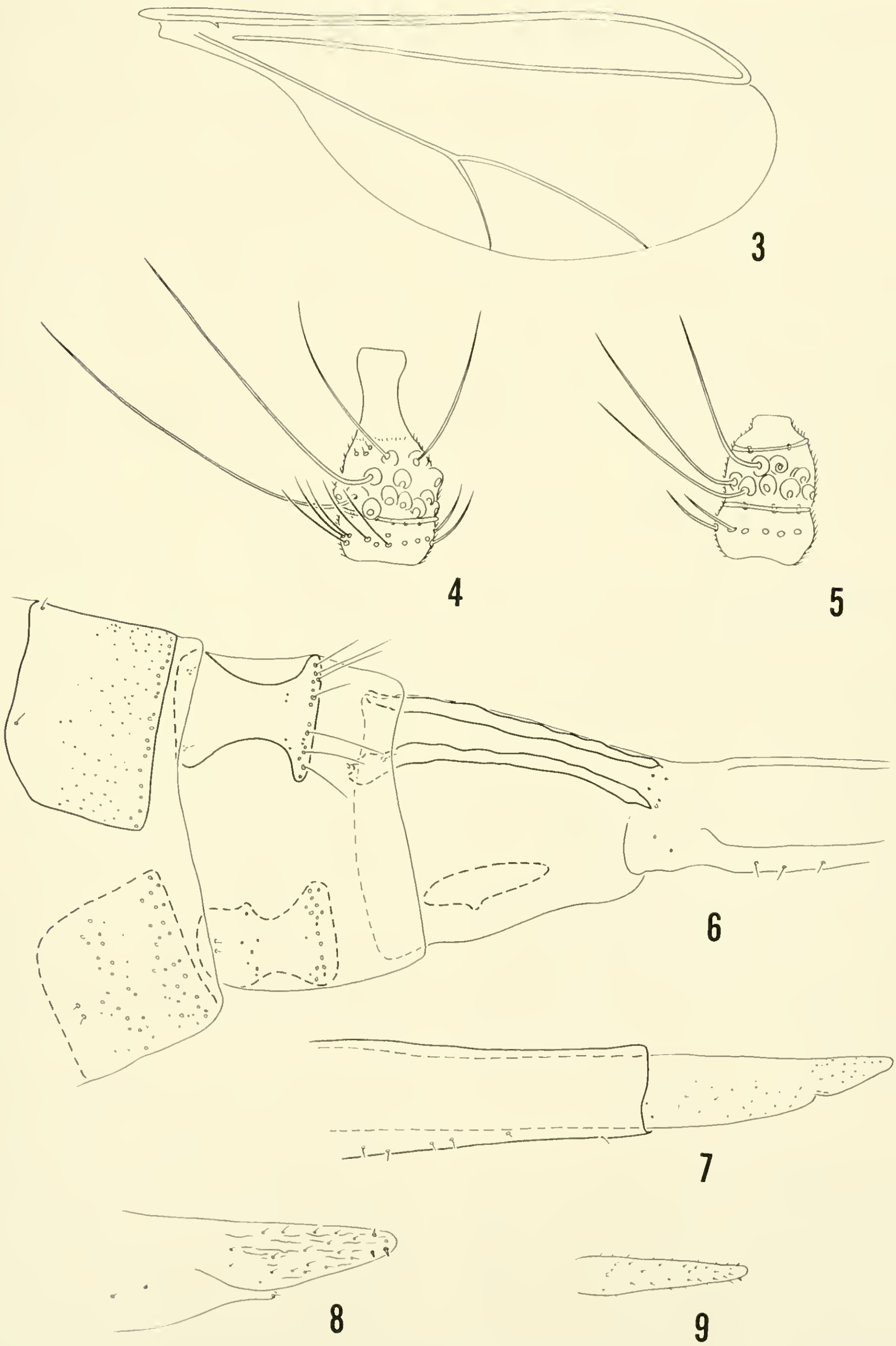
Adults were reared from enlarged, green, galled leaves that had been picked from the plant and placed in glass bottles. All specimens were killed and stored in 70% ethanol. Some larvae and adults were mounted for microscopic study in Canada balsam, using the method outlined in Gagné (1989). In the descriptions that follow, anatomical terminology of the adult stage follows usage in McAlpine et al. (1981) and that of the larval stage follows that in Gagné (1989). The new species is to be attributed to RJG.

Dasineura lupinorum **Gagné,**
New Species

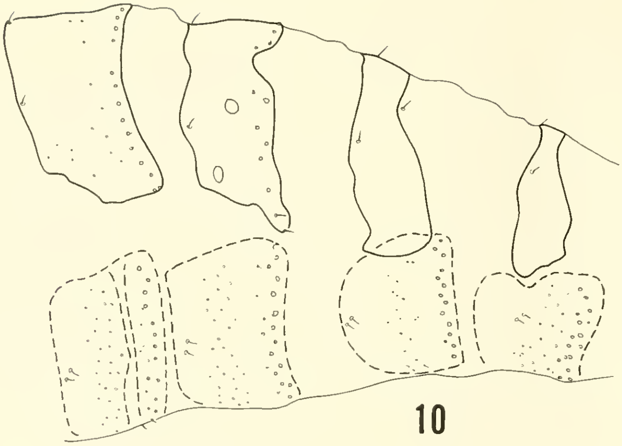
Adult.—Wing length: male, 1.3–1.8 mm (n = 10); female 1.3–1.7 mm (n = 10).

Head: Eyes 3–4 facets long at vertex; facets circular, separated by ½ to 1 facet diameter on top half of eye, closely adjacent on bottom half of eye. Vertex of occiput broadly rounded. Frons with setae and scales. Labella hemisperical, each with 6–8 setae. Palpus 4 segmented. Male antenna with 13–14 flagellomeres, the third as in Fig. 4. Female antenna with 12–14 flagellomeres, the third as in Fig. 5.

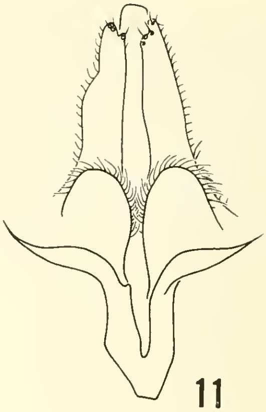
Thorax: Scutum with 2 lateral and 2 dorsocentral rows of mixed setae and scales. Scutellum with a group of setae on each side. Mesanepisternum covered with scales on dorsal half. Mesepimeron with 6–10 setae. Wing (Fig. 3) with R_5 joining C anterior to



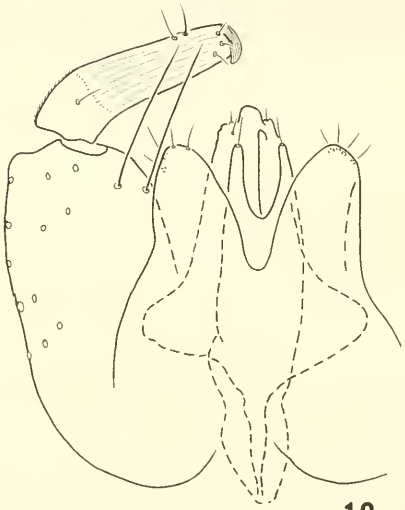
Figs. 3–9. *Dasineura lupinorum.* 3, Wing. 4, Male third flagellomere, dorsal. 5, Female third flagellomere, dorsal. 6, Female sixth through eighth abdominal segments, dorsolateral. 7, Ovipositor, lateral. 8, Detail of fused cerci and hypoproct, lateral. 9, Detail of fused cerci, dorsal.



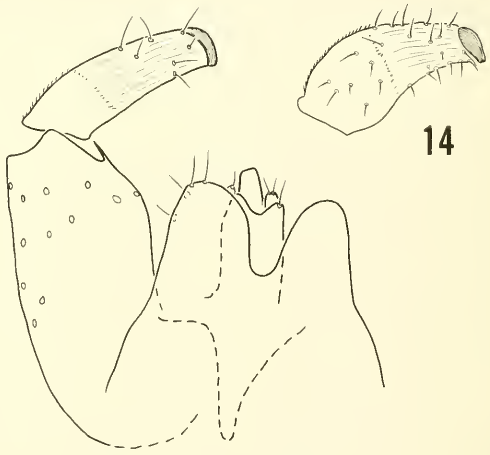
10



11

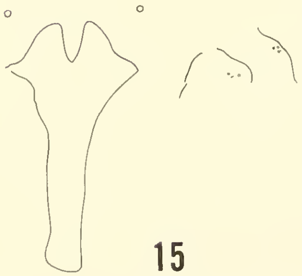


12

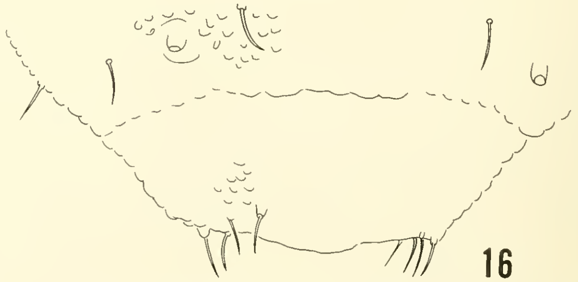


13

14



15



16

Figs. 10–16. 10–12, *Dasineura lupinorum.* 10, Male fifth through eighth abdominal segments, dorsolateral. 13, Claspettes and aedeagus, dorsal. 14, Male genitalia, dorsal. 13, *Dasineura maritima* male genitalia, dorsal. 14, *Dasineura lupini* gonostylus, dorsal. 15, 16, *Dasineura lupinorum.* 15, Larval spatula and associated papillae. 16, Larval terminal segments, dorsal.

wing apex. Claws toothed, empodia as long as claws.

Male abdomen (Figs. 10–12): First through fifth tergites entire, rectangular, with single, uninterrupted, posterior row of setae and scattered setae anteriorly; sixth tergite with anterior setal row interrupted mesally, seventh and eighth tergites reduced in size, bare except for anterior pair of trichoid setae. Cerci broadly rounded, with several setae along posterior margin; hypoproct with two long narrow lobes, each with distal seta; claspettes elongate, attenuate, with dorsobasal lobes; gonocoxites cylindrical, unlobed; gonostyli cylindrical, weakly and evenly tapered from base to apex, setulose at base, striate beyond to short distal tooth.

Female abdomen (Figs. 6–9): First through sixth tergites rectangular, with single row of posterior setae, anterior pair of trichoid setae, and almost completely covered with scales elsewhere; seventh tergite much narrower, concave laterally, with posterior row of setae and scales, anterior pair of trichoid setae, and 0 to several scales elsewhere; eighth tergite much longer and divided into two elongate sclerites; distal half of ovipositor elongate, moderately flattened bilaterally; cerci fused, greatly flattened bilaterally; hypoproct narrow, longer than wide.

Third instar.—Integument rugose. Spatula (Fig. 15) clove shaped. All papillae basic for supertribe present (Gagné 1989); terminal papillae (Fig. 16) with 8 setae of equal length.

Holotype.—Male, emerged VII-1992 from larva from folded leaves of *Lupinus arboreus,* collected VII-1992, Bodega Marine Reserve, Bodega Bay, California, D. R. Strong, deposited in the National Museum of Natural History, Washington, D.C. Paratypes (all in USNM except 2 ♂ and 2 ♀ in California Academy of Sciences, San Francisco, California): 3 ♂, 5 ♀, and 10 larvae, same pertinent data as for holotype; 4 ♂, 4 ♀, same pertinent data as holotype except collected and reared V-1992, ♂, ♀, same data except from *L. variicolor*; 4 ♂, 3 ♀, same data except from *L. chamissonis.* Other material (all in alcohol in USNM): Additional adults and larvae from *L. arboreus* and adults from *L. chamissonis,* all from Bodega Bay, VII-1992, D. R. Strong. Adults, all reared in spring, 1947, from lupines in California by A. E. Pritchard: from *L. albifrons,* "Sharp Pk."; from *L. arboreus,* Davenport, Santa Cruz Co., Montara and San Gregorio, San Mateo Co., and Stinson Beach, Marin Co.; and from *L. variicolor,* Montara, San Mateo Co. Galls from *L. albifrons,* Fresno, California, no date, C. C. Jenney. Galls from *L. albifrons,* Lone Mt., San Francisco, California, IV-1876, C. R. Osten Sacken.

Etymology.—The specific name *lupinorum* is a noun in the genitive plural, meaning "of lupines."

Remarks.—The characteristic gonostyli of this species have a shape similar to those of *Dasineura maritima* Felt (Fig. 13), known from leaf folds on *Lathyrus maritimus* (L.) Bigel. in Massachusetts, and of *Dasineura trifolii* (Loew), known from leaf folds on *Trifolium pratense* L. and *Trifolium repens* L. in Europe and the United States. Other *Dasineura* species have the gonostyli much more bulbous on the basal half, as does *Dasineura lupini* Felt (Fig. 14), reared from bud galls of *Lupinus arboreus* in California (see Russo 1979 for notes on the biology of this species). Larvae of all three species from leaf folds are similar also. The ovipositor of *D. lupinorum* is distinctive for its bilaterally flattened ovipositor; that of the other two leaf rollers is cylindrical.

ACKNOWLEDGMENTS

We are grateful to Susan Wainwright and Richard McKinney for contributing information on the biology of *D. lupinorum*; P. Malikul for preparing the microscopic slides; S. Grupp for inking the illustrations; and B. A. Hawkins, J. C. Miller, A. L. Norrbom, N. J. Vandenberg, and an anonymous reviewer for their comments on drafts of the manuscript. The field work was supported by National Science Foundation grant BSR

9007429 to DRS and the University of California Bodega Marine Reserve.

LITERATURE CITED

Felt, E. P. 1918. Key to American insect galls. New York State Museum Bulletin 200: 5–310, pls. 5–16.

———. 1940. Plant Galls and Gall Makers. Comstock Publishing Co., Ithaca, NY. vii + 364 pp.

Gagné, R. J. 1989. The Plant-Feeding Gall Midges of North America. Cornell University Press, Ithaca, New York. xiii and 355 pp. and 4 pls.

Larsson, S. and D. R. Strong. 1992. Oviposition choice and larval survival of *Dasineura marginemtorquens* (Diptera, Cecidomyiidae) on resistant and susceptible *Salix viminalis*. Ecological Entomology 17: 227–232.

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. Research Branch, Agriculture Canada, Monograph 27. vi + 674 pp.

Osten Sacken, C. R. 1877. Western Diptera: Descriptions of new genera and species of Diptera from the region west of the Mississippi and especially from California. U.S. Geological Survey Bulletin 3: 189–354.

Russo, R. A. 1979. Plant Galls of the California Region. Boxwood Press, Pacific Grove, California. xi + 203 pp.

Strong, D. R., S. Larsson, and U. Gullberg. In press. Heritability of host plant resistance to herbivory changes with gall midge density during an outbreak on willow. Evolution.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 547–553

ON THE BIOLOGY OF *PENEPODIUM GORYANUM* (LEPELETIER) IN WOODEN TRAP-NESTS (HYMENOPTERA, SPHECIDAE)[1]

MARCOS V. B. GARCIA AND JOACHIM ADIS

(MVBG) EMBRAPA—Centro de Pesquisa Agroflorestal da Amazônia, Caixa Postal 319, 69.000 Manaus/AM, Brazil; (JA) Max-Planck Institut für Limnologie, AG Tropenökologie, Postfach 165, D-24302 Plön, Germany.

Abstract.—The nesting habits and life cycle of *Penepodium goryanum* (Lepeletier) 1845 were studied in 1991 in a central Amazonian blackwater inundation-forest. Nests were obtained from artificial sites for nesting (trap-nests) and consisted of a single cell per cavity, provisioned with cockroaches of the genus *Eunyctibora.* The characteristics of the nest are given as well as information on the life cycle, seasonality, parasites and prey preferences of *P. goryanum.* The effects of the flood pulse on the seasonality of *P. goryanum* are discussed.

Resumo.—O hábito de nidificação e biologia de *Penepodium goryanum* (Lepeletier) 1845 foram estudados em uma floresta de inundação (igapó) na Amazônia Central, durante 1991. Ninhos foram obtidos em ninho-armadilhas artificiais e consistiam em única célula por cavidade, provisionada com baratas do gênero *Eunyctibora.* Características do ninho são fornecidas bem como informações sobre o ciclo de vida, sazonalidade, preferência por presas e parasitismo de *P. goryanum.* Os efeitos do pulso de inundação na sazonalidade de *P. goryanum* são discutidos.

Key Words: Nesting habits, inundation, Amazon, Neotropics, Sphecidae

The new genus *Penepodium* Menke was described in Bohart and Menke's (1976) revision of the Sphecidae. They list 22 species and these are distributed from Mexico to Argentina. Biological data exist for only a few species: Williams (1928) described in detail the nesting habits of *P. haematogastrum* (Spinola) and *P. luteipenne* (Fabricius) (as *flavipenne*), and Richards (1937) provided notes on *P. mocsaryi* (Kohl) and *P. goryanum* (Lepeletier).

Scarcity of biological data on solitary wasps is due principally to the difficulty in locating their nests. Using wooden trap-nests (artificial sites for nesting) permits one to collect and study species which use pre-existing holes for nesting. In this paper we present data on the nesting habits and life cycle of *Penepodium goryanum* reared in trap-nests.

STUDY AREA AND METHODS

The study was carried out during 1991. The study area is a blackwater inundation-forest located about 20 kilometers upstream from Manaus on the left bank of the Rio Tarumã-Mirím (03°02′S, 60°11′W), a tributary of the Rio Negro (cf. Adis 1992a). This area is subject to a rainy season (between December and May, with a mean precipitation of ca. 1550 mm), and a "dry" (drier)

---

[1] From cooperation between Max-Planck-Institute for Limnology, Tropical Ecology Working Group, Plön, Germany, and National Institute for Amazonian Research (INPA), Manaus/AM, Brazil.

season, (between June and November, with a mean precipitation of ca. 550 mm) (cf. Ribeiro and Adis 1984). The inundation forest is covered by several meters of flood water for five to seven months each year (March/April–August/September), depending on the terrain elevation (cf. Adis 1992b).

Various investigators have successfully used the trap-nest method for study of the biology and population dynamics of solitary wasps and bees (cf. Medler 1967, Krombein 1967, Medler and Fye 1956, Matthews and Fischer 1964, Collins and Jennings 1984, Jayasingh and Freeman 1980, Coville and Coville 1980, Fricke 1991).

Different authors have used trap-nests of various dimensions and made out of different materials, according to the objectives of their studies. In our case we adopted trap-nests similar to those used by Medler (1967) and Krombein (1967), but slightly modified. We used blocks of wood (*Protium* sp., Burseraceae) 40 × 40 × 100 mm, drilled longitudinally to a depth of 80 mm with the apertures, 4.8, 9.5 and 12.7 mm in diameter. Before being drilled, the wood blocks were sawed in half longitudinally and then held together with adhesive tape to permit the examination of the cavities when opened. Nine blocks (3 of each diameter) were held together with a rubber band (Fig. 1G). Forty bundles were attached to tree trunks horizontally (two per tree). One bundle was placed at a height of 5 meters (above the maximum flood level) and one at about 2.5 meters, in the inundation stratum of the forest. The latter was moved according to the water-level to prevent flooding. Bundles with traps made out of different wood, *Triplaris surinamensis* Cham. (Polygonaceae), *Macrolobium acaciaefolium* Benth. (Leg., Caesalpiniaceae), *Aldina latifolia* Spruce ex Benth. var. *latifolia* (Leg., Fabaceae) and *Mora paraensis* Ducke (Leg., Caesalpiniaceae) were attached to four trees. Traps were examined approximately every 15 days and those with completed nests were collected and substituted by another of the same diameter.

RESULTS

Characteristics of the nests

The nest consisted of one single cell closed at the entrance with a plug of mud, 3.7–7.4 mm thick (mean = 5.1 ± 1.0, N = 20). The external surface of the closing plug had a coating of resin (N = 29) (Fig. 1H), plant wax (N = 11) or bits of debris such as small pieces of leaves, lichens or fragments of wood adhering to the coating of resin (N = 9). In general the nest was closed only with a single wall (N = 105), but some had two, side by side (N = 2), or separated by a distance of 7.4–14.8 mm (mean = 11.5 ± 2.9 mm, N = 4). The surface of the internal wall also had a coating of resin, and a deposit of debris. The resin became very hard after some time, and in some cases, mixed with the mud, made the wall even harder.

Females of *P. goryanum* hunted adult cockroaches of the genus *Eunyctibora* sp. (Epilampridae, Nyctiborinae) to provision their nests. In each nest, one (N = 1), two (N = 16), three (N = 5) or four (N = 1) prey were found (Fig. 1B). The egg, about 2 mm long, was laid behind the forecoxa of the prey (Fig. 1A, arrow). We observed that the locality where the egg was laid and the presence of adhering substances did not permit the prey to remove it. The prey remained paralyzed for only a short time, and in nests opened 2 days after closing we observed the cockroaches to be active and capable of flight. In nests controlled under laboratory conditions, eggs were only found in the very first prey brought into the nest; however, the cockroaches captured may have changed position. Female wasps preferred traps with 12.7 mm aperture (N = 103), although a few used those of 9.5 mm aperture (N = 11). The females did not build nests in traps of 4.8 mm aperture.

Development and life cycle

Time from egg to adult ranged between 38 and 48 days in 19 individuals, and in 6 other individuals between 81 and 198 days.

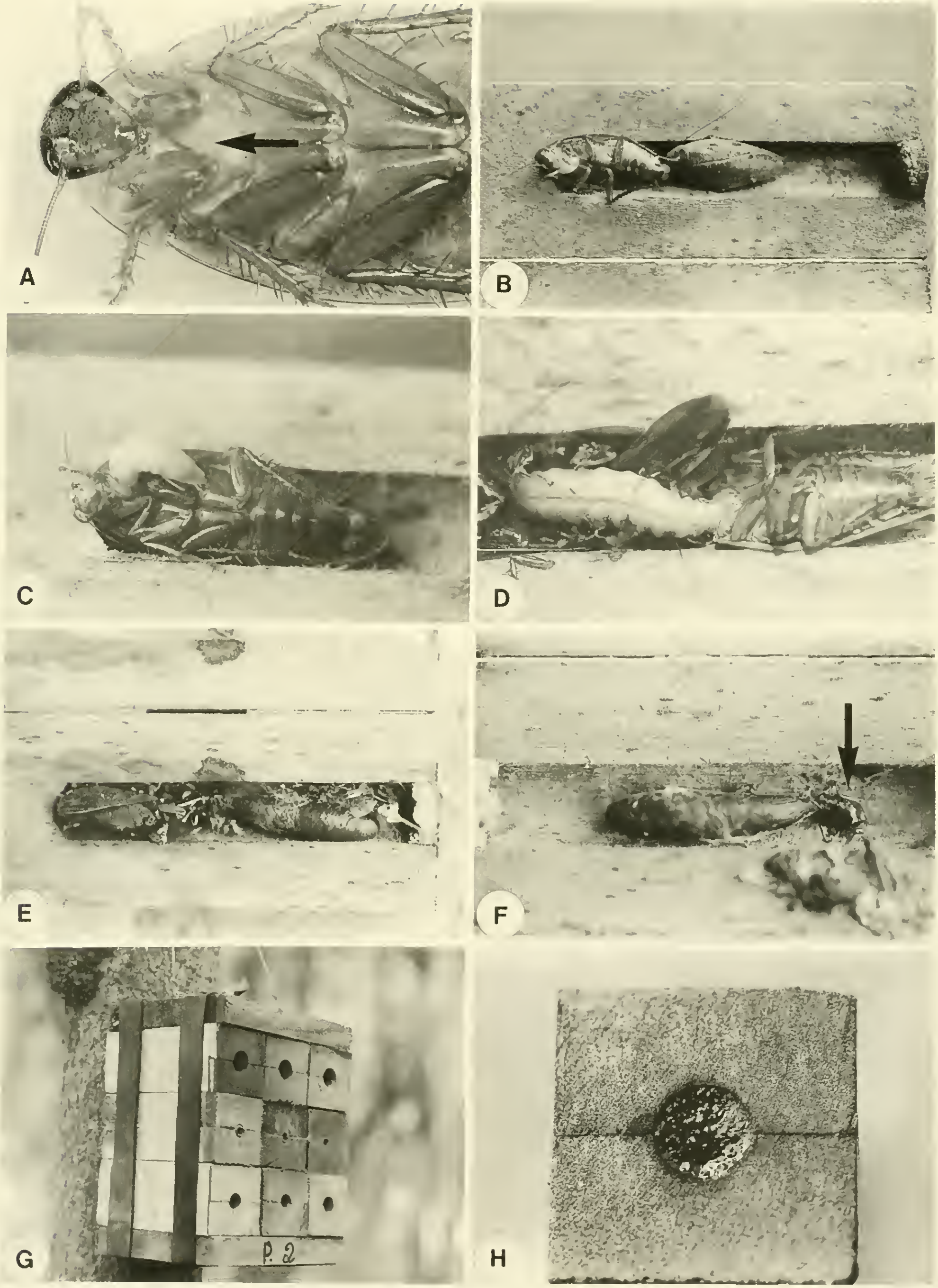


Fig. 1. Nest characteristics of *P. goryanum.* A, Egg laid behind the forecoxa of the prey. B, View of the nest opened two days after closing. C, D, Larval development after 3 and 6 days, respectively. E, Aspect of the nest during the pupal stage. F, Larva in defecation phase (see arrow). G, Bundle of wooden trap-nests attached on tree trunk. H, Nest entrance with a coating of resin.

In the second case, dormancy was observed in the prepupal stage.

The larva hatched after two days and remained behind the forecoxa of the prey where it began to feed by introducing part of the head and the body (Fig. 1C). The feeding period lasted 6 to 8 days (mean = 7.2 ± 0.6, N = 8), at the end of which the larva attained 2–3 cm in length. All of the internal contents of the prey was consumed, even the smaller parts such as the femur and head were emptied (Fig. 1D).

Between the end of the feeding period and the construction of the cocoon, the larva remained practically immobile for about 24 hours. Cocoon construction took about 48 h. It began with the production of fine silken threads that were attached at various points along the tunnel walls. The larva first constructed a silk mesh around the body, maintaining it suspended, and then began the construction of the cocoon wall. Initially the cocoon was transparent and eventually became dark amber (with a brittle cocoon wall after drying), and ranged between 27–37 mm in length (mean = 30.0 ± 3.6, N = 15) (Fig. 1E). At the posterior end of the cocoon an orifice remained opened through which feces were eliminated. The feces hardened after they dried, obstructing the opening and, in some cases, fixing the cocoon to the wall (Fig. 1F, arrow). The prepupal stage lasted 9–12 days (mean = 10.0 ± 1.2, N = 4), or 48–176 days (mean = 127.4 ± 46.5, N = 8) for individuals which entered dormancy. The pupal stage lasted 20–27 days (mean = 23.6 ± 2.4, N = 12). In all individuals reared in the laboratory, males were produced in greater numbers than females (28 ♂♂ : 10 ♀♀).

Nesting activity

The greatest nesting activity occurred between December and March (rainy season, but forest not flooded) and June through September (dry season, forest flooded). The maximum of provisioned cells occurred in February and August (Fig. 2: bottom). The correlation of nesting frequency with precipitation and the water level was not significant (r = 0.22, N = 12, $P = 0.49$ and r = 0.41, N = 12, $P = 0.18$, respectively) (see Fig. 2: top). The chi-square test indicated no significant difference in the nesting frequency among the types of wood ($\chi^2 = 4$, df = 4, $P = 0.41$) (Table 1).

Mortality and parasites

In 53% of the nests examined the individuals did not reach the adult stage. Among the causes of mortality, 80% unknown, we observed parasitism by *Melittobia* sp. (Eulophidae, Hymenoptera) (15%), *Anthrax* sp. (1.6%) and *Lepidophora* sp. (1.6%) (Bombyliidae, Diptera), and an unidentified species of Perilampidae, Hymenoptera (1.6%).

DISCUSSION

Fricke (1992) observed that the nesting frequency of *Passaloecus* spp. (Pemphredoninae, Sphecidae) varied according to the tree species in which trap-nest bundles were attached, and suggested that the availability of natural nesting cavities, closure material such as resin, and the presence of suitable prey nearby were the reasons for this selection of nesting sites. Although we do not know the tree species where *P. goryanum* nests naturally, the random selection for nesting in traps made of various woods shows that the type of wood chosen for the traps did not influence nesting rates (Table 1).

Bohart and Menke (1976) placed members of *Penepodium* in three species groups, *goryanum, luteipenne* and *foeniforme.* As described by Williams (1928), *P. luteipenne* and *P. haematogastrum* (*luteipenne* group) excavate their nests in the ground or in banks. Richards (1937) cited *P. mocsaryi* (*goryanum* group) as collecting mud, and gave a record of a female of *P. goryanum* collected at the moment that it was inserting a cockroach into an abandoned tunnel of a *Passalus* sp. (Coleoptera) in a rotten stump. Williams also observed *P. goryanum* gathering mud.

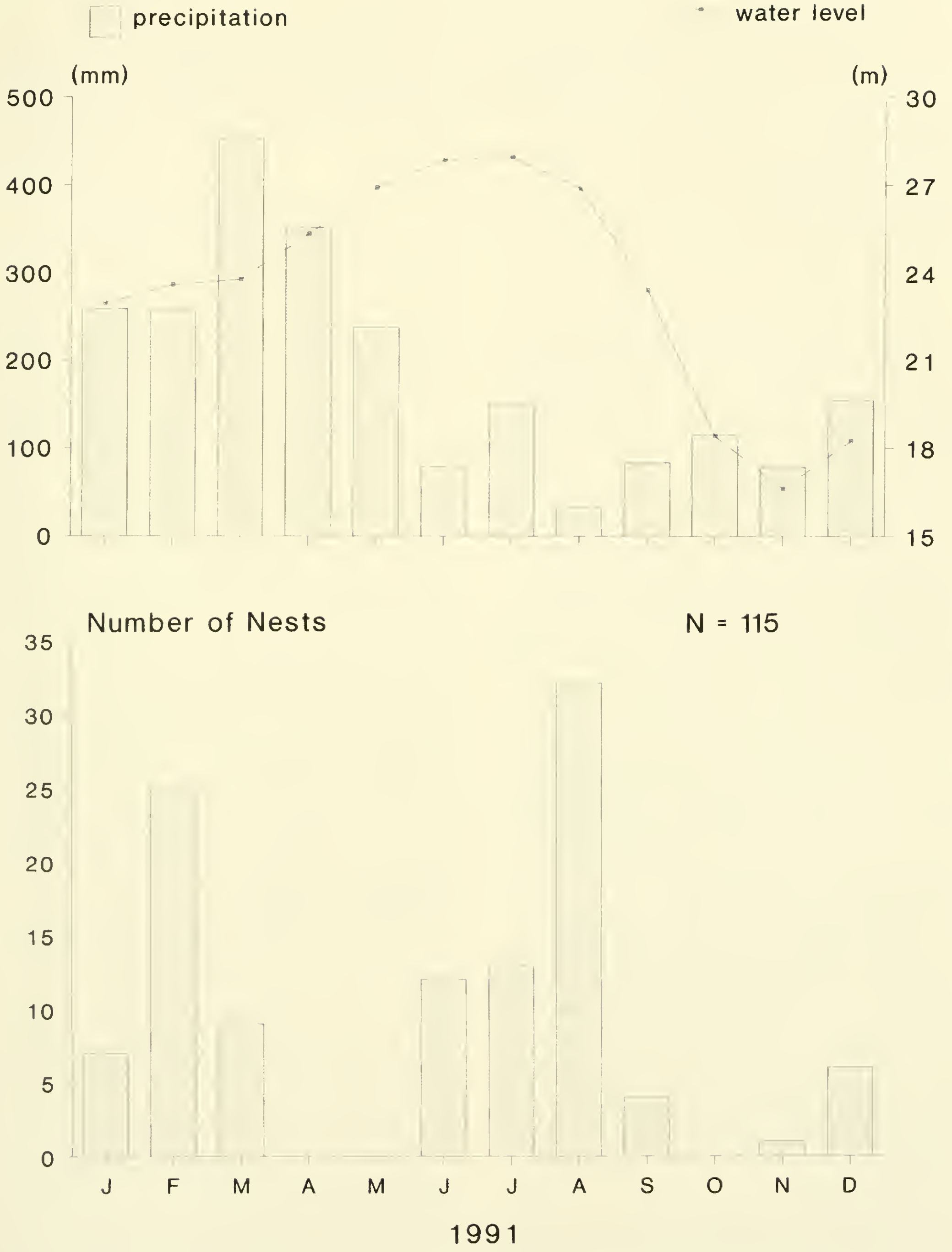


Fig. 2. Top, Annual precipitation and water level. Bottom, Nesting activity of *P. goryanum*.

Table 1. Nesting frequency of *P. goryanum* for different wood species.

Species	Trap-nests Frequency (9.5 and 12.7 mm)	Observed Frequency	Expected Frequency*	(χ^2)
Aldina latifolia	4	2	3.2	(0.45)
Mora paraensis	4	3	3.2	(0.0125)
Macrolobium acaciaefolium	4	1	3.2	(1.5125)
Triplaris surinamensis	4	5	3.2	(1.0125)
Protium sp.	4	5	3.2	(1.0125)

* $\chi^2_{\text{Total}} = 4$, df $= 4$, $P = 0.41$.

Various behavioral characteristics have been used for diagnosis of species, genera or families of solitary wasps (cf. Evans 1966). Based on William's and Richard's observations, Bohart and Menke (1976) suggested, that the *luteipenne* species group excavates nests in the ground, and that the *goryanum* species group nests in pre-existing cavities. Our observations confirm that *P. goryanum* uses pre-existing cavities.

In sphecid wasps the preference for prey may occur at the subfamily, generic or species level; thus, the type of prey can be a useful taxonomical tool. The species of *Penepodium* studied by Williams (1928) provisioned their nests with cockroaches of the genus *Epilampra* Burmeister. We observed *P. goryanum* collecting cockroaches of the genus *Eunyctibora* Shelford; the specimens appeared to be conspecific.

According to Coville (1982), in the United States, wasps of the subgenus *Trypargilum* spp. are usually univoltine and overwinter in diapause in the prepupal phase, and in tropical regions they are bivoltine or "multivoltine" (= plurivoltine). Probably, in tropical climates the availability of prey is the principal factor responsible for the development of reproductive strategies in sphecid wasps.

The great variation in developmental times between individuals of *P. goryanum*, because of dormancy in the prepupal stage, probably is a strategy used to overcome adverse conditions such as humidity or scarcity of prey. Various studies have shown that in tropical forests some insect groups can have their seasonality and abundance triggered by food availability, and that even small changes in rain pattern can have a great effect on the quantity and availability of food (Wolda 1978). Fisk (1982) verified a seasonal variation in a population of cockroaches in the forest canopy in Panama and Costa Rica. They were abundant during the rainy season, coinciding with the greatest leaf production, and scarce during the dry season when there were fewer leaves. Fisk also observed that some genera, *Epilampra* among them, did not occur in the canopy, and probably were more abundant on the ground. Irmler and Furch (1979), studying populations of *Epilampra irmleri* Rocha e Silva and Aguiar in our same study site, observed that it was abundant in the litter during low water, reaching 75% of the total cockroach population.

Although we do not have observations on the ecology of *Eunyctibora*, it is possible that the nesting activity of *P. goryanum* is linked to the population fluctuations of the prey, probably caused by the flood pulse (cf. Junk et al. 1989). If the prey (*Eunyctibora* sp.) has terricolous habits, it is probable that at the beginning and at the end of the inundation it becomes scarce because of low reproductive rates when the individuals are migrating from the ground to the canopy and canopy to ground. On the other hand, if it is an arboricolous species, it is affected by predation or competition by the terricolous migrating fauna, particularly in March and April, the beginning of the forest inundation, and at the end of it, in September (cf. Adis 1992b). The variation in abundance of *P. goryanum* during the year can only be called seasonality if the pattern repeats itself in different years and our data as yet does not permit us to know whether this is the case.

ACKNOWLEDGMENTS

We would like to thank Dr. Sérvio Túlio P. Amarante (Museu de Zoologia, University of São Paulo, Brazil) and Dr. Arnold Menke (USDA, U.S. National Museum, Washington, D.C., USA) for identification of the wasps, and Dr. Cláudio José Becker (Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, Brazil) for identifying the cockroaches. Dr. Karl V. Krombein (Smithsonian Institution, Washington, D.C.) and Dr. Arnold Menke are thanked for valuable comments on the manuscript.

LITERATURE CITED

Adis, J. 1992a. How to survive six months in a flooded soil: Strategies in Chilopoda and Symphyla from Central Amazonian floodplains. Symposium on life-history traits in tropical invertebrates. INTECOL, Yokohama, Japan 1990. (J. Adis and S. Tanaka, eds.). Studies on Neotropical Fauna and Environment 27(2-3): 117–129.

———. 1992b. Überlebensstrategien terrestrischer Invertebraten in Überschwemmungswäldern Zentralamazoniens. Verhandlungen des naturwissenschaftlichen Vereins in Hamburg. (NF)33: 21–114.

Bohart, R. M. and A. S. Menke. 1976. Sphecid Wasps of the World. University of California Press, Berkeley. 695 pp.

Collins, J. A. and D. T. Jennings. 1984. A simplified holder for eumenid nesting blocks (Hymenoptera: Eumenidae). Entomological News 95(2): 58–62.

Coville, R. E. 1982. Wasps of the genus *Trypoxylon* subgenus *Trypargilum* in North America (Hymenoptera: Sphecidae). University of California Publications in Entomology 97: 1–147.

Coville, R. E. and P. L. Coville. 1980. Nesting biology and male behavior of *Trypoxylon* (*Trypargilum*) *tenoctitlan* in Costa Rica (Hymenoptera: Sphecidae). Annals of the Entomological Society of America 73: 110–119.

Evans, H. E. 1966. The behavior patterns of solitary wasps. Annual Review of Entomology 11: 123–154.

Fisk, F. W. 1982. Abundance and diversity of arboreal Blattaria in moist tropical forests of the Panama canal area and Costa Rica. Transactions of the American Entomological Society 108(4): 479–489.

Fricke, J. M. 1991. Trap-nest design for small trap-nesting Hymenoptera. The Great Lakes Entomologist 24(2): 121–122.

———. 1992. Influence of tree species on frequency of trap-nest use by *Passaloecus* species (Hymenoptera: Sphecidae). The Great Lakes Entomologist 25(1): 51–53.

Irmler, U. and K. Furch. 1979. Production, energy, and nutrient turnover of the cockroach *Epilampra irmleri* Rocha e Silva and Aguiar in a Central-Amazonian inundation forest. Amazoniana 6(4): 497–520.

Jayasingh, D. B. and B. E. Freeman. 1980. The comparative population dynamics of eight solitary bees and wasp (Aculeata: Apocrita: Hymenoptera) trap-nested in Jamaica. Biotropica 12(3): 214–219.

Junk, W. J., P. B. Bayley, and R. E. Sparks. 1989. The flood pulse concept in river-floodplain systems. *In* Dodge, P., ed., Proceedings of the International Large River Symposium. Canadian Special Publication of Fisheries and Aquatic Sciences 106: 110–127.

Krombein, K. V. 1967. Trap-nesting Wasps and Bees: Life Histories, Nests and Associates. Smithsonian Press, Washington, D.C. 570 pp.

Matthews, R. W. and R. L. Fischer. 1964. A modified trap-nest for twig-nesting Aculeata. Proceedings. North Central Branch. Entomological Society of America 19: 79–81.

Medler, J. T. 1967. Biology of *Trypoxylon* in trap nests in Wisconsin (Hymenoptera: Sphecidae). American Midland Naturalist 78: 344–358.

Medler, J. T. and R. E. Fye. 1956. Biology of *Ancistrocerus antilope* (Panzer) (Hymenoptera, Vespidae) in trap-nests in Wisconsin. Annals of the Entomological Society of America 49: 97–102.

Ribeiro, M. de N. G. and J. Adis. 1984. Local rainfall variability—a potential bias for bioecological studies in the Central Amazon. Acta Amazônica 14: 159–174.

Richards, O. W. 1937. Results of the Oxford University expedition to British Guiana, 1929. Hymenoptera, Sphecidae and Bembecidae. Transactions of the Royal Entomological Society of London 86: 101–118.

Williams, F. X. 1928. Studies in tropical wasps—Their hosts and associates (with descriptions of new species). Bulletin of the Experiment Station of the Hawaiian Sugar Planters' Association, Entomological Series 19: 1–179.

Wolda, H. 1978. Seasonal fluctuations in rainfall, food and abundance of tropical insects. The Journal of Animal Ecology 47: 369–381.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 554–557

A NEW SPECIES OF *SPHECOMYIELLA* (DIPTERA: PYRGOTIDAE) FROM NORTH AMERICA

Boris C. Kondratieff and Scott J. Fitzgerald

Department of Entomology, Colorado State University, Fort Collins, Colorado 80523.

Abstract.—*Sphecomyiella nelsoni* n. sp. is described from Arizona, and is distinguished from *S. valida* (Harris) by the shape of the epandrium of the male and the apex of the ovipositor of the female; both species are illustrated for comparison. A holotype male and 40 paratypes are designated.

Key Words: Diptera, Pyrgotidae, *Sphecomyiella,* new species, Arizona

The Pyrgotidae are a lineage of Tephritoidea, containing approximately 330 species worldwide, in which the larvae have evolved as internal parasitoids of adult scarabaeid beetles (Steyskal 1987). Females of these flies are reported to oviposit directly onto the abdomen of the adult beetle in flight. Adults of most Pyrgotidae species apparently are nocturnally active, and some genera such as *Sphecomyiella* and *Pyrgota* can often be collected at lights.

A review of the North American Pyrgotidae was given by Steyskal (1978). He recognized eight species in five genera north of Mexico. All of these genera are included in the Pyrgotinae.

Sphecomyiella Hendel (1933) has been most recently considered monotypic, including only *S. valida* (Harris). This species has been considered to have a wide geographic range, including much of eastern North America, west to Arizona (Steyskal 1987).

The recent discovery of this genus in Colorado stimulated a review of *Sphecomyiella.* Comparison of the type of *S. valida,* and the type of *Pyrgota millepunctata* Loew, a previously recognized junior subjective synonym, with material from throughout eastern and central North America, and especially Arizona and Colorado, indicated the presence of an undescribed species.

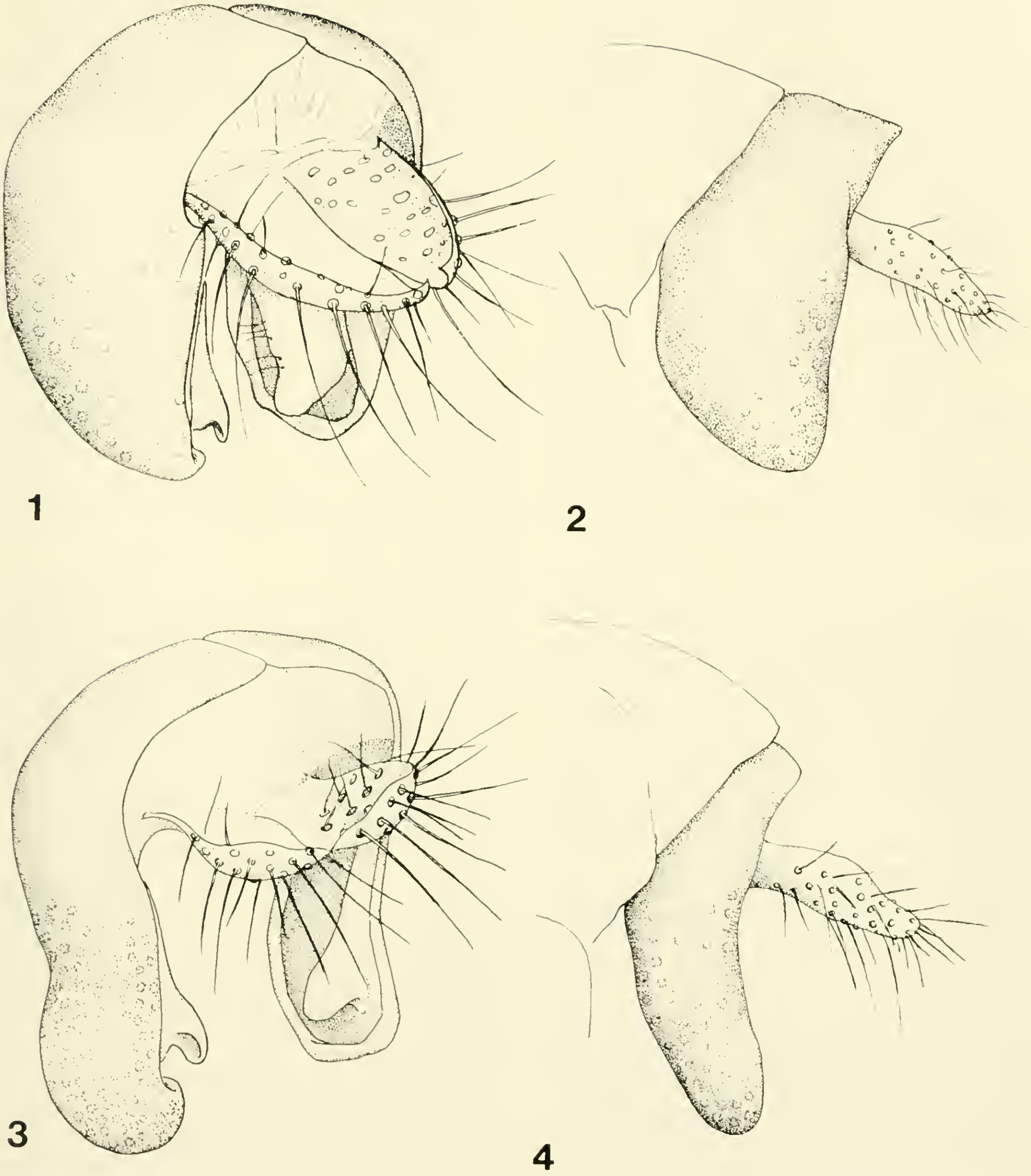
The genus *Stirothrinax* Enderlein (1942) which presently includes two described species, *S. cribratus* Enderlein (Mexico) and *S. knudseni* Mayer (1953) (Costa Rica) is probably a synonym of *Sphecomyiella.* Specimens of both species have been examined and are separable from *S. valida* and the new species described herein. However, a thorough revision of all Neotropical genera is necessary before a formal synonymy is proposed.

The terminology follows Steyskal (1987). Acronyms for the depositories of specimens listed in the text are as follows: Brigham Young University, Monte L. Bean Life Science Museum (BYU); Colorado State University, C. P. Gillette Museum of Arthropod Diversity (CSU); Harvard University, Museum of Comparative Zoology (MCZ); Illinois Natural History Survey (INHS); and National Museum of Natural History, Smithsonian Institution (USNM).

Sphecomyiella nelsoni Kondratieff and Fitzgerald, New Species

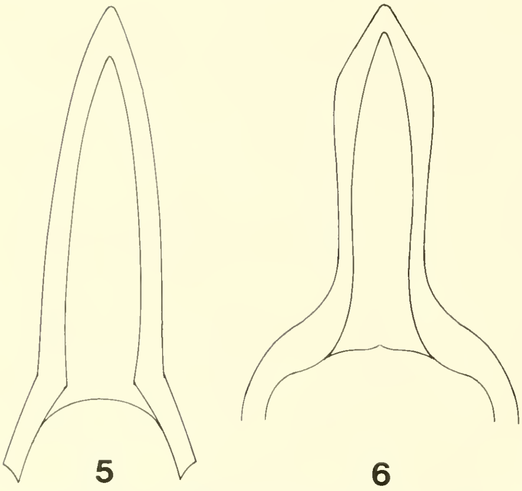
Figs. 3, 4, 6

Holotype male: (USNM), Santa Cruz Co., Arizona, 1 August 1960. S. L. Wood, J. B.



Figs. 1–4. Male terminalia, *Sphecomyiella valida*; 1. Oblique view, 2. Lateral view. *Sphecomyiella nelsoni*, 3. Oblique view, 4. Lateral view.

Karren, and H. Shurtleff, Madera Canyon, Paratypes, same data as holotype, 1 male, 1 female (CSU), 5 males, 9 females (BYU); Cochise Co., 18 July 1930 Leonora K. Gloyd, Huachuca Mts., 1 female (USNM); 1 August 1991, P. A. Opler, Harshaw Canyon, 7 miles SE of Patagonia, MVL, 2 males (CSU); Gila Co., 5 August, F. H. Parker, Pinal Mts., 2 females (USNM); same data but 12 July 1945, 1 male, 1 female (USNM); Gila Co., Globe, 23 July 1948, F. G. Werner and W. L. Nuttling, at light, 2 males (USNM); Graham Co., 17 July 1917, R. C. Shannon, Fort Grant, 1 male (USNM); Pima Co., 18 July 1938, J. Russell, Vail, 2 females (USNM); Santa Cruz Co., July 1919,



Figs. 5, 6. Female ovipositor apex; 5. *Sphecomyiella valida,* 6. *Sphecomyiella nelsoni.*

Kusche, Washington Mts., 1 male (USNM); 15 July 1920, Nogales, Washington Mts., 2 males, 2 females (USNM); 19 July 1938, R. H. Beamer, Santa Rita Mts., 1 male, 1 female (USNM); 10–26 July 1964, D. R. Davis, Madera Canyon, Bog Springs Campground, 1 male, 3 females (USNM); 30 July 1991, P. A. Opler, Madera Canyon, Santa Rita Lodge, UVL, 1 male (CSU).

Diagnosis.—Both sexes of *S. nelsoni* are similar to *S. valida* in habitus, but the male can be distinguished by the shape of the epandrium and the female by the apex of the ovipositor. In lateral and oblique view, the epandrium (Figs. 3, 4) of *S. nelsoni* is elongate and digitiform, whereas in *S. valida* it is broad and obliquely truncate (Figs. 1, 2). The ovipositor of *S. nelsoni* flares out near the tip (Fig. 6); whereas in *S. valida,* the tip tapers evenly to a point (Fig. 5).

Description.—*Male:* Face light brown except for antennal grooves, margins of oral cavity and frontal genal suture brownish black. Lower facial margin pale. Vertex brown with thin pale median stripe. Ocellar and postocellar bristles conspicuous (ocelli absent). Brown black spot at base of ocellar bristles. Antennae 2 mm, light brown, setae black on pedicel and scape. Short, fine erect yellow hairs on flagellum. Thorax pale yellow, mesonotum with five wide brown black stripes, lateral stripes restricted to postsutural scutum, sublateral stripes constricted or sometimes divided at transverse suture. Postpronotal lobes brown. Scutellum and moderately developed subscutellum brown. Wings 8–11.5 mm, mottled black with pale spots, covered with microtrichia. Costa and R_1 with setulae above. Longitudinal veins brown. Halters light brown. Abdominal tergites brown black, posterior margins with fine yellow hairs. Abdominal sternites reduced laterally, brown black. Pleural membrane red brown. Femur and tibia brown black, tarsi brown yellow. Tarsal claws brown basally, black distally. Postabdomen as Figs. 3 and 4.

Female: General coloration similar to male; wing length 7–11 mm. Sclerotized portion of oviposter elongate, flaring out near apex; base broadly rounded (Fig. 6).

Etymology.—The specific name honors Eugene E. Nelson, entomologist, Tri-River Area Extension Office, Colorado State University, Grand Junction, Colorado, whose Colorado collections stimulated this review.

Remarks.—Apparently *S. nelsoni* is restricted to southern Arizona, and may be associated with the numerous species of Melolonthinae and Rutelinae inhabitating the Arizona Uplands of the Sonoran desert. Many of the specimens examined were collected at light.

Sphecomyiella valida varies remarkably in size. Larger individuals are generally from eastern and central North America. A comparison of the terminalia of the smallest males and females, measuring 6.5–7.5 mm wing length (Colorado) to specimens measuring 10–14 mm wing length (eastern and central North America) indicated no important taxonomic differences. *Sphecomyiella valida* is a relatively common species throughout eastern and central North America and also occurs in northern Mexico, and the following records are representative of many specimens examined.

CANADA: Ontario, 7 May 1895, Port Hope, 1 female (USNM); ARKANSAS: Washington Co., 11 May 1927, D. G. Hall, 1 male (USNM); COLORADO: Delta County, 16 July 1992, E. E. Nelson, Paonia, light trap. 7 males, 5 females (CSU); CONNECTICUT: Lyme, 29 May 1910, W. R. Walton, 1 male, 1 female (USNM); FLORIDA: Duval Co., 17 April 1960, P. H. Thompson, Jacksonville, 1 male (USNM); Santa Rosa Co., 23 June 1973, W. W. Wirth, Blackwater R. St. Forest, 1 male (USNM); INDIANA: Tippecanoe Co., 11 May 1916, J. M. Aldrich, La Fayette, 1 male (USNM); IOWA: Johnson Co., 6 June 1937, J. P. Morrison, Iowa City, 1 male (USNM); KANSAS: Pottawatomie Co., fall 1895, F. F. Crevecoeuer, Onaga, 2 males (CSU); Sumner Co., no date E. G. Kelly, Wellington, 1 male (USNM); Shawnee Co., no date, Popenoe, Topeka, 1 male (USNM); ILLINOIS: Champaign Co., 11 June 1909, Urbana, 1 male (INHS); same data but 11 May 1915, 1 female (INHS); MASSACHUSETTS: Holotype male, *Sphecomyia valida,* MCZ type #26402; Essex Co., no date, Burgess, Beverly, 2 males (USNM); MARYLAND: Montgomery Co., Plummers Island 18 June 1905, W. L. McAtee, 1 female (USNM); same data but 12 June 1909, A. K. Fisher, 1 female (USNM); Camp Meade, 5 June 1919, R. C. Shannon, 1 male (USNM); MICHIGAN: Livingston Co., 5 June 1943, C. Sabrosky, E. S. George Reserve, 1 male (USNM); MISSISSIPPI: Jackson Co., June 1966, E. A. Richmond, Horn Island, 1 male (USNM); MISSOURI: Newton County, 27 June 1989, B. Kondratieff and M. Harris, George Washington Carver National Monument, 1 male (CSU); NEBRASKA: Otoe Co., 19 June 1969, W. W. Wirth, Dunbar, 1 male (USNM): NORTH CAROLINA: Macon Co., 3–8 June 1961, O. S. Flint, Jr., Highlands, 1 male (USNM); NEW JERSEY: Mercer Co., 7 April 1958, C. Fluck, 1 female (USNM); NEW YORK: Orange Co., 1 June 1908, W. Robinson, West Point, 1 male (USNM); Suffolk Co., 16 June 1911, A. Busck, Long Island, 1 male (USNM); Tompkins Co., 4 May 1961, D. Ferguson, Ithaca, 6 females (USNM); SOUTH CAROLINA: Barnwell Co., 15 June 1984, Kondratieff, SRS, 1 female (CSU); TENNESSEE: Montgomery Co., 25 May 1918, Clarksville, 1 male (USNM); TEXAS: Brazos Co., 2 March 1929, H. J. Reinhard, College Station, 1 male (USNM); Bexar Co., no date, W. William and N. M. McGuire, Camp Bullis Rd, 1 male, 1 female (USNM); Hemphill Co., 11–12 July 1974, E. L. Todd, Canadian Wildlife Mgt. Area, 1 male, 1 female (USNM); "CAROLINA:" Holotype female, *Pyrgota millepunctata,* MCZ type #13237. MEXICO: Coahuila, 17 July 1969, J. M. Mathieu, M. V. Sanderson and E. Friezer, Rancho la Encantada, Sierra de la Encantada, 1 male (INHS).

Acknowledgments

We sincerely thank Cleone T. Graham, Museum of Comparative Zoology, Harvard University for loan of types, and Dr. Allen L. Norrbom, Systematic Entomology Laboratory, USDA for his kind hospitality and providing critical material. Dr. Richard W. Baumann, Monte L. Bean Life Science Museum, Brigham Young University and Kathleen R. Methven, Illinois Natural History Survey, provided additional material. Quade H. Paul illustrated both species.

Literature Cited

Enderlein, G. 1942. Klassifikation der Pyrgotiden. Stzungsberichte. Gesellschaft Naturforschender Freunde zu Berlin, 2(1941): 98–134.

Hendel, F. 1933. Pyrgotidae. 36. *In* Lindner, E., ed., Die Fliegen der palaearktischen Region. Vol. 5. Stuttgart.

Mayer, H. 1953. Zwei neue Pyrgotidae (Diptera acalyptratae). Annalen des Naturhistorischen Museums in Wien 59: 220–222.

Steyskal, G. C. 1978. Synopsis of the North American Pyrgotidae (Diptera). Proceedings of the Entomological Society of Washington 80: 149–155.

———. 1987. Pyrgotidae, pp. 813–816. *In* McAlpine, J. F., B. V. Peterson, E. Shewell, G. E. Teskey, J. R. Vockeroth, and D. M. Wood, eds., Manual of Nearctic Diptera. Vol. 2. Agriculture Canada Monograph 28.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 558–561

A NEW SPECIES OF *GHILIANELLA* AND THE FEMALE OF *GHINALLELIA CLAVIVENTRIS* (BERGROTH) (HETEROPTERA: REDUVIIDAE: EMESINAE)

J. Maldonado Capriles

Professor Emeritus, Department of Crop Protection, College of Agricultural Sciences, University of Puerto Rico, Mayagüez, Puerto Rico 00681. Mailing address: Urb. Aponte 6 I 1, Cayey, Puerto Rico 00736.

Abstract.—The female of *Ghinallelia claviventris* (Bergroth) and *Ghilianella oblongata* n. sp. are described and illustrated. Wygodzinsky's (1966) key to the species in *Ghinallelia* is modified to accommodate *G. claviventris.* Both genera are Neotropical.

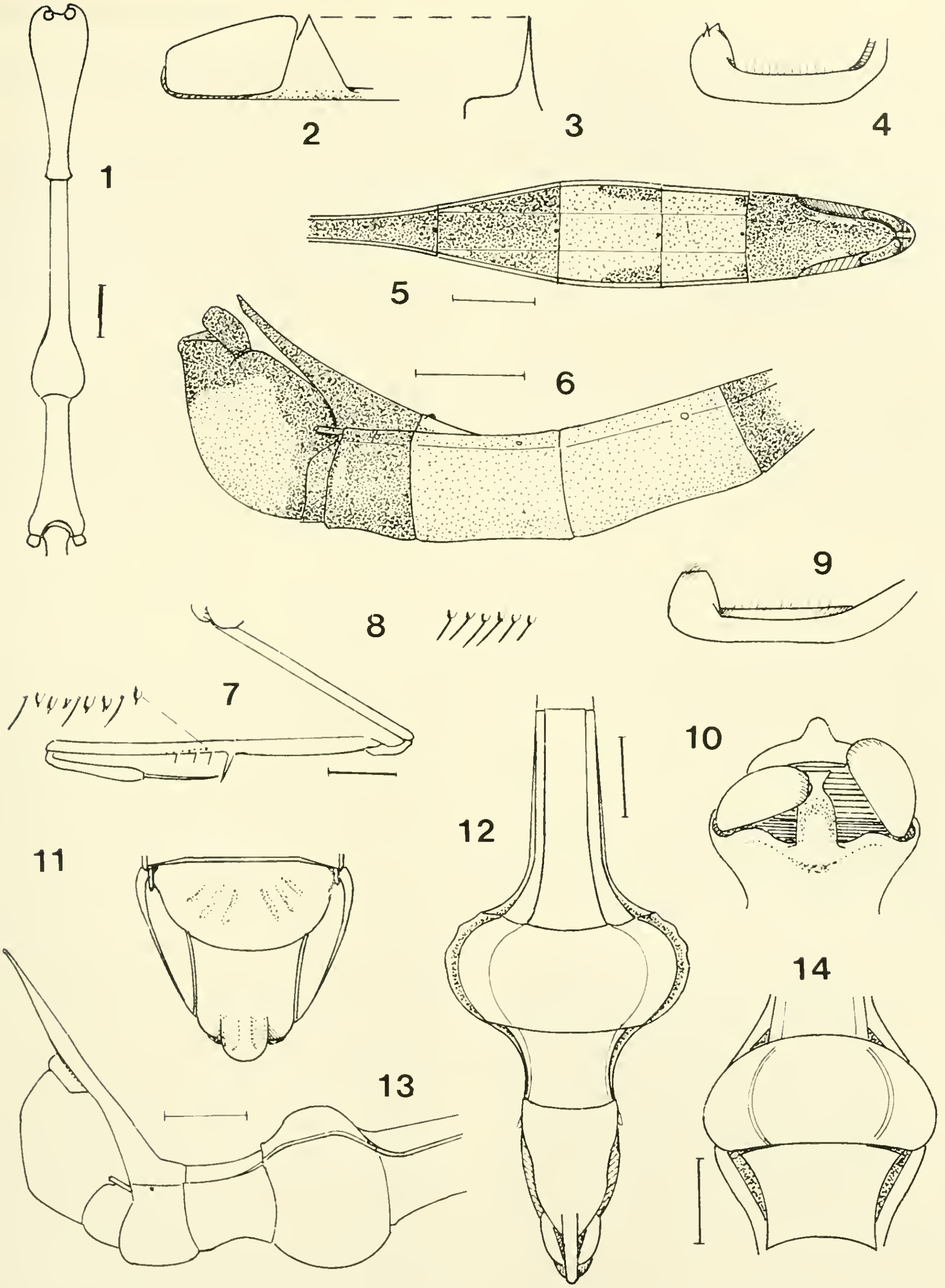
Key Words: Heteroptera, Reduviidae, female *Ghinallelia claviventris, Ghilianella oblongata* n. sp.

The specimens treated in this paper were discovered among reduviids kindly lent to me by Dr. Harry Brailovsky, from Universidad Nacional Autónoma de México. The repositories are indicated under the corresponding descriptions. All measurements are in mm.

Ghilianella oblongata Maldonado, New Species
Figs. 1–7

Male.—*Coloration:* Mostly black; abdominal segments 5 and 6 brownish yellow (Fig. 6), their terga with three small apical black areas (Fig. 5); apical margin of seventh sternum and hypopygium ventrally grayish yellow, both areas slightly darker than fifth and sixth sterna.

Head and body sparsely granulose. Body with moderately abundant short, decumbent, silvery pilosity. Head densely covered with yellow, decumbent scalelike setae; this type of setae scarce on thoracic segments, lacking in abdomen. Head—length 1.81, anterior lobe from interocular sulcus to apex 0.69, width across eyes 1.0, eyes width 0.25, interocular space 0.56; interantennal spine broad basally, short, horizontal. Antennal segments: I, 9.88; II, 7.75; III, 1.25; IV, 1.13; glabrous. Rostral segments: I, 0.50; II, 0.53; III, 1.13. Fore legs (Fig. 7): coxa 3.81, trochanter 0.88, femur 5.63, tibia 1.63; tarsus 1.31, unsegmented; claws two, outer curved, much longer than inner one, inner adpressed to base of outer; armature of femur—first posteroventral spine about three times its length from base; anteroventral series (Fig. 7) with alternating long and short setigerous spines and irregularly placed setae, the last ¼ of the series with consecutively shorter spines. Thorax (Fig. 1): lengths of segments 2.88, 3.94, 2.19; anterior segment the thickest, with a caudal slightly bigibbous elevation; prosternum with a shallow v-shaped apical notch. Abdomen (Figs. 5, 6): oblong after narrow first segments; slightly widening to apex of third segment, fourth widening to apex, fifth the widest, tapering from fifth to basal half of seventh; terga inside lateral margins of abdomen; third to sixth terga with small wart at middle of posterior margin; lateral posterior angles of terga fourth to sixth slightly raised above level of following tergum; seventh tergum



Figs. 1–14. 1–7. *Ghilianella oblongata* Maldonado, n. sp., male holotype. 1, thorax, dorsal aspect; 2, paramere and hypopygial spine, caudal aspect; 3, hypopygial spine, lateral aspect; 4, paramere, dorsal aspect; 5, abdomen, dorsal aspect; 6, abdomen, lateral aspect; 7, fore leg, detail of anteroventral series. 8–14. *Ghinallelia claviventris* (Bergroth). 8, setae of anteroventral series of fore femur; 9, paramere, male, dorsal aspect; 10, apex of hypopygium, male, caudal aspect; 11, genital segments, female, caudal aspect; 12, last abdominal segments, male, dorsal aspect; 13, last abdominal segments, male, lateral aspect; 14, fifth and sixth abdominal terga, female, dorsal aspect. All scale lines equivalent to 1 mm.

raised toward apex, narrowing from basal third to acute apex and almost reaching level of apex of parameres, transversely rugose, rugosities fine on basal half, thicker on apical half. Hypopygium opening upward; apical spine triangular, flat, vertical, hidden by parameres; parameres relatively deep and thin, incurved (Figs. 2–4). Overall length 17.1–17.3.

Holotype: Male, ECUADOR, Pichincha prov., Tinalandia, 10 km east of Santo Domingo de los Colorados, ca 2500 ft, 11–17.v.1986, J. E. Eger coll.; in National Museum of Natural History (NMNH), Washington, DC. Paratypes: 3 males, same data, one in UNAM, two in the author's collection.

The combination of an oblong abdomen in dorsal view, and pale-colored abdominal segments 5 and 6 is unique. The species keys close to *G. gladiator* McAtee and Malloch in Wygodzinsky's key (1966: 474). The abdomen of *G. oblongata* is slightly widest at segment 5 and in *G. gladiator* it is conspicuously widest at segment 5. Consequently, the second part of couplet 29 of the key must be modified and shortened to read: "Abdomen widest at level of third, fourth or fifth (missing in key) segment . . . 34a." Then:

34a. Seventh tergum relatively broad subapically, not surpassing apex of pygophore; abdominal segments 5 and 6 pale colored; abdomen slightly widest at segment 5 . . . . *G. oblongata* Maldonado n. sp.

Seventh tergum remarkably slender and elongate, projecting beyond apex of pygophore at least by length of latter; abdomen uniformly colored or terga with a pair of small round spots of pile on hind margin 34b

34b. Abdomen widest across fourth segment, etc. . . . . *G. assanutrix* Bergroth

Abdomen widest across fifth segment, etc. . . . . *G. gladiator* McAtee & Malloch

Ghinallelia claviventris (Bergroth)

Figs. 8–14

Ghilianella claviventris Bergroth, 1906: 318, male, Venezuela.

Ghinallelia claviventris: Wygodzinsky, 1966: 488.

Female.—Head, pronotum, antennae, middle and hind tibiae dark brown. Fore legs, middle and hind femora, abdomen brown. Body almost glabrous, microsetae very scarce except at base of head and on thoracic segments. Head and thorax granulose.

Head: Length 2.00, anterior lobe of head length 1.06, posterior lobe of head 0.94, width across eyes 1.00; eyes small, distant from upper and lower margins of head, width of eye 0.19, interantennal spine wide basally, horizontal; lateral margins of posterior lobe slightly bisinuous; collum poorly defined. Antennal segments: I, 11.11; II, 9.22; very short microsetose, others missing. Rostrum: I, 0.25; II, 0.56; III, 2.50; apex of second reaching midlength of eye. Fore legs general shape as in Fig. 7: coxa 4.06, trochanter 0.88, femur 6.06, tibia 1.81, tarsi 1.56; claws: internal long, external very small and adpressed to internal; both series of armature of femur arising at three times the length of the first spine, anteroventral series consisting of fine setae arising from small, wart like bases (Fig. 8), not interrupted basally, the longest less than half length of first, irregularly interspersed with long setae; first spine of posteroventral series 1.3 times diameter of segment. Thoracic segments: 2.94, 3.63, 2.56; pronotum narrowing to base, meso- and metanotum broader basally. Abdomen: gradually widening to basal fourth of fourth, thence abruptly widening to apex of segment; fifth forming widest part of bulbosity (Fig. 14); sixth broad basally, narrower apically, sides and apical margin slightly concave. Genital segments: eighth tergum semicircular, half as long as seventh; ninth tergum slightly longer than eighth, with a tongue-like, short, slightly elevated, apical projection (Fig. 11). Overall length 26.5 mm.

Specimens studied: female, La Trilla, VENEZUELA, 10.vii.81; in the collection of the Institute of Biology at the Universidad Nacional Autonoma, Mexico. A male collected at the same time and place, in the author's collection.

Both sexes of *Ghinallelia claviventris* coincide in the shape and pilosity of the thorax and by having the bulbous abdominal segment formed by the fifth segment mostly. This last character identifies the species. The female runs to couplet 23 of Wygodzinsky's key together with *G. globifera* (Bergroth). The abdomen of the latter is oblong, hence the trivial name, and the second segment is slightly wider than the others. Details of abdomen and genitalia of the male of the former are illustrated in Figs. 9, 10, 11, 13. The male of *G. globifera* has a bulbous abdominal swelling but the widest part is formed by the fourth segment.

LITERATURE CITED

Bergroth, E. 1906. Zur kenntnis der Ploeariinen. Verhandlungen der Kaiserlich-Königlichen Zoologisch-botanischen Gessellschaft in Wien 56: 304–321.

Wygodzinsky, P. 1966. A Monograph of the Emesinae (Reduviidae, Hemiptera). Bulletin of the American Museum of Natural History 133: 1–614.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 562–563

REDESCRIPTION OF *NESOCASTOLUS NIGROCORIS* (FRACKER AND BRUNER) AND NOTES ON THE GENUS (HETEROPTERA: REDUVIIDAE: HARPACTORINAE)

J. MALDONADO CAPRILES

Professor Emeritus, Department of Crop Protection, College of Agricultural Sciences, University of Puerto Rico, Mayaguëz, Puerto Rico 00681. Mailing address: Urb. Aponte 6 I 1, Cayey, Puerto Rico 00736.

Abstract.—The holotype and paratypes of *Nesocastolus nigrocoris* (Fracker and Bruner) were examined. Differentiating characters between this species and *Castolus* Stål are given.

Key Words: *Nesocastolus nigrocoris, Castolus* sp., Reduviidae

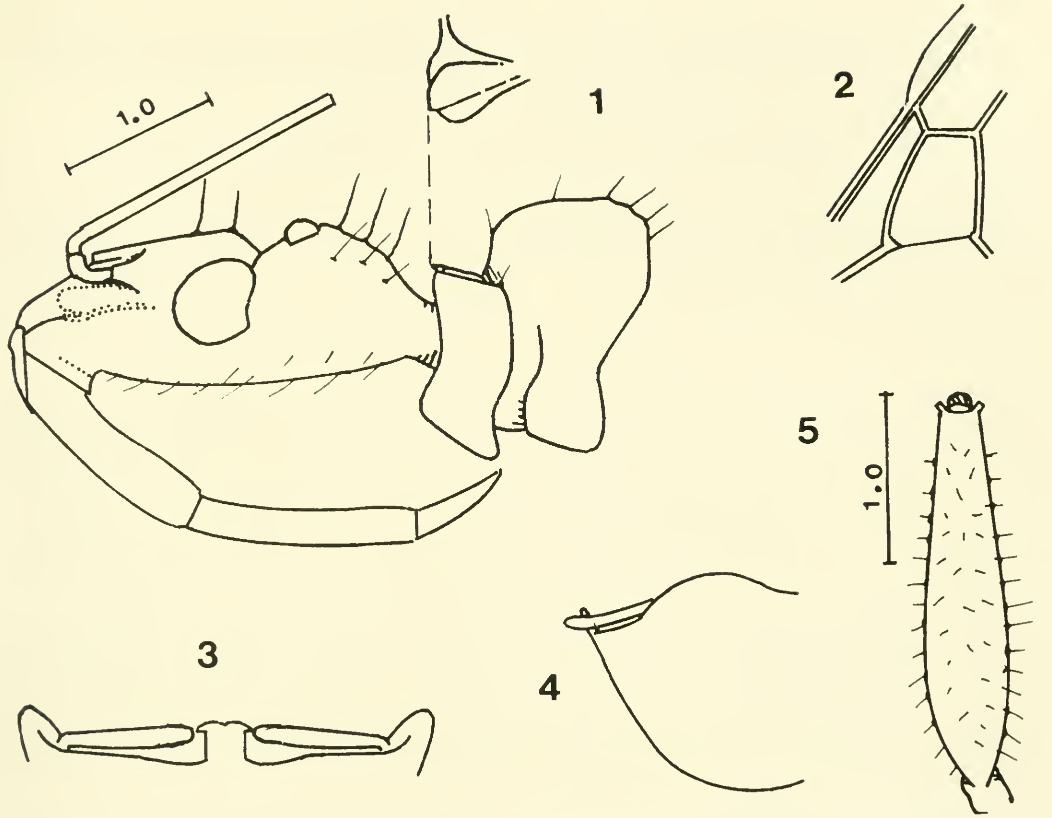
---

Bruner and Barber (1937) erected the genus *Nesocastolus* to include *Castolus multicinctus* var. *nigrocoris* Fracker and Bruner, 1924, known only from Cuba. They gave this variety species rank and designated it the type of the genus. They studied seven other specimens four of which, besides the female holotype, are at the National Museum of Natural History (NMNH) in Washington, D.C. The specimens are from Santiago de las Vegas, El Cano, and Caibaren. Herein I describe the male and compare the three other specimens with the type. The species is quite variable, within a given geographic locality, so, no subspecific names should be given to these forms. In the notes that follow all measurements are in mm.

The specimens at NMNH are labeled as follows: female holotype, Santiago de las Vegas, S. C. Bruner, no date; specimens compared with type: female, Santiago de las Vegas, Habana, EEA, Cuba, April 26, 1926, S. C. Bruner; female, El Cano, Cuba, EEA, Nov. 20, 1931, S. C. Bruner; female, Santiago de las Vegas, May 25, 1924, B. Barreto and a male, labeled Santiago de las Vegas, May 26, 1921, BTB(arreto).

Nesocastolus, as mentioned by Bruner and Barber, looks close to *Castolus.* The latter has the first antennal longer than the second and much longer than head, first rostral segment longer than second and setae without enlarged bases. The setae of *Nesocastolus* arise from low conical bases. I expand their notes about how to differentiate these two genera and I add a few other characters.

All comparisons refer to species of *Castolus.* Anterior femora shorter and stouter (3.18; 0.62 at thickest point, prebasal, Fig. 5), and shorter as compared with thorax (2.63, 3.18). The hemelytra of females at most slightly surpass the abdomen, whereas in *Castolus* they surpass it by close to 2.00. In the latter genus the apex of the pterostigma almost reaches the apex of the abdomen, a useful generic character. The discal cell of the corium is unusually quadrangular (Fig. 2). It is elongate in most neotropical genera. The genus lacks a mesopleural plica, an important character not mentioned by the authors of both papers. The anterior lobe of the pronotum raises almost vertically behind the collar (Fig. 2). The moderately long, fine, vertical setae of the head, legs, and thorax arise from low, conical bases that give the corresponding margin a slight but clear, seemingly undulate appearance (notice upper margin of head and pronotum,



Figs. 1–5. *Nesocastolus nigrocoris* (Fracker and Bruner); female. 1, head and pronotum, lateral aspect, with dorsal detail of anterior angle of pronotum. Male holotype. 2, corial discal cell; 3, hypopygial margin, caudal aspect; 4, hypopygium, lateral aspect; 5, profemur, dorsal aspect.

Fig. 1). Species of *Castolus* typically have short, slender parameres, with their apices well separated from the hypopygial caudal spine and a group of setae between them. The parameres of *Nesocastolus nigrocoris* reach the hypopygial spine and the hypopygial margin lacks a group of setae (Figs. 3, 4).

The other three females studied vary in coloration from the described female. The female collected in 1924 by Barreto, has a mostly red head, both lobes of thorax red, hemelytra red with black membrane, basal half of femora red, and mostly black sterna. The male has the posterior lobe of the pronotum black, the head mostly black, black hemelytra except for reddish humeral angles, tibia red basally, and mostly red abdominal sterna. This specimen has a swollen gular region that gives the head an oval outline on lateral view. This swelling, not mentioned by Bruner and Barber, is probably an abnormality, but if not it would be an excellent differentiating character. In all the female specimens (Fig. 1) the lower and upper surfaces of the head are subparallel.

LITERATURE CITED

Bruner, S. C. and H. G. Barber. 1937. Additional notes on Cuban Reduviidae (Hemiptera—Heteroptera). Memorias de la Sociedad cubana de Historia Natural 11: 181–190.

Fracker, S. B. and S. C. Brunner. 1924. Notes on some neotropical Reduviidae. Annals of the Entomological Society of America 17: 163–174.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 564–573

NEW SPECIES AND RECORDS OF COSTA RICAN *AUSTROTINODES* (TRICHOPTERA: ECNOMIDAE)

Fernando Muñoz Q. and Ralph W. Holzenthal

(FMQ) Instituto Nacional de Biodiversidad, INBio, Apartado 22-3100, Santo Domingo de Heredia, Costa Rica; (RWH) Department of Entomology, University of Minnesota, St. Paul, Minnesota 55108, U.S.A.

Abstract.—Two new species of *Austrotinodes* (Trichoptera: Ecnomidae) from Costa Rica are described and illustrated: *A. doublesi* and *A. inbio.* In addition, *A. contubernalis* Flint and Denning and *A. panamensis* Flint are illustrated and recorded from Costa Rica for the first time. *Austrotinodes sedmani* Flint is illustrated and new distribution records in Costa Rica are documented. Finally, a key to the males of Costa Rican *Austrotinodes* is presented.

Resumen.—Dos nuevas especies de *Austrotinodes* (Trichoptera: Ecnomidae) de Costa Rica se ilustran y describen: *A. doublesi* y *A. inbio.* Además, se ilustran y reportan por primera vez para Costa Rica *A. contubernalis* Flint y Denning y *A. panamensis* Flint. Se ilustra y documenta un nuevo reporte de distribución en Costa Rica de *A. sedmani* Flint. Finalmente, se presenta una clave para la identificación de los machos de las especies de *Austrotinodes* de Costa Rica.

Key Words: Trichoptera, *Austrotinodes,* new species, Costa Rica

---

Schmid (1955) established the genus *Austrotinodes* for two species from Chile. Flint (1973) presented a review of the genus and descriptions of four new species, three of them from Mexico and Central America. In 1989, Flint and Denning reexamined the genus and presented a list of the known species. They described fourteen new species, and presented new records, including *A. sedmani* Flint as the first record of the genus for Costa Rica. Collections made in Costa Rica from 1986 through 1992 by Holzenthal and his colleagues resulted in new distribution records for Costa Rica, as well as two new species. In this paper, we describe these two species, present the new distribution records for Costa Rica, and provide a key for the species of Costa Rican *Austrotinodes.* Terminology used for genitalic structures follows that presented by Flint and Denning (1989). This paper represents the results of an ongoing project, sponsored by the National Science Foundation, the University of Minnesota Insect Collection, and the Instituto Nacional de Biodiversidad (INBio) of Costa Rica, to discover and describe the caddisfly fauna of Costa Rica. Types of species described and other specimens examined are deposited in the collections of the University of Minnesota Insect Collection, St. Paul, Minnesota (UMSP), Instituto Nacional de Biodiversidad, Costa Rica (INBio) and the National Museum of Natural History, Smithsonian

Institution, Washington, D.C. (NMNH). All specimens are pinned unless otherwise noted.

Austrotinodes doublesi Muñoz and Holzenthal, New Species

Fig. 1

Diagnosis.—This new species can be distinguished from all other species of the genus by the unusual shape and large size of the phallic guide. Also, the intermediate appendage is long and simple with a single apical seta and the shape of lobe "a" of the inferior appendage is enlarged and is rounded basally and thin apically.

Description.—*Male:* Forewing length 4 mm. Body sclerites generally pale brown, dorsum of head with light setae. Thorax dark brown dorsally, pale brown ventrally. Leg segments with brown setae. Forewings covered with fine, brown setae and with small scattered patches of lighter brown setae, principally along the costal margin. *Genitalia* (Fig. 1): Segment IX deeply divided, sternum elongated; in lateral view, very narrow basally, enlarging apically, ventral margin slightly convex; in ventral view, apical margin convex. Phallic guide very heavily sclerotized, large, elevated and arched over inferior appendages, apex sharply pointed, in lateral view, reaching middle of lobe "b" of inferior appendage. Inferior appendages attached subapicomesally on sternum IX, reduced, fused mesally; in ventral view, posterior margin with mesal emargination; in lateral view, lobe "a" rounded basally and lobe "b" slightly elevated and rounded, darkened. Tergum X divided into pair of semimembranous oval lobes, in lateral view, each part with dorsum convex, posterior margin with weak mesal emargination, bearing slender setae along inner margin. Preanal appendage long, broad, parallel-sided, apex broadly rounded, margins crenulated, surface setose. Intermediate appendage long, approximately length of preanal appendage, slender, simple, slightly curved, bearing an enlarged apical rugose seta. Phallus with sclerotized base and membranous apical region; lateral process of phallus long, slender, enlarging to rounded apex, subapically with an enlarged curved seta; apical region with few short setae and slender, slightly darkened membranous apical lobe, bearing an enlarged rugose seta.

Type material.—*Holotype:* Male, Costa Rica: Parque Nacional Guanacaste, Estación Pitilla, Río Orosí, 10.991°N, 85.428°W, 700 m, 19–20.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH). *Paratypes:* Costa Rica: Guanacaste: Parque Nacional Guanacaste, Estación Maritza, Río Tempisquito, 10.958°N, 83.497°W, 550 m, 19–20.vii.1987, Holzenthal, Morse, Clausen, 1 male (UMSP); same except, ca. 0.7 km N Est. Maritza, 10.96°N, 85.50°W, 550 m, 31.viii.1990, Huisman and Quesada, 2 males (in alcohol) (UMSP, INBio).

Etymology.—Named in honor of our close friend Mr. James C. Doublés, whose tragic death saddened us deeply and ended a promising career in trichopterology.

Austrotinodes inbio Muñoz and Holzenthal, New Species

Fig. 2

Diagnosis.—This species is closest to *A. fortunata* Flint and Denning and *A. contubernalis* Flint and Denning, differing from those species in the shape and setation of the intermediate appendage. In *A. inbio*, the intermediate appendage is slender and tubular with a very long mesoventral seta, but it lacks the mesodorsal seta of *A. contubernalis* and the apical seta of *A. fortunata*. In addition, in the new species sternum IX is longer than in *A. contubernalis*. Also, the shape of the apical margin of the inferior appendages is different among the three species when viewed ventrally; in the new species it is essentially straight, in *A. fortunata* it is convex mesally, and in *A. contubernalis*

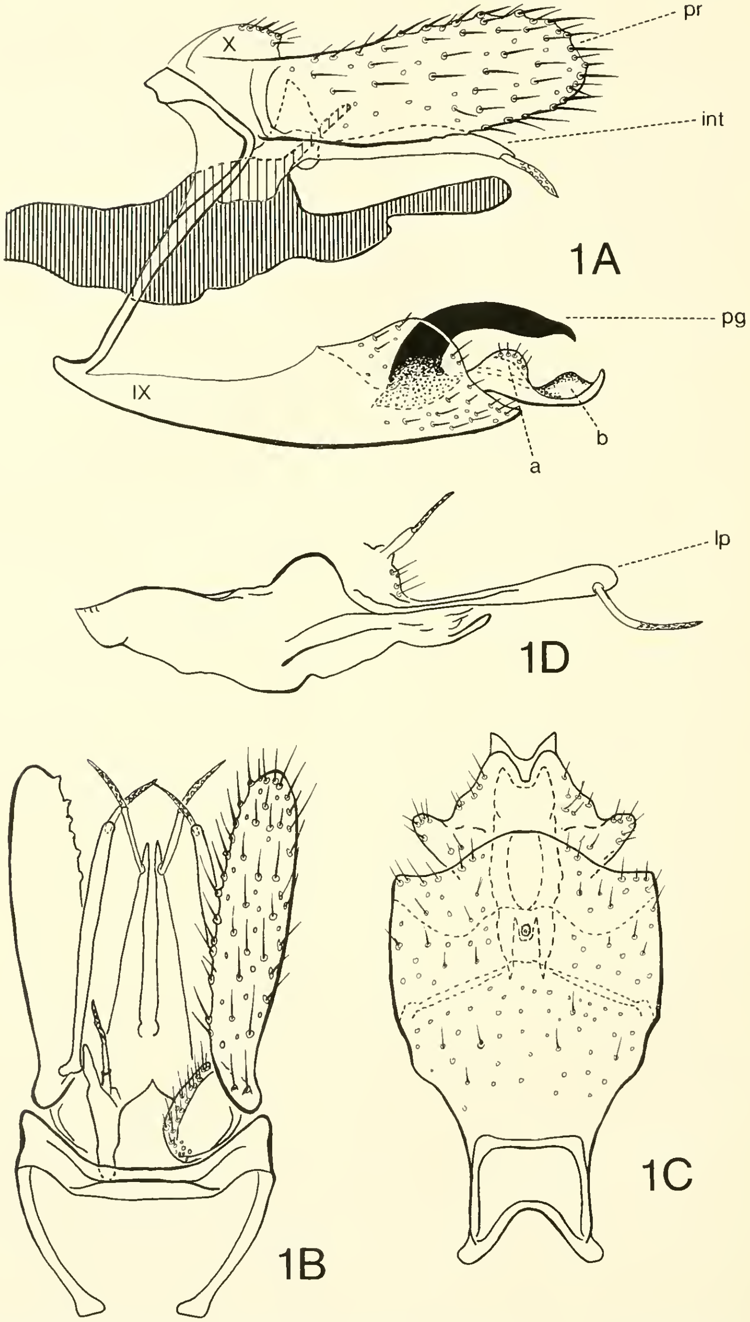


Fig. 1. *Austrotinodes doublesi,* new species, male genitalia: A, lateral view. B, dorsal view. C, ventral view. D, phallus, lateral view. Abbreviations: a = lobe "a" of inferior appendage; b = lobe "b" of inferior appendage; int = intermediate appendage; lp = lateral process of phallus; pg = phallic guide; pr = preanal appendage; IX = abdominal sternum IX; X = abdominal tergum X.

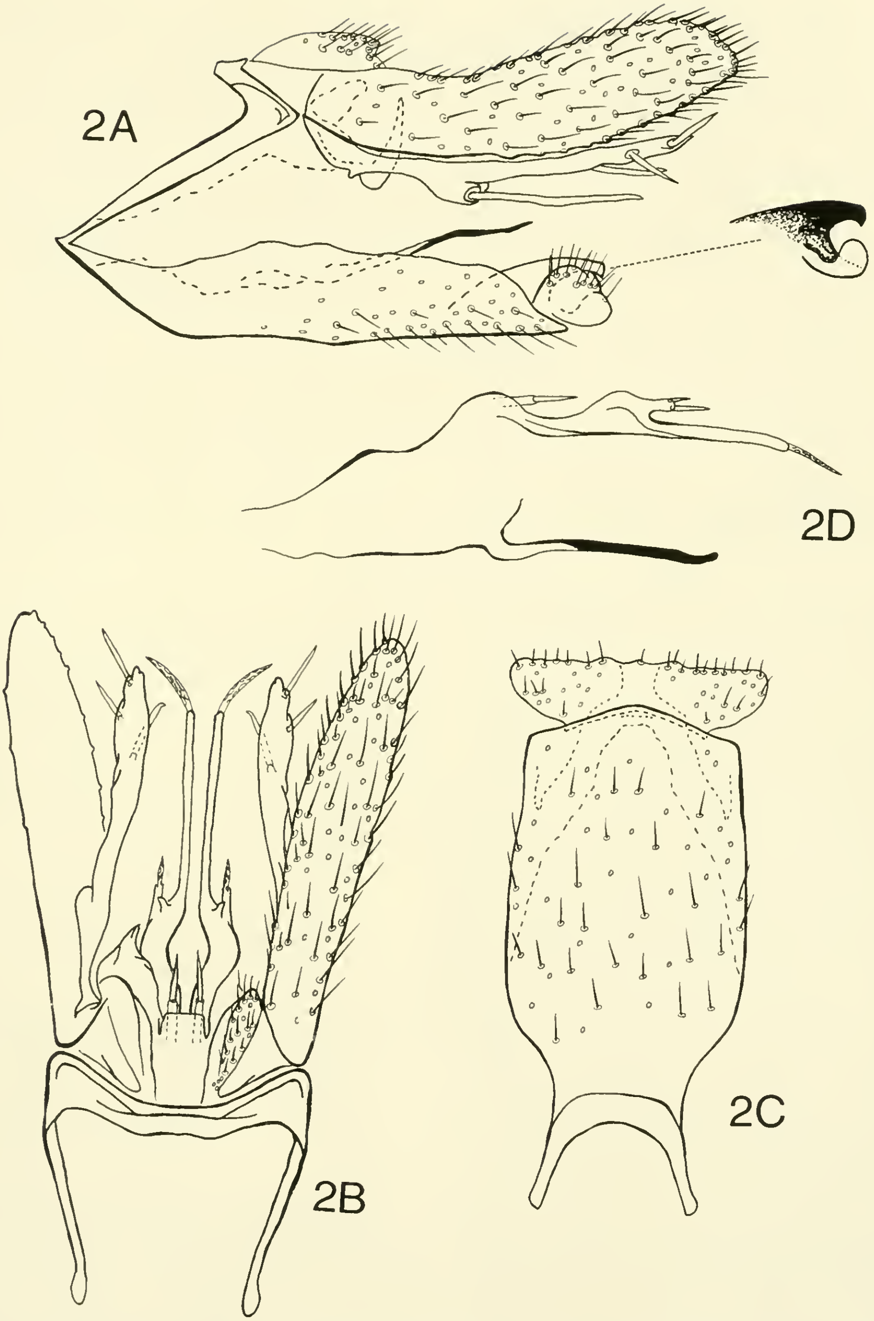


Fig. 2. *Austrotinodes inbio,* new species, male genitalia: A, lateral view (inset: phallic guide). B, dorsal view. C, ventral view. D, phallus of the paratype, lateral view.

it has a mesal emargination. Finally, the shape and setation of the lateral process of the phallus also differ between the three species; in *A. inbio* the lateral process is enlarged and curved basally, in *A. fortunata* it is slender and straight basally. The lateral process of the phallus of the new species bears a curved seta apically and in *A. contubernalis* it bears a straight, subapical pointed seta.

Description.—*Male:* Forewing length 4 mm. Body sclerites pale brown, dorsum of head and thorax dark brown with pale yellow and brown setae, thorax light brown ventrally. Leg segments with brown setae. Forewings covered with fine, brown setae and with small scattered patches of lighter brown setae, principally along the costal margin. *Genitalia* (Fig. 2): Segment IX deeply divided, sternum elongated; in ventral view, about 2 times as long as wide; in lateral view, enlarging medially, ventral margin curved basally; in ventral view, apical margin convex. Phallic guide sclerotized, darkened, dorsal margin convex, ventral margin strongly concave; apex with inferior corner pointed, reaching tip of lobe "b" of inferior appendage. Inferior appendages attached subapicomesally on sternum IX, reduced, fused mesally; in ventral view, slightly wider than sternum IX, with apical margin essentially straight, lateral margins curved; in lateral view, lobe "a" rounded and lobe "b" slightly elevated and rounded. Tergum X divided into pair of semimembranous oval lobes; in lateral view, each lobe with dorsal margin convex, posterior margin with weak mesal emargination; bearing slender setae along inner margin. Preanal appendage long, roughly parallel-sided, but narrowest basally, apex rounded, margins crenulated, surface setose. Intermediate appendage long, approximately length of preanal appendage, slender, tubular; basoventrally with short spurlike projection; mesoventrally with enlarged, very long seta; subapically with 3 enlarged setae. Phallus with sclerotized base and membranous apical region; in dorsal view, lateral process of phallus enlarged and curved basally with a short mesodorsal spurlike projection bearing 2 apical setae; apically, lateral process long, slender, straight, bearing a curved, enlarged, rugose seta apically; dorsally, phallus with a short projection bearing an enlarged seta; in lateral view, apicoventral lobe of phallus long, very slender, darkened.

Type material.—*Holotype:* Male, Costa Rica: Alajuela: Reserva Forestal San Ramón, Río San Lorencito and tribs., 10.216°N, 84.607°W, 980 m, 24–27.ii.1987, I. & A. Chacón (NMNH). *Paratype:* Costa Rica: Guanacaste: Parque Nacional Guanacaste, Maritza, Río Tempisquito Sur, 10.95°N, 85.84°W, 600 m, 30.viii.1990, Huisman & Quesada, 1 male (in alcohol) (UMSP).

Etymology.—Named for the Instituto Nacional de Biodiversidad de Costa Rica or "INBio" and dedicated to the parataxonomists, curators, collaborators and administrators who have helped us during our studies. The goal of this unique institution is to survey and document the biodiversity of Costa Rica.

Austrotinodes contubernalis
Flint and Denning
Fig. 3

Austrotinodes contubernalis Flint and Denning 1989: 116, figs. 25–27, male, Panamá (NMNH).

Distribution.—Panamá, Costa Rica (new record).

Diagnosis.—This species is close to *A. inbio,* new species, and *A. fortunata* Flint and Denning from Panamá. The apicoventral lobes of the phalli are similar among the three species, but in *A. contubernalis* it is curved, with an enlarged and rounded apex. Also, *A. contubernalis* can be distinguished from the other species by the straight, subapical seta of the lateral process of the phallus; in the other species these setae are apical. The intermediate appendage of *A.*

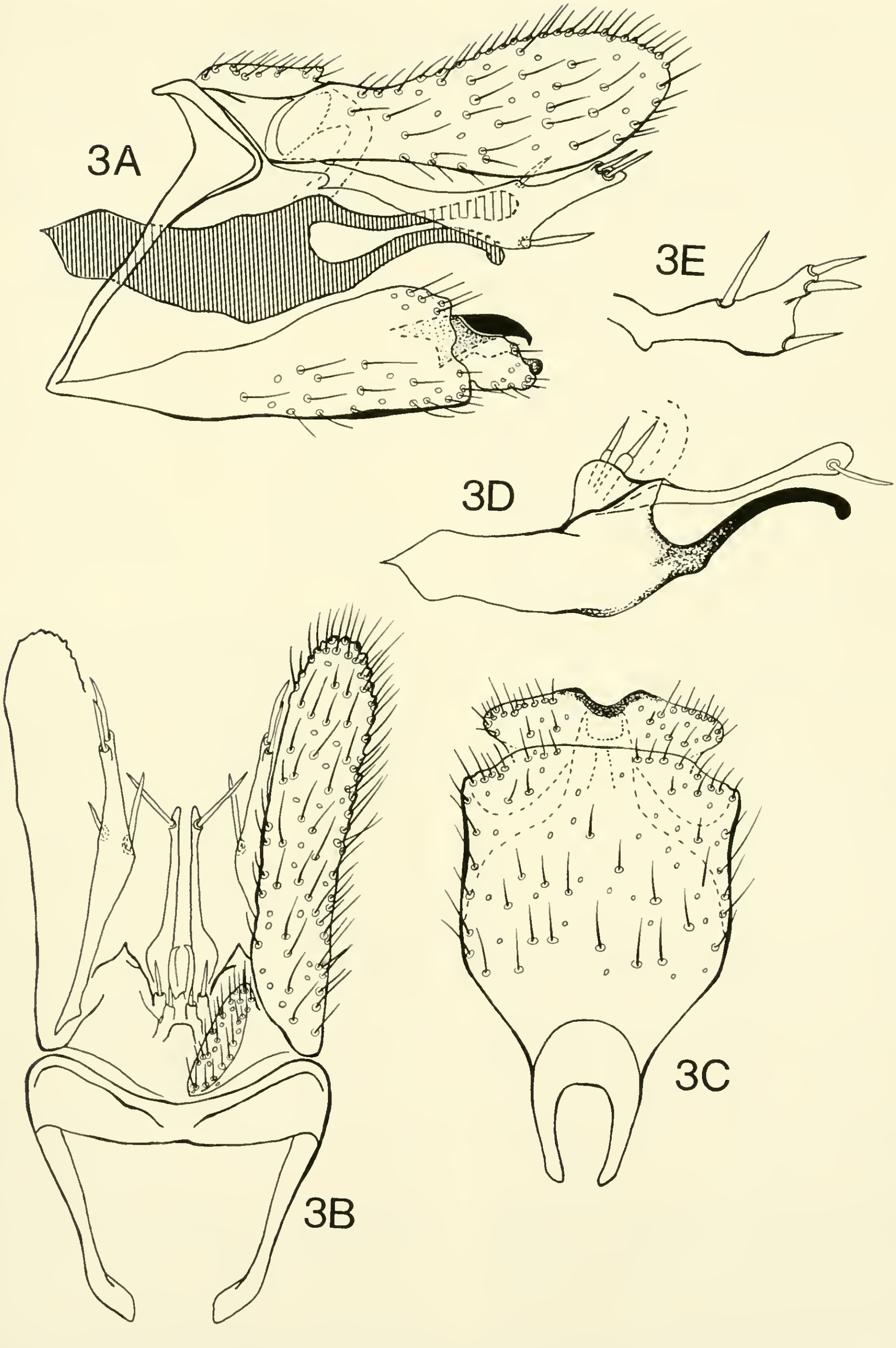


Fig. 3. *Austrotinodes contubernalis,* Flint and Denning, male genitalia: A, lateral view. B, dorsal view. C, ventral view. D, phallus, lateral view. E, intermediate appendage (from Río Jaba), lateral view.

contubernalis has a mesodorsal seta that is absent in the other two species. Finally, the example from Río Jaba varies from the other examples in the form of the intermediate appendage, in that it is very enlarged apically (Fig. 3E). Also, the apex of the apicoventral lobe of the phallus is slender and pointed.

New distribution records.—Costa Rica: Cartago: Reserva Tapantí, Quebrada Palmitos and falls, 9.72°N, 83.78°W, 1400 m, 2–3.vi.1990, Holzenthal, Blahnik, Muñoz, 2 males, 2 females (UMSP); same, except 23.viii.1990, Holzenthal, Huisman, 1 male (INBio); Puntarenas: Parque Nacional Corcovado, Piedra el Arco, 8.582°N, 83.709°W, 20 m, 10–11.iv.1989, Holzenthal and Blahnik, 1 male (UMSP); Río Jaba at rock quarry 1.4 km W (air) Las Cruces, 8.79°N, 82.97°W, 1150 m, 9.viii.1990, Holzenthal, Blahnik, Muñoz, 1 male, 1 female (UMSP).

Austrotinodes panamensis Flint
Fig. 4

Austrotinodes panamensis Flint 1973: 138, figs. 25, 26, male, Panamá (USNM); Flint and Denning 1989: 109, 112.

Distribution.—Panamá, Costa Rica (new record).

Diagnosis.—This species is closest to *A. sedmani* Flint. It differs most from *A. sedmani* in the shape and setation of the intermediate appendage. In *A. panamensis*, the intermediate appendage, in lateral view is curved and enlarged apicoventrally; in dorsal view, the apical margin has a curved emargination and bears three apical setae. Also, in *A. sedmani*, the intermediate appendage is narrow throughout its length in lateral view and, in dorsal view, is abruptly bent mesally and bears three apical setae that are shorter than in *A. panamensis*.

New distribution records.—Costa Rica: Guanacaste: P[arque] N[acional] Guanacaste, Estación Maritza, Río Tempisquito, 10.958°N, 85.497°W, 550 m, 30–31.viii.1990, Huisman, Blahnik, Quesada, 1 male (in alcohol) (UMSP). Puntarenas: Parque Nacional Corcovado, Estación Sirena, Río Camaronal, 8.482°N, 83.589°W, 30 m, 13.iv.1989, Holzenthal and Blahnik, 1 male (INBio); Reserva Biológica Carara, Quebrada Bonita, 9.775°N, 84.605°W, 35 m, 18–20.v.1990, Holzenthal and Blahnik, 5 males (3 in alcohol) (UMSP).

Austrotinodes sedmani Flint
Fig. 5

Austrotinodes sedmani Flint 1973: 140: figs. 21–24, male, Guatemala (USNM); McElravy et al. 1981: 152 (as *Austrotinodes* undescribed sp. "A"); McElravy et al. 1982: 307; Flint and Denning 1989: 109, 110, figs. 7–9 (redescription).

Distribution.—Guatemala, Panamá, Costa Rica.

Diagnosis.—This species is closest to *A. panamensis* Flint, differing from that species in the shape and setation of the intermediate appendage as described in the diagnosis of *A. panamensis*. According to Flint and Denning (1989), there is variability of the genitalia of the species, but there does not appear to be any pattern in the variations. Variation occurs in the intermediate appendage, the lateral process of the phallus, and the inferior appendage. The intermediate appendage varies in the apical region where it may be very enlarged and with or without an apical emargination. The lateral processes of the phallus vary principally in the shape of the apical setae, which are enlarged in the Costa Rican example from Quebrada Sanguijuela. The inferior appendages of the newly collected material are similar to the northern examples, but with a slight mesal emargination in ventral view.

New distribution record.—Costa Rica: Puntarenas: Reserva Biológica Carara, Quebrada Binita, 9.775°N, 84.605°W, 35 m, 11.iii.1991, Holzenthal, Muñoz, Huisman, 1 male (UMSP); San José: Parque Nacional Braulio Carrillo, Estación Carrillo, Quebrada Sanguijuela, 10.160°N, 83.963°W, 800

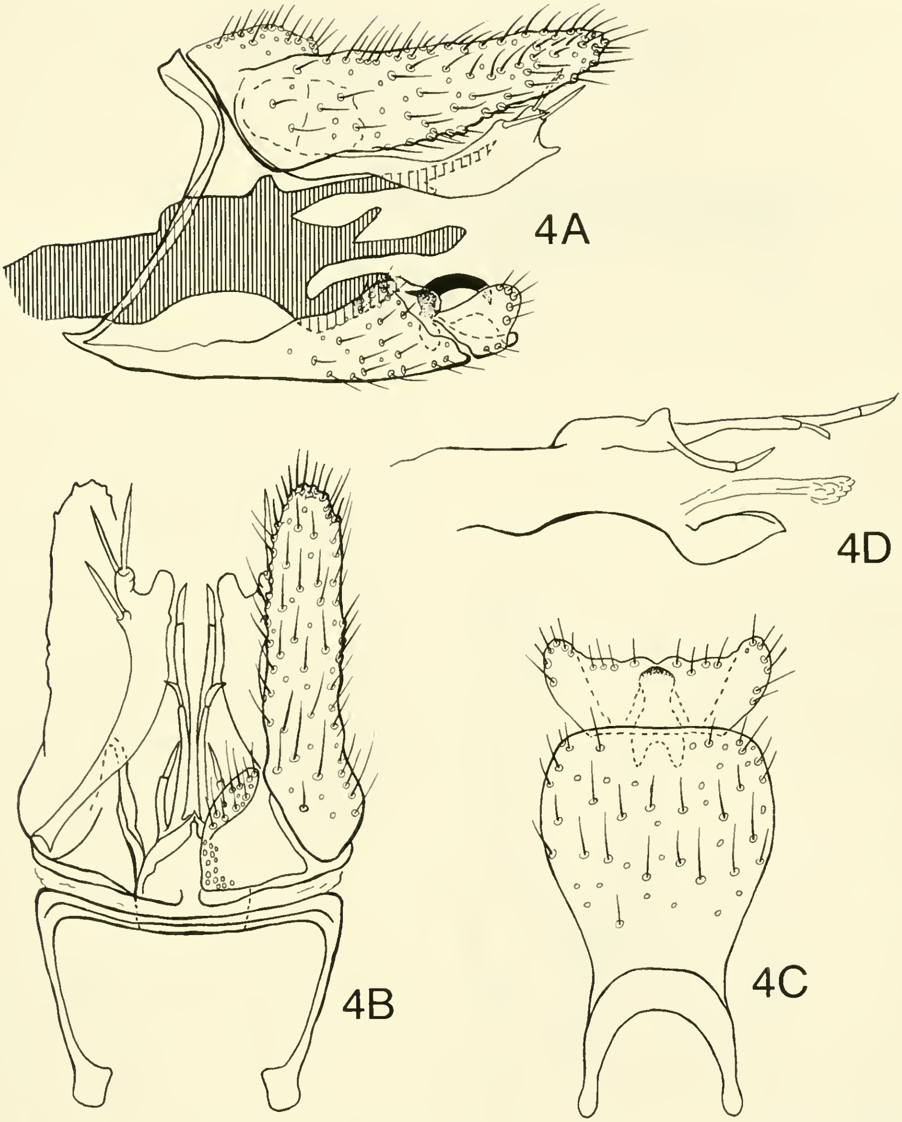


Fig. 4. *Austrotinodes panamensis*, Flint, male genitalia: A, lateral view. B, dorsal view. C, ventral view. D, phallus, lateral view.

m, 22–28.viii.1986, I. and A. Chacón, 1 male (UMSP).

KEY TO THE MALES OF COSTA RICAN *AUSTROTINODES*

1. Intermediate appendage long, slender throughout its length, simple, bearing only a single apical seta; phallic guide very large, very dark (Fig. 1) . . . . *A. doublesi*

– Intermediate appendage long, generally enlarging apically, bearing several apical and subapical setae; phallic guide much smaller than above, dark 2

2. Phallus with apicoventral lobe short, rounded, lightly sclerotized; two pairs of lateral processes of phallus, each slender and straight (best seen dorsally) and a pair of short, dorsobasal processes 3

– Phallus with apicoventral lobe long, slender,

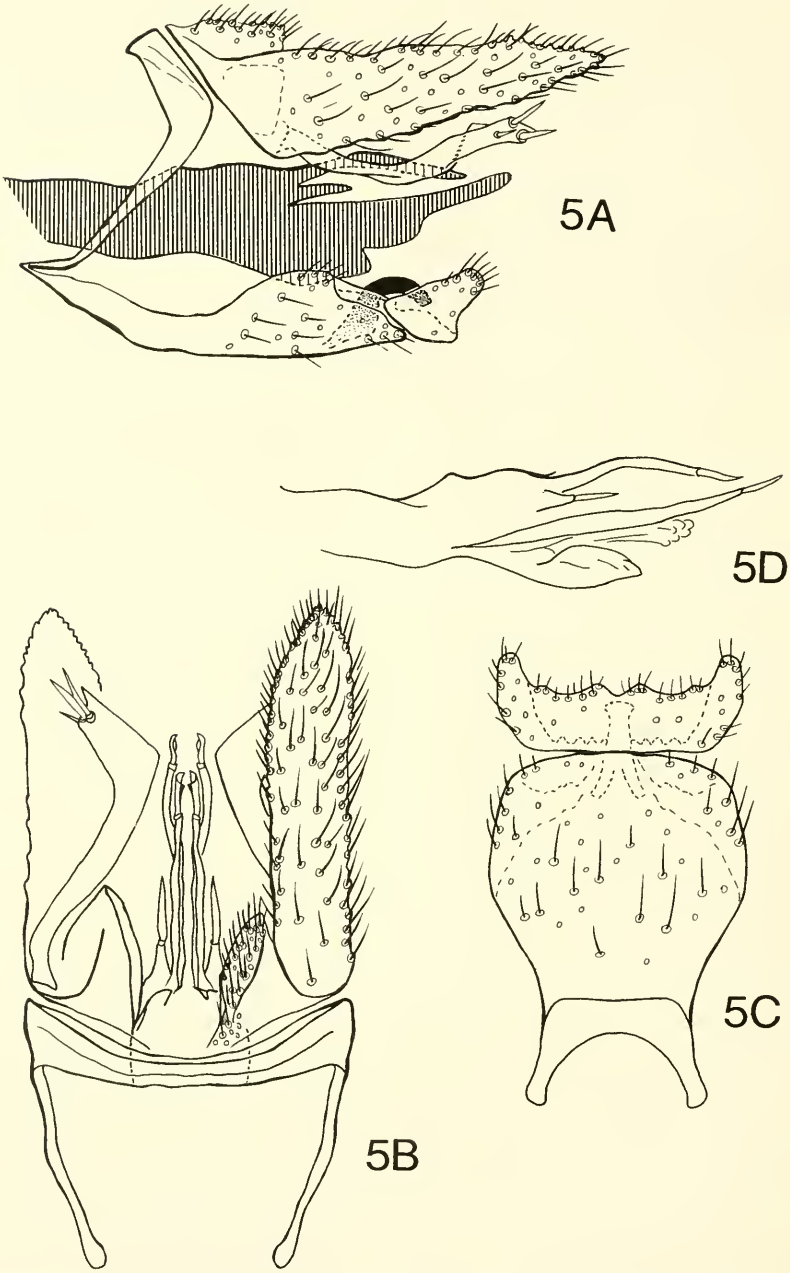


Fig. 5. *Austrotinodes sedmani,* Flint, male genitalia: A, lateral view. B, dorsal view. C, ventral view. D, phallus, lateral view.

very dark; one pair of lateral processes of phallus, which are enlarged and curved basally, when viewed dorsally 4

3\. Intermediate appendage curved, enlarging apically, with three terminal setae, apically with U-shaped emargination (best seen dorsally) (Fig. 4) .... *A. panamensis*

– Intermediate appendage slightly twisted mesoventrally and sharply curved mesally at apical third, when viewed dorsally, with three terminal setae, apical emargination variable (Fig. 5) .... *A. sedmani*

4. Intermediate appendage with one mesoventral seta, two apical setae, and a short mesodorsal seta (Fig. 3) .... *A. contubernalis*

– Intermediate appendage with three subapical setae and a very long mesoventral seta (Fig. 2) .... *A. inbio*

ACKNOWLEDGMENTS

Appreciation is extended to C. M. and O. S. Flint, Jr., J. C. Morse, P. Clausen, J. Huisman, E. Quesada, R. Blahnik, I. and A. Chacón for assistance in collecting specimens and companionship in the field. We also thank the Servicio de Parques Nacionales and the Instituto Nacional de Biodiversidad for collecting permits and logistic support. We are also indebted to Mr. Tony Andersen, Honorary Consul to Costa Rica for the State of Minnesota, for his support of this research. R. Blahnik, J. Huisman and M. Monson reviewed the manuscript and made many useful suggestions. This material is based upon work supported by National Science Foundation grant BSR-8917684. Paper No. 20,225, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul, Minnesota.

LITERATURE CITED

Flint, O. S., Jr. 1973. Studies of Neotropical caddisflies, XVI: The genus *Austrotinodes* (Trichoptera: Psychomyiidae). Proceedings of the Biological Society of Washington 86(11): 127–142.

Flint, O. S., Jr. and D. G. Denning. 1989. Studies of Neotropical Caddisflies, XLI: New species and records of *Austrotinodes* (Trichoptera: Psychomyiidae). Pan-Pacific Entomologist 65(2): 108–122.

McElravy, E. P., V. H. Resh, H. Wolda, and O. S. Flint, Jr. 1981. Diversity of adult Trichoptera in a "non-seasonal" tropical environment, pp. 149–156. *In* Moretti, G. P., ed., Proceedings of the 3rd International Symposium on Trichoptera. Junk, The Hague.

McElravy, E. P., H. Wolda, and V. H. Resh. 1982. Seasonality and annual variability of caddisfly adults (Trichoptera) in a "non seasonal" tropical environment. Archiv für Hydrobiologie 94: 302–307.

Schmid, F. 1955. Contribution à la connaissance des Trichoptères Néotropicaux. Mémoires de la Société vaudoise des Sciences Naturelles 11(69): 117–160.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 574–582

GENITALIC ANALYSIS OF MALES AND FEMALES IN THE *ENCHENOPA BINOTATA* (SAY) COMPLEX (MEMBRACIDAE: HOMOPTERA)

GORDON PRATT AND THOMAS K. WOOD

Department of Entomology and Applied Ecology, University of Delaware, Newark, Delaware 19717.

Abstract.—Male and female genitalia of nine species (8 undescribed, 1 of uncertain identity) of the *Enchenopa binotata* complex were compared to *Campylenchia latipes* and *Enchenopa ignidorsum* to detect diagnostic characters for identification. Discrete character differences in male genitalia of the *E. binotata* complex were noted from *Campylenchia latipes* and *Enchenopa ignidorsum,* but not between members of the complex. These results demonstrate that genitalia are remarkably uniform and provide no practical diagnostic information within the *E. binotata* complex, other than slight size differences apparently related to overall body size. The lack of morphological differentiation of the members of the *E. binotata* complex is discussed in the context of speciation models.

Key Words: Host race, sympatric speciation, *Campylenchia*

The *Enchenopa binotata* (Say) complex of univoltine North American treehoppers, consists of an array of nine biological species (8 undescribed, 1 of uncertain identity) associated with eight genera and nine species of deciduous plants (Wood 1980, Wood in press, Wood and Guttman 1981, 1982, 1983, 1985, Pratt and Wood 1992). These species, in addition to host origin, can be distinguished by differences in allozyme frequencies (Guttman et al. 1981, 1989, Guttman and Weigt 1989, Pratt, Wood, and Datz in prep.), nymphal characters (Pratt and Wood 1992), and adult female pronotal shape and size (Wood and Datz in prep.). Although pronotal shape and size differ among females of the various species, these characters are continuous and not discrete. The apparent lack of external discrete adult characters makes the species difficult to identify and formally describe.

Differences in male genitalia have been successful in providing diagnostic species characters in the Cicadellidae (Young 1957, Delong and Freytag 1967, Delong 1967) and to some extent in the closely related Membracidae (Broomfield 1976). In general, morphological differences in male genitalia of Membracidae have also been useful in delimiting genera (Caldwell 1949, Kopp and Yonke 1979) or complexes of species (Dietrich and Deitz 1991, McKamey and Deitz 1991). These suggested genitalic characters could be useful to either delimit each presumptive *Enchenopa binotata* species in the complex or subdivide the complex into an array which would facilitate identification and formal description.

METHODS AND MATERIALS

At least six males and five females from each of the following host plants of the *Enchenopa binotata* complex were examined: *Ptelea trifoliata* (Linnaeus), *Juglans nigra* (Linnaeus), *Juglans cinerea* (Linnaeus), *Cercis canadensis* (Linnaeus), *Celastrus* *scandens* (Linnaeus), *Liriodendron tulipifera* (Linnaeus), *Robinia pseudoacacia* Linnaeus, *Carya ovalis* (Wang) Sargent, and *Viburnum lentago* Linnaeus. Two individuals of each sex also were examined of *Enchenopa ignidorsum* Walker (Le Selva, Costa Rica) and *Campylenchia latipes* (Say) (Wilmington, Clinton Co., Ohio and Little Orleans, Maryland). [*Campylenchia latipes* was compared to the members of the *E. binotata* complex, since it belongs to a closely related genus and was used as an outgroup in two phylogenetic analyses of the complex (Pratt and Wood, 1992).]

The abdomen from each individual was removed and cleared in 10% NaOH overnight at room temperature. The genitalia were removed and washed in 70% ethanol, and stored in glycerin. One of each species was dissected with sharp tweezers by pulling the styles and aedeagi away from the membranous connective tissue. The male genitalia and dissected parts were affixed with petroleum jelly within glycerin to the bottom of a petri dish and drawn to scale using a camera lucida mounted on a Leica Wild® M10 Stereoscopic microscope (Figs. 1–5).

Genitalia drawn intact were maintained as such for future reference. Their localities by host (Fig. 1) are as follows: A) Lycombine Co., Pennsylvania (code MBL-9) (*Robinia*); B) Greyson, Kentucky (*Cercis*); C) Wooster, Ohio (*Juglans nigra*); D) Wilmington, Clinton Co., Ohio (*Ptelea*); E) Winchester, Virginia (*Viburnum*); F) 3 miles south of Kennet Square, Pennsylvania (*Celastrus*); G) Ithaca, Oswega Co., New York (*Juglans cinerea*); H) Newark, Newcastle Co., Delaware (*Liriodendron*); and I) Wilmington, Clinton Co., Ohio (*Carya*). The localities of dissected specimens (Figs. 2, 3) are the same as above except: A) Harrisburg, Pennsylvania (*Robinia*); B) Wilmington, Clinton Co., Ohio (2-MC-35) (*Cercis*); C) Newark, Newcastle Co., Delaware (*Juglans nigra*); and F) Harrisburg, Pennsylvania (*Celastrus*). Additional specimens were examined from the above localities and from Little Orleans, Maryland (*Celastrus*) and Nichols Arboretum, Ann Arbor, Michigan (*Ptelea*).

To examine intraspecific variation, aedeagi were dissected as above from four additional specimens of a host associated species (host *Cercis*) (Fig. 5): A) Wilmington, Clinton Co., Ohio (DRD 34); B) Junction of routes 46 and 59, Indiana (MRD 10); C) Saint Louis, Missouri; and D) Elletsville, Indiana (DRD 37). The specimen from 3B was redrawn as Fig. 5E. Voucher specimens from this study will be deposited in the Entomology Museum at the Smithsonian Institute.

RESULTS

Subtle differences in the shape of the male genitalic structures among the species of the *E. binotata* complex (Figs. 1–3) were due to individual variation and not species differences. Other than slight differences in size of genitalic structures, we were unable to detect any discrete morphological differences in either sex among any of the nine biological species of the *E. binotata* complex. Although the subgenital plate of the species with host *Cercis* (Fig. 1B) is slightly narrower than the others, this character is not discrete, since it will not distinguish it from the species with hosts *Viburnum* (Fig. 1E) and *Celastrus* (Fig. 1F). The genitalia are remarkable in their uniformity.

Size differences in the subgenital plates of the male are probably related to overall body size. The *E. binotata* that use the hosts *Liriodendron* and *Carya,* and *Campylenchia latipes* are generally the largest, whereas the *E. binotata* that use the hosts *Viburnum* and *Ptelea,* and *Enchenopa ignidorsum* are the smallest of the species compared (Figs. 1, 4).

Although the styles of the *E. binotata* complex do not seem to differ from one another (Fig. 2), the anterior arms of the aedeagi do appear to differ (Fig. 3A–I). The member of the *E. binotata* complex which appears to differ most in shape of the aedeagus, is the species which uses *Cercis* as

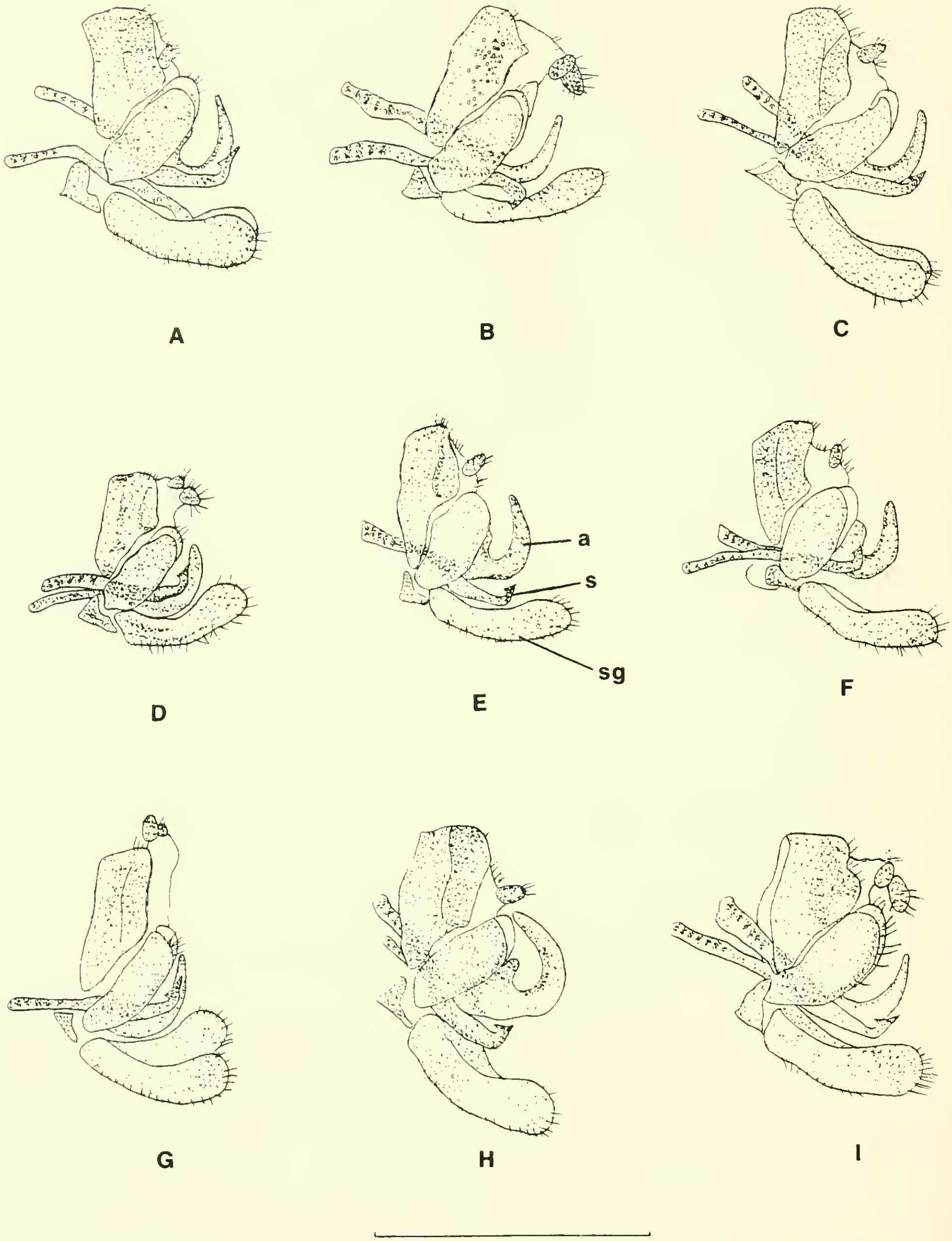


Fig. 1. Male genitalia of species of the *Enchenopa binotata* complex, which are designated by their host A) *Robinia,* B) *Cercis,* C) *Juglans nigra,* D) *Ptelea,* E) *Viburnum,* F) *Celastrus,* G) *Juglans cinerea,* H) *Liriodendron,* and I) *Carya* (all to same scale; the length of the bar is 1 mm). The structures are as follows: sg = subgenital plate, a = aedeagus, s = style.

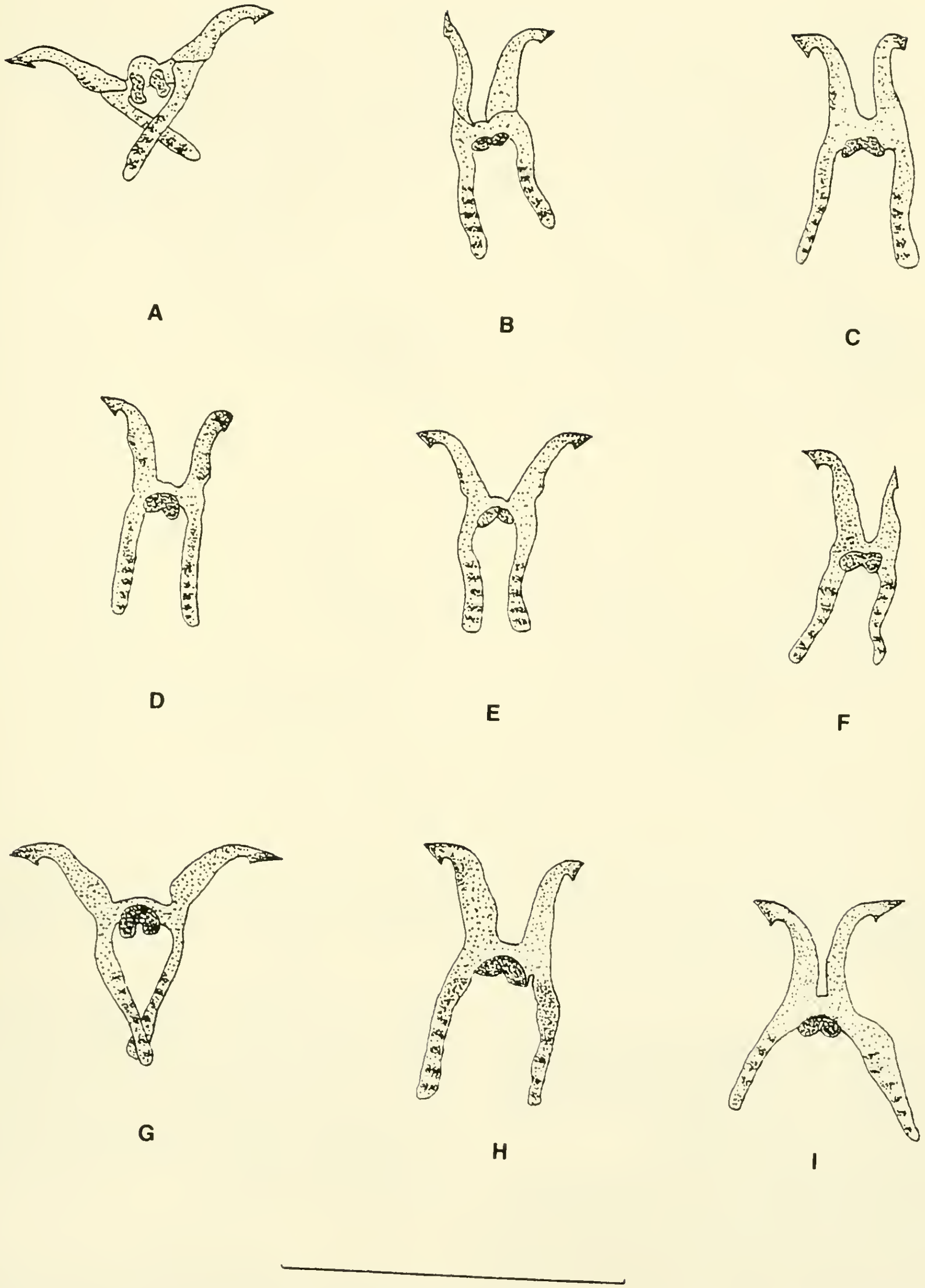


Fig. 2. The dissected styles of male genitalia of species of the *Enchenopa binotata* complex, which are designated by their host A) *Robinia*, B) *Cercis*, C) *Juglans nigra*, D) *Ptelea*, E) *Viburnum*, F) *Celastrus*, G) *Juglans cinerea*, H) *Liriodendron*, and I) *Carya* (all to same scale; the length of the bar is 1 mm).

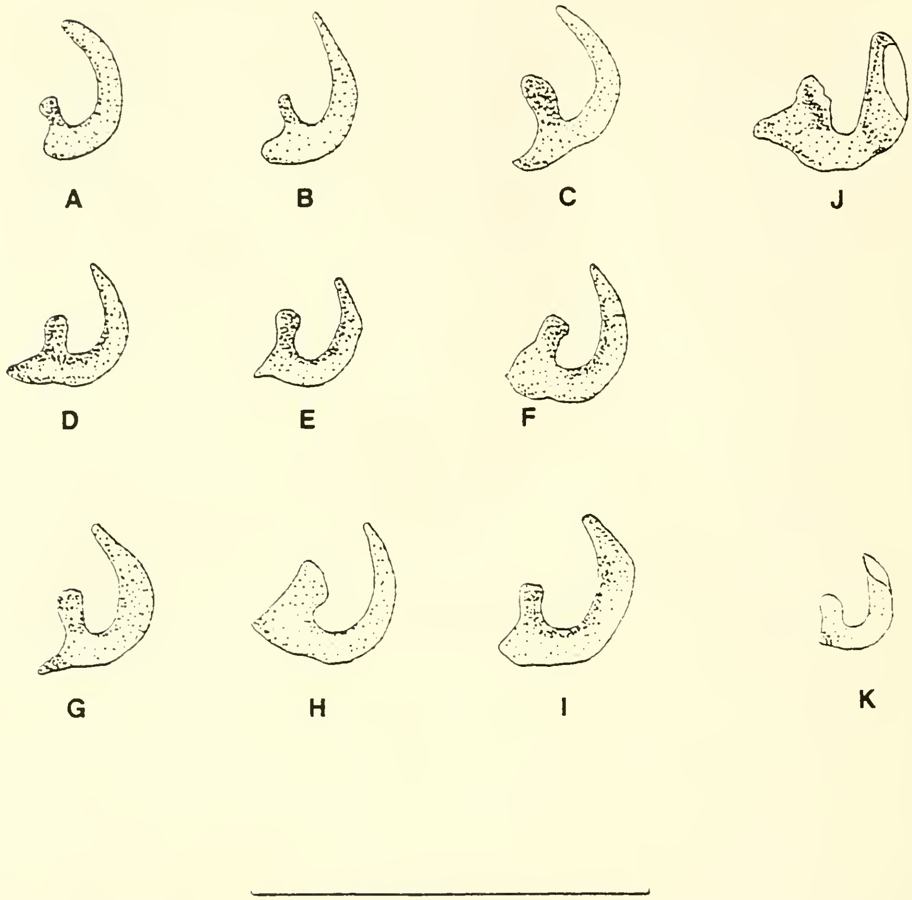


Fig. 3. The dissected aedeagi of male genitalia of species of the *Enchenopa binotata* complex, which are designated by their host A) *Robinia*, B) *Cercis*, C) *Juglans nigra*, D) *Ptelea*, E) *Viburnum*, F) *Celastrus*, G) *Juglans cinerea*, H) *Liriodendron*, and I) *Carya* and J) *Campylenchia latipes*, and K) *Enchenopa ignidorsum* (all to same scale; the length of the bar is 1 mm).

a host; so five individuals of this species were examined to identify intraspecific variation (Fig. 5). The anterior arms of this species seem to vary as greatly as do the species of the *E. binotata* complex.

The male genitalia of *Campylenchia latipes* and *Enchenopa ignidorsum* differ from the *E. binotata* complex in subtle but discrete characters. These include the shapes of the posterior arm of the aedeagi and of the styles (Figs. 2, 3, 4). In *Campylenchia latipes* the posterior arm of the style was bent, whereas all *Enchenopa* were not. In *Enchenopa ignidorsum* the anterior arms of the styles were reduced compared to the other species. On the other hand the female genitalia of *Campylenchia latipes* and *Enchenopa* species were not found to differ [see Dennis (1952), Fig. 2 for generalized female genitalia]. These observations between *Campylenchia latipes* and the *Enchenopa binotata* complex have been noted previously (Dennis 1952).

DISCUSSION

The lack of diagnostic genitalic characters provides no basis for identification or subdivision of the species complex. Although the members of the *E. binotata* complex seem to differ in the shape of the anterior arms of the aedeagi, these differences are as great intraspecifically as interspecifically

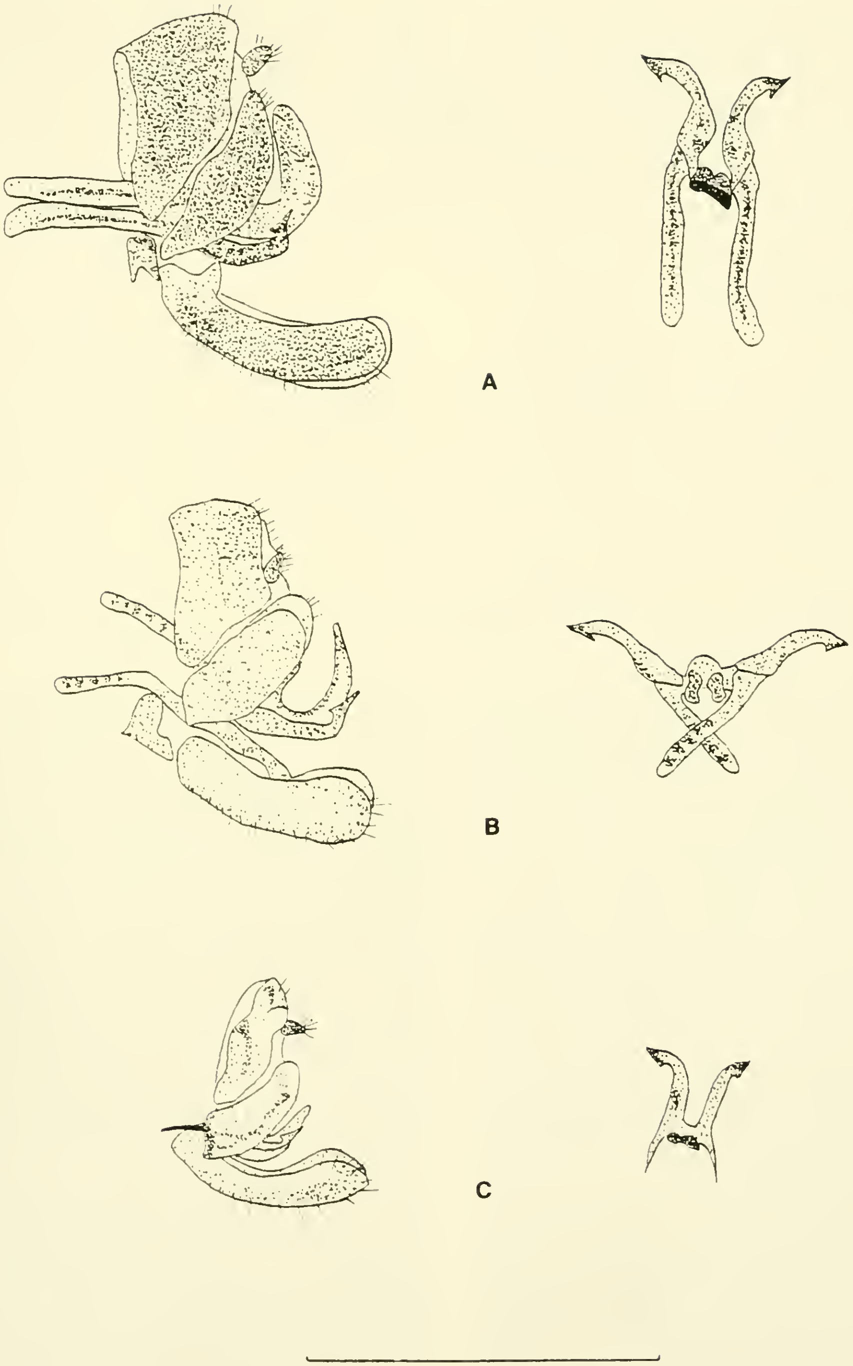


Fig. 4. Male genitalia of A) *Campylenchia latipes,* B) *Enchenopa binotata* host *Robinia* (from Figs. 1A, 2A), and C) *Enchenopa ignidorsum* (all to same scale; the length of the bar is 1 mm).

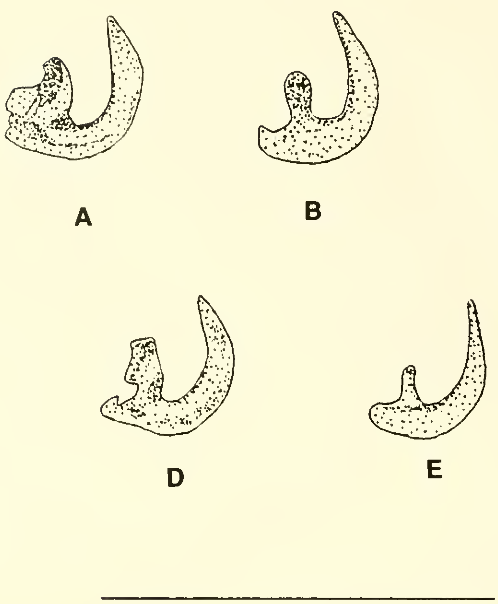


Fig. 5. The dissected aedeagi of 5 *E. binotata* (host *Cercis*), (all to same scale; the length of the bar is 1 mm).

(Figs. 3, 5). Dennis (1960) has also noted similar variation in the anterior arm of another treehopper species. He examined over 1000 male genitalia and found the anterior arm varies greatly, while the posterior arm exhibits little variation.

Even though *Campylenchia latipes* is taxonomically more distant to the *E. binotata* complex than is *Enchenopa ignidorsum,* it seems as similar in male genitalia to the *E. binotata* complex as is *E. ignidorsum.* The only two characters which separate *C. latipes* from the *E. binotata* complex are the bent styles (Fig. 4) and the broad posterior arm of the aedeagus (Fig. 3). *Enchenopa ignidorsum* differs from both *Campylenchia latipes* and the members of the *E. binotata* complex (Fig. 4) by the shortened anterior arms of the styles, the compressed ninth segment, and the long single segmented subgenital plates (the others are composed of two separate segments).

Negative results in general are not reported, but they are of value with the *E. binotata* complex. Clear genitalic differences in this complex could be viewed as evidence that the members of this complex may have been geographically isolated followed by secondary contact causing selection for genitalic differences as an interspecific reproductive isolating mechanism (Shapiro and Porter 1989). Eberhard (1992) suggests that sexual selection may play an important role in speciation with some insects. The absence of genitalic differentiation within this species complex suggests that selection on these characters has not been intense. If sexual selection has promoted divergence in this complex, it has acted on other structures such as the pronotum.

Because the genitalia of the various members of the *E. binotata* complex differ interspecifically only in size (due to body size), there are probably no mechanical impediments to hybridization among the species associated with the different hosts—except perhaps those due to size. Speciation in these treehoppers has been hypothesized to have occurred through shifts in host plant usage (Wood 1980, Wood and Guttman 1981, 1982, 1983, 1985). In this hypothesis the primary mode of reproductive isolation in the complex is due to host-induced asynchronous mating or diurnal mating preferences (Wood in press, Wood and Keese 1990, Wood et al. 1990, Wood et al. in prep.). The lack of genitalic differences in the *E. binotata* complex does not support alternative models.

ACKNOWLEDGMENTS

We appreciate the support of the Competitive USDA Grants Program. This is miscellaneous paper number 1479 of the Delaware Agricultural Experiment Station, and contribution number 650 of the Department of Entomology and Applied Ecology, and number 178 of the Life Science Ecology program at the University of Delaware, Newark, DE.

LITERATURE CITED

Broomfield, P. S. 1976. A revision of the genus *Amastris* (Homoptera: Membracidae). Bulletin of the British Museum (Nat. Hist.), Entomol. 33: 347–460.

Caldwell, J. S. 1949. A generic revision of the treehoppers of the tribe Ceresini in America north of Mexico, based on a study of the male genitalia. Proceedings of the United States National Museum 98: 491–521.

Delong, D. M. 1967. A monographic study of the North American species of the genus *Ballana* (Homoptera: Cicadellidae). Ohio Journal of Science 64: 305–370.

Delong, D. M. and P. H. Freytag. 1967. Studies of the world Gyponinae (Homoptera, Cicadellidae): A synopsis of the genus *Ponana*. Contributions to the American Entomological Institute 1: 1–86.

Dennis, C. J. 1952. Genitalia of the Membracidae of Wisconsin. Canadian Entomologist 84: 157–173.

———. 1960. The genitalia of the buffalo treehopper *Stictocephala bulbalus* (Fabricius). American Midland Naturalist 64: 459–473.

Dietrich, C. H. and L. L. Deitz. 1991. Revision of the Neotropical tribe Aconophorini (Homoptera: Membracidae). North Carolina Agricultural Research Service Technical Bulletin 293: 1–134.

Eberhard, W. G. 1992. Species isolation, genital mechanics, and the evolution of species-specific genitalia in three species of *Macrodactylus* beetles (Coleoptera, Scarabeidae, Melonthinae). Evolution 46: 1774–1783.

Guttman, S. I. and L. A. Weigt. 1989. Macrogeographic genetic variation in the *Enchenopa binotata* complex (Homoptera: Membracidae). Annals of the Entomological Society of America 82: 156–165.

Guttman, S. I., T. Wilson, and L. A. Weigt. 1989. Microgeographic genetic variation in the *Enchenopa binotata* complex (Homoptera: Membracidae). Annals of the Entomological Society of America 82: 225–231.

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.

Kopp, D. D. and T. R. Yonke. 1979. A taxonomic review of the tribe Ceresini (Homoptera: Membracidae). Miscellaneous Publications, Entomological Society of America 112: 1–97.

McKamey, S. H. and L. L. Deitz. 1991. Revision of the Neotropical treehopper genus *Metcalfiella* (Homoptera: Membracidae). North Carolina Agricultural Research Service Technical Bulletin 294: 1–89.

Pratt, G. and T. K. Wood. 1992. A phylogenetic analysis of the *Enchenopa binotata* species complex (Homoptera: Membracidae) using nymphal characters. Systematic Entomology 17: 351–357.

Shapiro, A. M. and A. H. Porter. 1989. The lock-and-key hypothesis: Evolutionary and biosystematic interpretation of insect genitalia. Annual Review of Entomology 34: 231–245.

Wood, T. K. 1980. Intraspecific divergence in *Enchenopa binotata* Say (Homoptera: Membracidae) effected by host plant adaptation. Evolution 34: 147–160.

———. In press. Speciation of the *Enchenopa binotata* complex (Insecta: Homoptera: Membracidae). Symposium of the Biological Linnean Society.

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. F. and H. Dingle, eds., Life History Patterns: Habitat and Geographic Variation. Springer-Verlag, New York, Heidelberg, Berlin.

———. 1982. Ecological and behavioral basis for reproductive isolation in the sympatric *Enchenopa binotata* complex (Homoptera: Membracidae). Evolution 26: 233–242.

———. 1983. The *Enchenopa binotata* complex: Sympatric speciation? Science 220: 310–312.

———. 1985. A new member of the *Enchenopa binotata* Say complex on tulip tree (*Liriodendron tulipifera*). Proceedings of the Entomological Society of Washington 87: 171–175.

Wood, T. K. and M. Keese. 1990. Host plant induced assortative mating in *Enchenopa* treehoppers. Evolution 44: 619–628.

Wood, T. K., K. L. Olmstead, S. I. Guttman. 1990. Insect phenology mediated by host-plant water relations. Evolution 44: 629–636.

Young, D. A. 1957. The leafhopper tribe Alebrini (Homoptera, Cicadellidae). Proceedings of the United States National Museum 107: 127–297.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 583–586

A NEW SPECIES OF *TRIALEURODES* (HOMOPTERA: ALEYRODIDAE) FROM *PHLOX*

Louise M. Russell

USDA, Plant Sciences Institute, Systematic Entomology Laboratory, Room 6, Building 004, BARC-W, Beltsville, Maryland 20705.

Abstract.—*Trialeurodes phlogis* Russell, new species, was found on a mat-forming moss pink, *Phlox subulata* L. (Polemoniaceae), growing wild in the shale barrens of Virginia. Characters are given for separating *T. phlogis* from other species of the Abutiloneus Group of *Trialeurodes.*

Key Words: Aleyrodidae, Abutiloneus Group, whitefly, *Phlox*

The whitefly *Trialeurodes phlogis* Russell, new species, was found on a mat-forming moss pink, *Phlox subulata* L. (Polemoniaceae), growing in shale barrens on Short Mountain, Virginia. Pupal cases were hidden on the underside of the small, narrow, ciliate leaves of the *Phlox* and were detected after adults had been shaken from the plants in previous seasons; earlier instars were not found.

Trialeurodes phlogis is of special interest because it is the second species of the Aleyrodidae to be reported from *Phlox* and indeed from the Polemoniaceae. Britton (1902) recorded the polyphagous species *Trialeurodes vaporariorum* (Westwood) from *Phlox.* He did not give the location of the plant, but it is likely that it grew in a garden or greenhouse and not in the wild.

Trialeurodes phlogis belongs in the Abutiloneus Group of species as defined in my treatment of North American *Trialeurodes* (Russell 1948). Definitive characters of this group are the absence of flocculent secretions, the absence of anterior marginal setae, the narrowness of marginal crenulations, the presence of only seven segments in the median area of the abdomen and the absence of stout spines or elongate setae from the proximal area of the legs.

The specific name *phlogis* is the genitive singular of *Phlox,* the host plant of the whitefly.

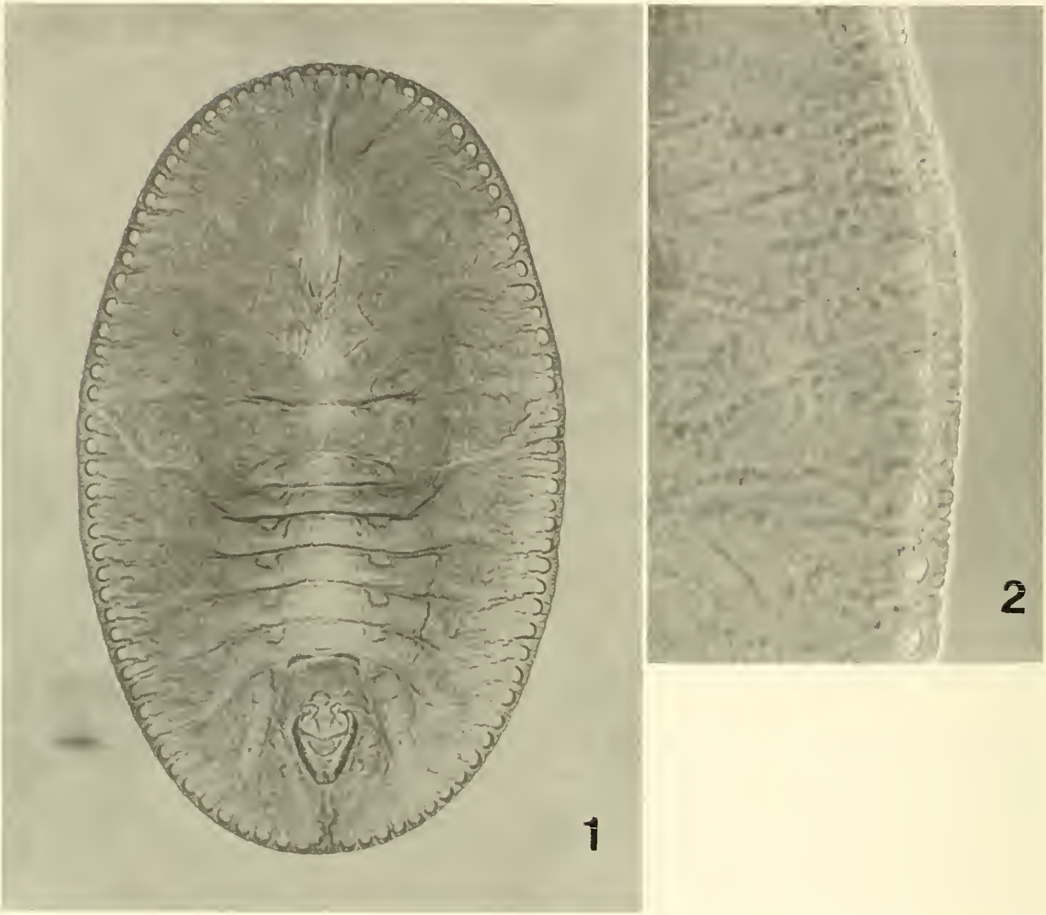
***Trialeurodes phlogis* Russell,**
New Species
(Figs. 1–6)

Pupal case.—Living on the lower surface of leaves.

Colorless, glassy, contiguous waxy rods emanating from the body margin, as long as width of body. Dorsum and venter with a thin covering of colorless wax; a palisade of white or yellowish, translucent wax extending from the ventral submargin to the leaf.

Body elliptical in outline 0.68–0.78 mm long and 0.42–0.50 wide, females larger than males. Dorsum slightly sclerotized, entirely dark on median area, except 8th abdominal segment anterior to vasiform orifice and submarginal area of abdomen, sometimes light; venter colorless and membranous.

Marginal crenulations weak, slightly variable in width, approximately 20 in 100 μ. Submarginal papillae in a single row close



Figs. 1, 2. *Trialeurodes phlogis.* 1, pupal case, dorsal view; 2, section of margin and distal portion of dorsum, dorsal view.

to body margin, terminating at caudal setae, totaling 84–102; 12–15 μ long and 18–24 wide, apices broadly curved. Submarginal disk pores and porettes slightly proximad of papillae. Submarginal furrows extending proximad from between papillae, separated by broad ridges extending into subdorsum or submedian area; outer submedian area with variously directed furrows, some on abdomen often lengthwise of body; median area smooth. Pairs of disk pores and porettes arranged approximately as follows: 2 or 3 inner submedian on cephalic segment, 1 inner submarginal on each thoracic and each abdominal segment except II and VIII; 0, 1 or 2 outer submedian on cephalic segment, 1 on each thoracic and each of abdominal segments III–VII; a subdorsal pair on each of meso- and metathorax. Length of setae about as follows: cephalic, first and eighth abdominal each 6–8 μ, the last located just posterior to the widest part of the vasiform orifice; caudal usually 24–30 μ but occasionally 58; posterior marginal 12 μ. Vasiform orifice elongate cordate, 68–78 μ long and 48–58 wide, its anterior end the length of the operculum from seventh abdominal suture, its posterior end about ⅓ more than length of operculum from posterior body margin, with a median tooth at

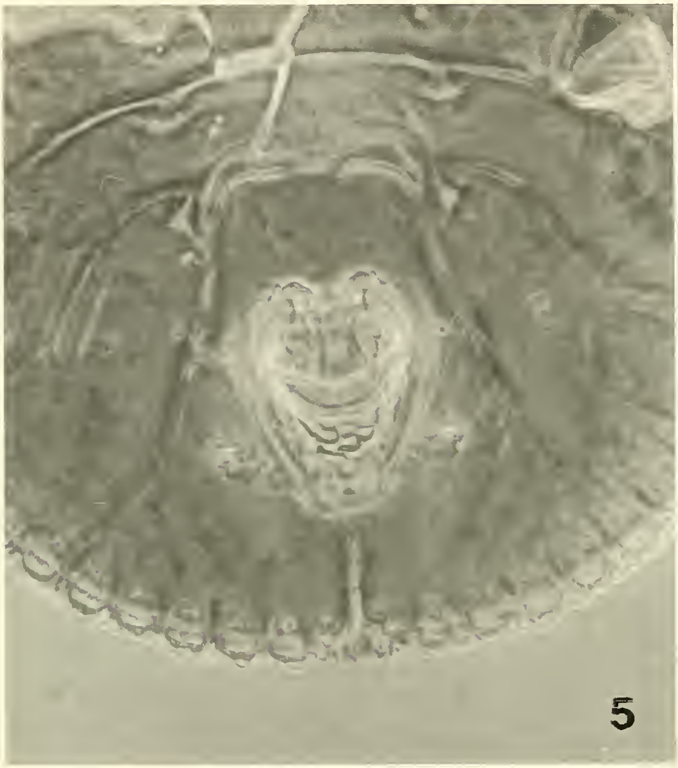
Figs. 3, 4. *Trialeurodes phlogis.* 3, pupal case, ventral view, some dorsal structures also visible; 4, section of ventral margin and distal portion of venter, wax tubes proximad of marginal crenulations, some dorsal structures also visible.

posterior end, its inner walls vertically ridged, its bottom toothed and extending ½ length of operculum. Operculum cordate, 42–50 μ long and 48–58 wide, curved at posterior end. Lingula slender, 44–54 μ long, its anterior 2 lobes usually covered by the operculum, its apex sometimes notched. Grooves beside posterior ⅔ of vasiform orifice extending to the narrow caudal furrow; a slight ridge distad of grooves broken near eighth abdominal setae, then continued to end of orifice; caudal ridges absent.

Ventral marginal wax tubes prominent. Ventral abdominal setae 68 μ long.

Type material.—Holotype and three paratypes mounted on slides, from *Phlox subulata* L. (Polemoniaceae), shale barrens on Short Mountain, southeast of Mt. Jackson, Shenandoah County, Virginia, 12-IV-1992, A. G. Wheeler, Jr.; seven mounted and four unmounted paratypes with same data except collected 17-IV-1991.

Discussion.—*Trialeurodes phlogis* is distinguished from other species of the Abutiloneus Group by characteristics of the dorsum, its predominantly dark color, light sclerotization and the sculpturing by ridges and furrows. In contrast to other species,



Figs. 5, 6. *Trialeurodes phlogis*. 5, posterior part of abdomen depicting characteristics of the vasiform orifice, tooth at end of the orifice, narrow grooves beside the orifice and the slight ridge, distad of the grooves; 6, pupal case on leaf of *Phlox*.

there is a low ridge outside the narrow groove on each side of the vasiform orifice that breaks just posterior to the widest part of the orifice near the eighth abdominal setae. *Trialeurodes phlogis* differs from species except *Trialeurodes euphorbiae* Russell (1948) in that the submarginal papillae are very close to the body margin. It differs from *T. euphorbiae* in several characteristics, most conspicuously in the narrower outline of the body, the greater length of the vasiform orifice and operculum as compared with their width, the stronger lobes of the lingula, the strong teeth in the vasiform orifice and in the termination of the row of submarginal papillae at the caudal setae.

ACKNOWLEDGMENTS

I am greatly indebted to A. G. Wheeler, Jr., Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania, for collecting these obscure specimens and for his review of the manuscript. For his review of the manuscript, I thank J. A. Davidson, Department of Entomology, University of Maryland, College Park, Maryland. I am most grateful to colleagues of the Systematic Entomology Laboratory, PSI, ARS, USDA for their assistance—P. M. Marsh and R. L. Smiley for their suggestions and M. B. Stoetzel for photographing the insects.

LITERATURE CITED

Britton, W. E. 1902. The whitefly or plantlouse Aleyrodes. Connecticut Agricultural Experiment Station Bulletin 140 (Entomology Series 8): 3–17.

Russell, L. M. 1948. The North American species of whiteflies of the genus Trialeurodes. U.S. Department of Agriculture Miscellaneous Publication 635. 85 pp.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 587–589

TAXONOMIC AND BIOLOGICAL NOTES ON THE GENUS *PHYTOMYZOPHAGA* (HYMENOPTERA: EULOPHIDAE)

M. E. SCHAUFF AND A. SALVO

(MES) Systematic Entomology Laboratory, USDA, ARS, PSI, % National Museum of Natural History, NHB 168, Washington, D.C. 20560, U.S.A.; (AS) Centro de Investigaciones Entomológicas de Córdoba, Avda. Vélez Sarsfield 299, CP 5000 Córdoba, Argentina.

Abstract.—The genus *Phytomyzophaga* Brèthes (Eulophidae) is synonymized with *Chrysocharis* Förster. The type species, *P. albipes* Brèthes, nec Ashmead, is given a new name (***brethesi***). Host records for this polyphagous leafminer (Agromyzidae) parasite are given.

Key Words: Taxonomy, Eulophidae, *Chrysocharis,* leafminer, parasite, South America

During biological studies on agromyzid leafminers in Argentina, one of us (AS) reared a large number of parasites of a species of entedonine eulophid from several species of hosts. The parasite was tentatively identified as a species described by J. Brèthes from Argentina. Further examination revealed that problems with the application of the Brèthes name required that some nomenclatural changes be made. This paper reports on those changes and also provides an opportunity for us to give a full listing of the host species from which this eulophid has been reared. Although many species of *Chrysocharis* have been reared from leafminers (Hansson 1987), few have been reared from as many identified hosts as has this species.

Chrysocharis Förster

Chrysocharis Förster, 1856.

Type species: C. pubicornis (Zetterstedt, 1838).

Phytomyzophaga Brèthes, 1923. **New Synonym.**

Type species: Phytomyzophaga albipes Brèthes. By Monotypy.

For a complete synonymy of *Chrysocharis,* see Schauff (1991).

We have examined the type of this genus and it agrees in all respects with the definition of *Chrysocharis* given by Schauff (1991). Therefore, we propose the above synonymy.

This species is somewhat unusual for *Chrysocharis* because it possesses plicae on the propodeum and most species in this genus do not. However, presence or absence of plicae is not a defining character for the genus and other species are known which possess this character.

Chrysocharis brethesi **Schauff and Salvo, NEW NAME**

Phytomyzophaga albipes Brèthes 1923. Lectotype female (present designation) [examined]. Junior secondary homonym of *Chrysocharis albipes* Ashmead (1904) [described as *Nesomyia albipes*].

Discussion.—In his original description

Table 1. List of hosts, host plants, and sources of host records for *C. brethesi.*

Agromyzid Host	Plant	Source of Record
Amauromyza maculosa	Unknown plant	Valladares 1982
Calycomyza eupatorivora	*Eupatorium hookerianum*	New record
	Eupatorium sp.	
C. malvae	*Malvastrum coromandelianum*	New record
	Malvaceae sp.	
C. lantanae	*Lantana* sp.	New record
C. playptera	Unknown	Valladares 1982
	Helianthus annus	Toselli 1982
	Tithonia rotundifolia	Cornaglia 1987
	Zinnia elegans	Cornaglia 1987
C. verbenivora	*Lippia turbinata*	New record
Chromatomyia platensis	Unknown	Valladares 1982 Costa Lima 1962 De Santis 1967
	Mentha sp.	New record
	M. piperita	New record
	M. rotundifolia	Toselli 1982 Cornaglia 1987
	Ocimum basilicum	Toselli 1982 Cornaglia 1987
	Salvia officinalis	Toselli 1982 Cornaglia 1987 Brèthes 1923
	S. splendens	Toselli 1982 Cornaglia 1987 Brèthes 1923
Japanagromyza polygoni	*Polygonum* sp.	New record
Liriomyza brassicae	*Brassica oleracea* var. *capitata*	New record
L. commelinae	*Commelina erecta*	Cornaglia 1987
L. huidobrensis	Unknown	Valladares 1982
	Calendula officinalis	Toselli 1982 Cornaglia 1987
	Licopersicum sculentum	Toselli 1982 Cornaglia 1987
	Papaver rhoeas	Toselli 1982 Cornaglia 1987
	Phlox sp.	Cornaglia 1987
	Tagetes sp.	New record
	Tropaeolum majus	Cornaglia 1987
	Zea mays	Toselli 1982 Cornaglia 1987
L. spencerella	Unknown	Valladares 1982
	Chrysanthemum sp.	Toselli 1982
Ophiomyia camarae	*Lantana camara*	Valladares 1982 Toselli 1982 Cornaglia 1987
O. verbenivora	Unknown	Valladares 1982
Phytomyza crassiseta	*Veronica anagallis-aquatica*	New record
Phytomyza williamsoni	*Clematis* sp.	Costa Lima 1962 DeSantis 1967

Fig. 1. Scanning electron micrograph of propodeum of *C. brethesi.*

Brèthes (1923) did not designate a type, but did indicate that he had seen at least 20 specimens of this species. One of us (MES) has examined a female specimen from the museum in Buenos Aires, labelled by Brèthes as "type," which is hereby designated as lectotype. The lectotype is slide mounted with the data "Museo Arg. C. Naturales sección Entomólogia. Parasito de *Phytomyza platensis* Br. Minador de *Salvia.* Buenos Aires, I-923. J. Brèthes. no. 1479. P. 38. *Phytomyzophaga albipes.* Type." The label with the species name is badly faded and some writing is not legible. A small red lectotype label has been affixed to the specimen.

Biology.—*C. brethesi* has been reared from a total of 13 hosts on 25 host plants. Percent parasitism ranges up to 55%. Observations indicate that this species is generally a larval-pupal parasitoid, but that on occasion, the adult wasp emerges from the larva prior to pupation.

Hosts.—The following summary of hosts (Table 1) for this species is drawn from rearings by one of us (AS) and from the literature.

ACKNOWLEDGMENTS

We thank Dr. G. Valladares for identifying the agromyzid hosts and Dr. A. Bachmann (Museo Argentino de Ciencias Naturales "Bernardino Rivadavia," Buenos Aires) for the loan of the type of *P. albipes.* We also thank J. LaSalle, L. DeSantis, R. White, J. Huber, and D. Nickle for reviewing the manuscript. A. Salvo was supported by a CONICOR grant.

LITERATURE CITED

Ashmead, W. H. 1904. Descriptions of new Hymenoptera from Japan. II. Journal of the New York Entomological Society 12: 146–165.

Brèthes, J. 1923. Sur un Diptère mineur des feuilles de *Salvia spendens* et deux Hyménoptères, ses parasites. Revue deZoologie Agricole et Appliquée. Bordeaux 22: 153–158.

Cornaglia, P. 1987. Eulophidae (Hymenoptera: Chalcidoidea): Nociones básicas en el estudio de las especies parasiticas de *Liriomyza* Mik. (Diptera: Agromyzidae). Seminario I y II. Inédito Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional De Cordoba.

Costa Lima, A. 1962. Insetos do Brasil. Himenópteros 12: 393 pp.

De Santis, L. 1967. Catálogo de himenópteros argentinos de la Serie Parasitica incluyendo Bethiloidea. Publicacion especial. Comision de Investigacion Cientifica. La Plata. 337 pp.

Förster, A. 1856. Hynmenopterologische studien. II. Chalcidiae und Prototrupii. Aachen. 152 pp.

Hansson, C. 1987. Revision of the New World species of *Chrysocharis* Förster (Hymenoptera: Eulophidae). Entomologica Scandinavica. Suppl. 31. 86 pp.

Schauff, M. E. 1991. The Holarctic genera of Entedoninae (Hymenoptera: Eulophidae). Contributions of the American Entomological Institute 26: 109 pp.

Toselli, S. 1982. Aportes al conocimiento de los parasitoides Chalcidoidea de Agromyzidae (Diptera). Trabajo de Adscripción. Inédito Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional De Cordoba.

Valladares, G. 1982. Agromyzidae (Diptera) de Cordoba. Tesis Doctoral. Inédito Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional De Cordoba.

Zetterstedt, J. W. 1838. Insecta Lapponica descripta. Lipsiae. 868 pp.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 590–602

TWO NEW SPECIES OF *SLATEROBIUS* HARRINGTON WITH COMMENTS ON THE ECOLOGY AND DISTRIBUTION OF THE GENUS (HEMIPTERA: LYGAEIDAE)

JAMES A. SLATER, MERRILL H. SWEET, AND HARRY BRAILOVSKY

(JAS) Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, Connecticut 06269, U.S.A.; (MHS) Department of Biology and Department of Entomology, Texas A&M University, College Station, Texas 77843, U.S.A.; (HB) Instituto de Biología, Universidad Nacional Autónoma de México, Departamento de Zoología, Laboratorio de Entomología, Apartado Postal No. 70-153 CP 04510 México, D.F., México.

Abstract.—Two new species, **Slaterobius chisos** Slater and Sweet from the southwestern United States and **Slaterobius nigritus** Slater and Brailovsky from Mexico, are described and illustrated as are details of the genitalia. A key to the species of *Slaterobius* is provided. *Slaterobius insignis* is recorded from Mexico and the fifth instar is described and illustrated. *Slaterobius quadristriatus,* previously known only from New Jersey and recorded for the first time from Wisconsin and Michigan, is the only arboreal species of the genus and feeds on pine seeds. The myrmecomorphic nature of the insects is discussed. Based on the known distribution and ecology of the species, a vicariant pattern of speciation is proposed, based on Pleistocene climatic changes.

Key Words: Myrmecomorphy, polymorphism, habitat, vicariance, Pleistocene

The genus *Slaterobius* was created by Harrington (1980) to contain two North American species, *S. insignis* (Uhler) and *S. quadristriatus* (Barber), which had previously been placed in the genus *Sphaerobius* Uhler. The type species of the latter, (*Sphaerobius gracilis* Uhler, described from St. Vincent Island in the West Indies) proved not to be congeneric with the North American species (Sweet 1964, Harrington 1980). We have recently had the opportunity to examine specimens from the southwestern United States and Mexico that represent two new species described below. The discovery of these species, together with new information about *S. quadristriatus* (Harrington pers. comm., Wheeler in litt.) allows us to propose a zoogeographical reconstruction of the phyletic history of the genus.

All measurements are in millimeters.

KEY TO SPECIES OF *SLATEROBIUS*

1. Hemelytra lacking upstanding setae and with four elongate, longitudinal stripes .... *quadristriatus* (Barber)
– Hemelytra bearing a series of elongate upstanding setae; and variously colored, never possessing 4 longitudinal pale stripes 2
2. Abdominal sterna 5–7 nearly glabrous, shining, strongly contrasting with a distinct lateral, silvery oblique stripe of pubescence across abdominal sterna 3–5 above stridulitrum .... *chisos* Slater and Sweet, new species
– Posterior abdominal segments evenly and densely pubescent, as strongly so as on segments 3–5, thus not contrasting in pubescence with stripe of silvery hairs running diagonally anterior to sterna 6 and 7 3
3. Legs and antennae black; head and pronotum nearly unicolorous dark-chocolate brown ... . *nigritus* Slater and Brailovsky, new species

– Legs yellow or pale reddish brown; antennal segments 1, 2, 3 pale, usually pale yellow; pronotum either yellow brown, or if anterior lobe dark-chocolate brown, then strongly contrasting with posterior lobe (rarely unicolorous) . . . . *insignis* (Uhler)

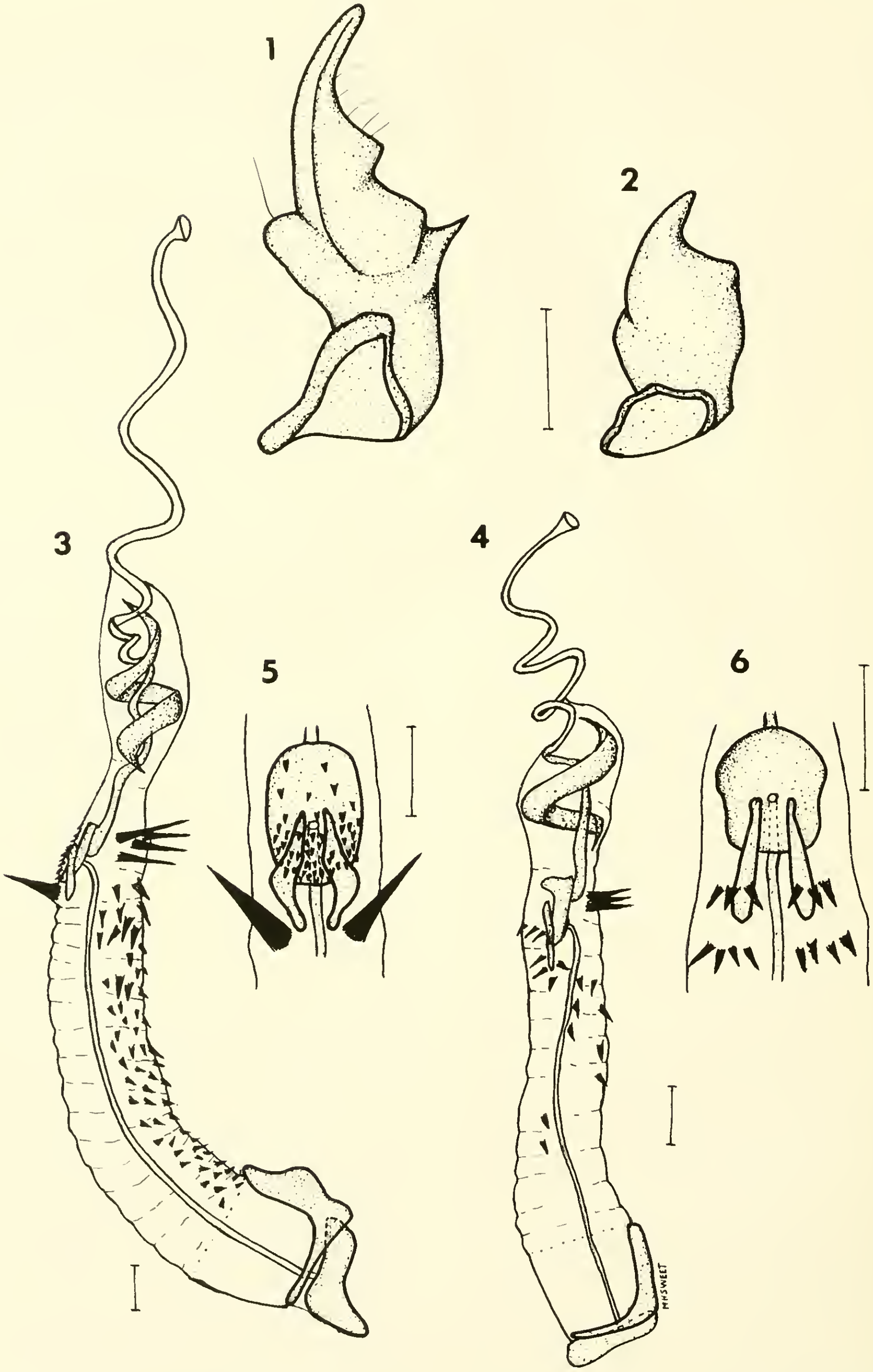
Slaterobius chisos **Slater and Sweet, New Species**

Figs. 2, 4, 6–8

Head, anterior pronotal lobe, basal ¾ of scutellum, and fourth antennal segment chocolate brown. Juga, apex of tylus and submarginal stripe light tan. Anterior pronotal collar, posterior pronotal lobe, basal ½ and subapical macula of hemelytra and first 3 antennal segments pale yellow. A large ovoid darker brown patch covering greater part of distal third of hemelytra and apex of corium, and with directly anterior distinct pale area. Abdomen black distally, reddish brown basally, as is swollen anterior lobe of metapleuron. Legs and antennae sordid yellowish brown. Head and anterior pronotal lobe impunctate, former with surface slightly crazed, latter smooth, both areas polished, contrasting strongly with dull surface of posterior pronotal lobe and hemelytra. A few deep punctures along anterior pronotal collar. Posterior pronotal lobe and hemelytra with scattered large punctures. Scutellum punctate laterad of median elevation. Dorsal surface bearing scattering of very long, upright, brown or black setae. A thick coating of decumbent silvery hairs present on prothorax adjacent to acetabulum, a thick band of silvery hairs covering entire mesopleuron and mesosternum forming a broad strip extending caudomesad on abdominal sternum from anterior margin of sternum 3 to posterior margin of sternum 5; silvery hairs also present on mesal area of sterna 2 and 3. Abdomen otherwise strongly polished and shining. Scutellum dull with a mesal patch of silvery pruinosity near base.

Shape strongly myrmecomorphic. Head moderately declivent, strongly ovoid in lateral view (Fig. 8). Tylus attaining distal end of first antennal segment. Eyes large, oblique, vertex moderately convex. Length head 0.98, width 0.90, interocular space 0.54. Anterior pronotal lobe strongly swollen, convex and globose, strongly elevated above surface of posterior lobe. Lateral pronotal margins deeply incised in area of transverse impression which is complete and deep. Posterior pronotal margin shallowly concave. Length of pronotum 0.84, width across humeri 0.80, length of anterior pronotal lobe 0.58, width across anterior lobe 0.76. Scutellum with a median elevation. Length of scutellum 0.60, width 0.38. Clavus and corium fused, but claval area discernible. Punctures in area of clavus irregular, not forming distinct rows. Lateral hemelytral margins slightly flared laterad ½ way from base, extending posteriorad to middle of abdominal sternum 5; apical margin slightly convex with membrane reduced to a small flange that does not exceed posterolateral angles of corium. Length of claval commissure 0.46. Midline distance from apex of clavus to apex of corium 0.50. Length of hemelytron 1.52. Anterior lobe of metapleuron strongly enlarged, visible from above (Figs. 7, 8). Metathoracic scent gland auricle rounded, not curving posteriorad, evaporative area obsolete. Profemora armed below on inner margin with 2 large and 4–5 small spines. Labium extending posteriorad to between mesocoxae, first segment reaching only to middle of head. Length of labial segments: I 0.46, II 0.52, III 0.40, IV 0.86. Antennae terete, fourth segment narrowly fusiform. Length of antennal segments: I 0.28, II 0.76, III 0.62, IV 0.86. Total body length 4.40.

Clasper (Fig. 2) short, stout with hook small. Aedeagus (Fig. 4) relatively small, gonoporal process of 3 turns with trumpet-like apex; helicoid process of 1¼ turns; no holding sclerites present; ejaculatory reservoir (Fig. 6) with long slender wings; conjunctiva armed with spines as in Figs. 4 and



Figs. 1–6. Male genitalia of *Slaterobius.* Clasper, frontal view. 1, *S. insignis.* 2, *S. chisos.* Aedeagus, lateral view. 3, *S. insignis.* 4, *S. chisos.* Ejaculatory reservoir, ventral view. 5, *S. insignis.* 6, *S. chisos.*

6; phallobase desclerotized, 2 L-shaped dorsal sclerites present. Parandria of genital capsule broadly triangular.

Type specimens.—*Holotype* ♂: TEXAS: Brewster Co., Big Bend National Park, Chisos Mts. Basin, 31.V.1974, M. H. Sweet. In American Museum of Natural History. *Paratypes*: TEXAS: 1 ♀, Brewster Co., Big Bend National Park, Lost Mine Peak, 26.VI.1964, M. H. Sweet. 1 ♂, 1 ♀, Brewster Co., Big Bend National Park, Chisos Mts. Basin, 31.V. 1974, M. H. Sweet. 1 ♂, Terrell Co., 35 mi. NE Sanderson, 18.VI.1979, M. A. Maahs, D. F. Bartell, R. D. Beckham. NEW MEXICO: 1 ♂ (Figs. 7, 8), Santa Fe Co., Los Alamos KLS site, pitfall, 13.V. 1976, F. Miero. In J. A. Slater, M. H. Sweet, and Texas Tech University collections.

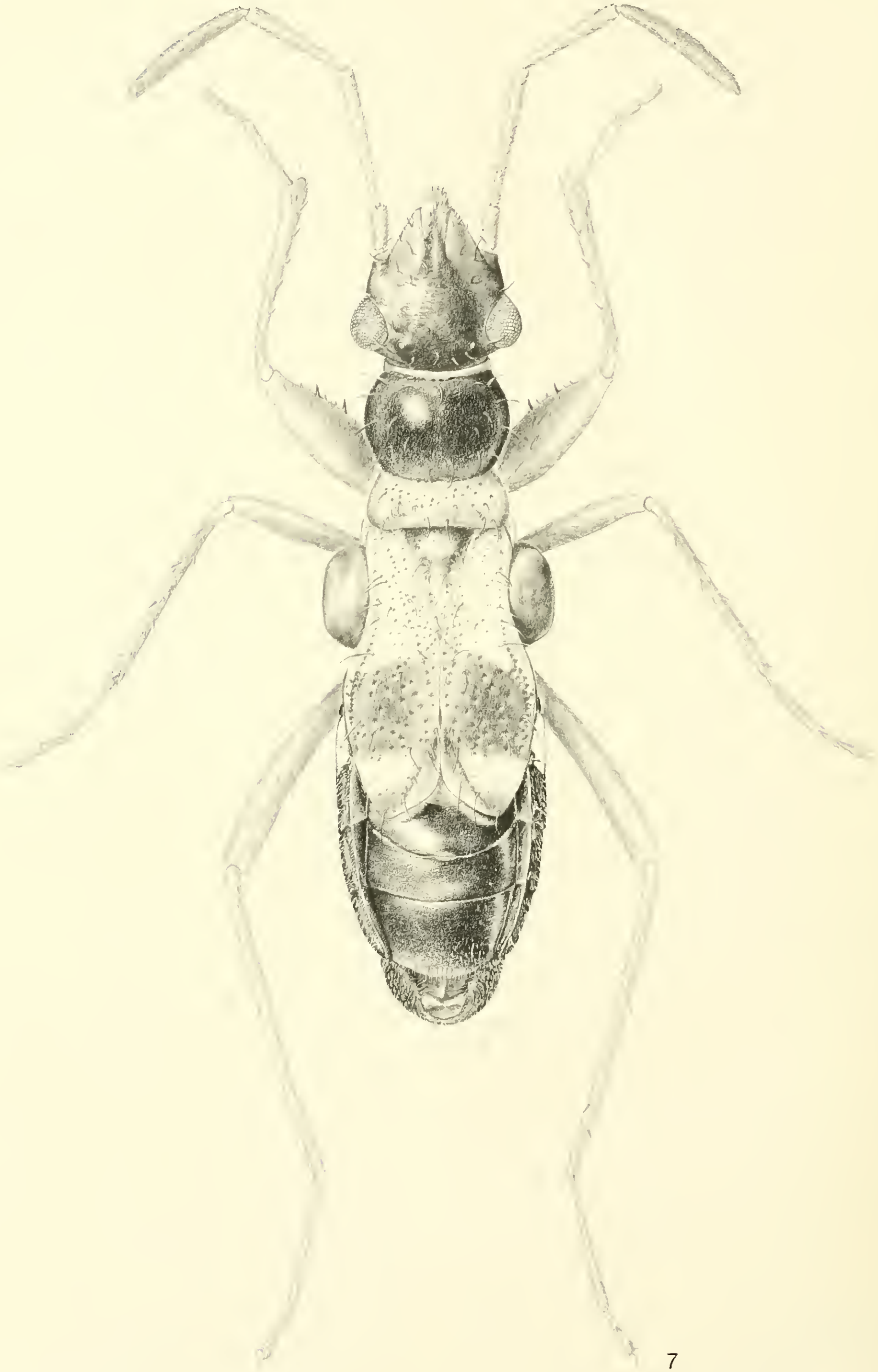
Etymology.—This striking ant mimic is named to commemorate the former Chisos Indians, who lived in the mountains of northeastern Mexico and Southwest Texas and who struggled with the Spanish for survival for over 200 years.

Variation.—Several of the paratypes differ strikingly in color, but we have been unable to find reliable structural differences. The female from Lost Mine Peak, one female from the Chisos Mts. Basin, and the male from NE of Sanderson are almost completely red. In these specimens, the posterior pronotal lobe and anterior portion of the hemelytra, while paler than the head, scutellum, and anterior portion of the hemelytra, are much less strongly contrasting than is true of the holotype. All of the paratypes have essentially the same color markings on the hemelytra as does the holotype, except the paratype from New Mexico, which lacks the pale area immediately anterior to the large distal brown patch, possibly because of the very pale color of the anterior part of the hemelytra (Fig. 7). When present, this pale area enhances the disruptive antlike appearance of the body. The specimens from Chisos Mts. Basin have more coarsely punctate pronotal lobes and have the collar concolorous with the rest of the anterior pronotal lobe. While the male paratype from New Mexico has the metapleuron enormously swollen (Figs. 7, 8), the other specimens also have the area noticeably tumidly produced, more so in males than in females.

All of the paratypes have exactly the same degree and conformation of the wing brachyptery as does the holotype. All agree in having the lateral areas of the abdominal sternum posterior to the band of silvery hairs nearly glabrous and strongly shining.

Diagnosis.—The genital structures described above readily separate this species from *S. insignis,* which also usually has pale legs. The clasper of *S. chisos* (Fig. 2) is stout with a simple short hook, while the clasper of *S. insignis* (Fig. 1) is larger and more complexly lobed. The pattern of conjunctival spines is quite different in the two species. *S. insignis* (Figs. 3, 5) has two ventral distal spines and many small dorsal spines, whereas *S. chisos* (Figs. 4, 6) has distal rows of three and four ventral spines and few dorsal spines. The phallobase of *S. insignis* has large dorsolateral humps. The ejaculatory pump (Fig. 6) and the ventral surface of the pump are covered with small spines in *S. insignis.* The parandria of the male capsule are truncate in *S. insignis* and broadly triangular in *S. chisos.*

Ecology.—The localities in the Chisos Mountains of the Big Bend National Park are both in the Upper Sonoran Pinyon-Juniper-Oak Zone, one on Lost Mine Peak and the other at 6000 ft. elevation above the Basin at Juniper Flats. The Lost Mine Peak specimen was found next to a grass clump (*Schizachyrium scoparium* [Michx.] Nash) on an open dry rock ledge among pinyon pines. The Juniper Flats area was a gently sloping open gravelly biotope surrounded by pinyon pine woodland. The insects (adults and nymphs) were found running rapidly among small stones and sparse grasses (mostly *Bouteloua* spp.). The insects were very effective ant mimics in both movements and appearance and were dif-



Figs. 7, 8. *Slaterobius chisos* Slater and Sweet, n. sp., paratype male. 7, dorsal view. 8, lateral view.

8

ficult to distinguish from the ants present in the same biotope. The only other lygaeids found in these areas were ubiquitous species of *Geocoris* and *Nysius.*

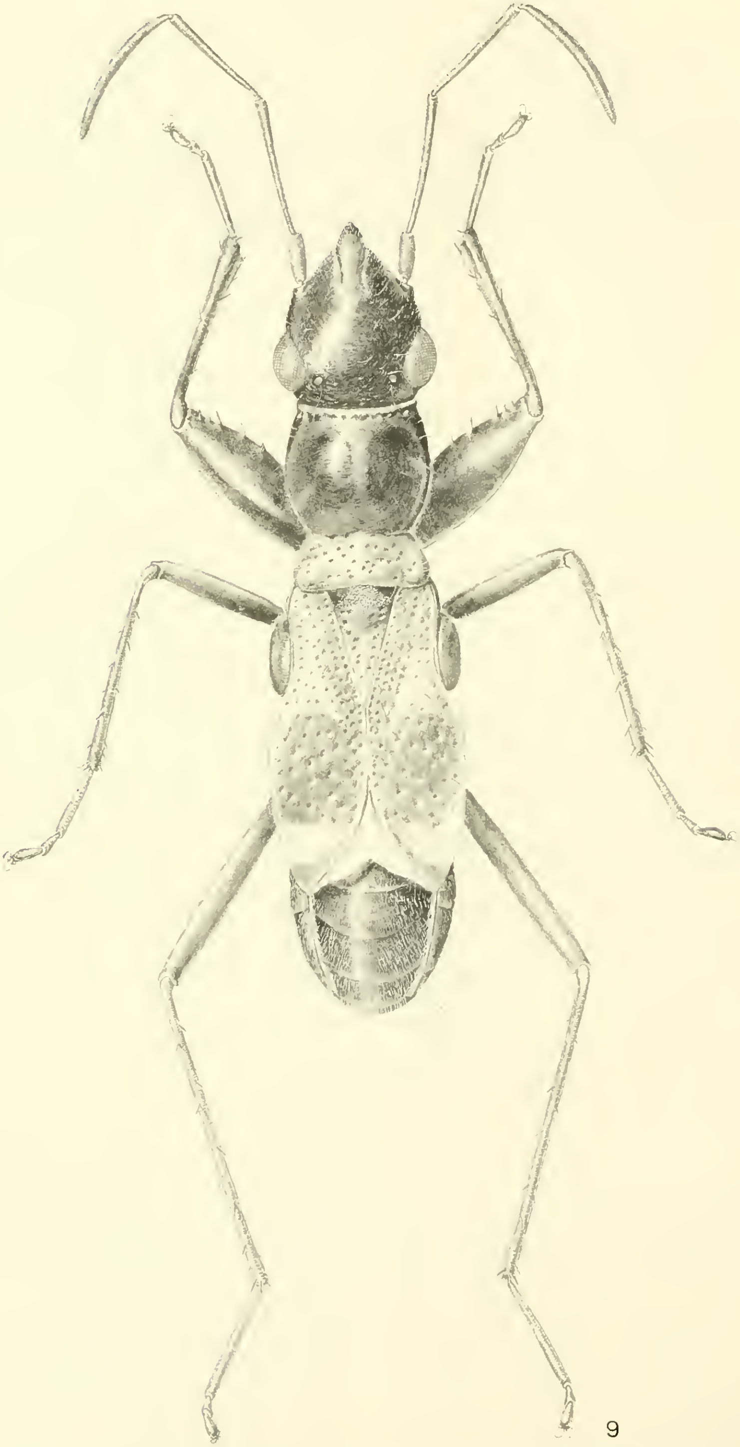
In the Lower Sonoran Zone of desert scrub and desert grassland of the surrounding Chihuahuan desert no *Slaterobius* were found although other long-legged myrmecomorphic Myodochini were present [*Ligyrocoris setosus* (Stål), *Pseudopamera aurivilliana* Distant, *P. nitidicollis* (Stål), and *P. nitidula* (Uhler)], which were not found in the Upper Sonoran Zone. This is similar to the ecological pattern of *Slaterobius insignis,* which in Colorado and New Mexico similarly occurs in Upper Sonoran to Transition Zone altitudes and is replaced by other myodochines in Lower Sonoran desert biotopes.

The distribution, together with the ecological information, suggests that *S. chisos* is probably widespread through the northern Sierra Madre de Orientale where it ecologically replaces the more northern and widespread *S. insignis.* It is thus intriguing that a single specimen of *S. insignis* was collected in the basin of the Chisos Mountains, Big Bend National Park, Texas, in a roadside habitat in the transition from Upper to Lower Sonoran Zones.

We venture to suggest that local populations of these flightless ant mimics would tend to become genetically isolated and would be excellent subjects for detailed population analyses.

Slaterobius nigritus
Slater and Brailovsky, New Species
Fig. 9

Very similar to *S. chisos* in general habitus and overall color pattern. Lateral area of abdominal sterna posterior to the diagonal silvery bar thickly clothed with decumbent hairs, as heavily clothed as along meson, thus no large glabrous area present. Legs and antennae completely black or dark-chocolate brown, except paler proximally on middle and hind femora and adjacent coxae. Head and pronotum nearly unicolorous dark-chocolate brown with pronotal calli area differentiated and nearly black. Length of head 1.00, width 0.96, interocular space 0.56. Length of pronotum 1.02, width 0.82. Length of anterior pronotal lobe 0.66, width 0.80. Length of scutellum 0.66, width 0.40. Length of claval commissure 0.50. Midline distance from apex of clavus to apex of corium 0.60. Length of corium 1.76. Length of labial segments I 0.50, II 0.50, III 0.32,



9

Fig. 9. *Slaterobius nigritus* Slater and Brailovsky, n. sp., holotype male, dorsal view.

IV 0.32. Length of antennal segments I 0.30, II 0.80, III 0.70, IV—missing. Total body length 4.68.

Type specimen.—Holotype ♂: MEXICO: TAMAULIPAS: Ciudad Victoria, E. Barrera. In Instituto de Biologia, UNAM, Mexico.

Etymology.—The specific name *nigritus* refers to the dark coloration of this species.

Diagnosis.—This species is very closely related to *S. chisos.* It is a more elongate species (Fig. 9) with the median length of the pronotum greater than the width of the head across the eyes. In *S. chisos* the head width is greater than the pronotal length. The pubescence on the abdomen is very different in the two species. In fact, the abdominal pubescence of *S. nigritus* is similar to that found in *S. insignis.*

Slaterobius insignis (Uhler)

As noted by Sweet (1964), this species is dimorphic in color with orange red and black morphs occurring together unrelated to sex or wing condition. They thus may resemble either red or black ants. Our Mexican specimens are all of the pale morph. All nymphs are reddish except for the yellow first instar.

Fifth-instar nymph (Fig. 10): COLORADO: Weld Co., Pawnee National Grassland, 17.5 miles N. Hunn Hq., 8–9.VIII. 1973, J. Slater, R. Baranowski.

General coloration bright red brown. Head and anterior pronotal lobe darker brown, contrasting with yellowish tan of posterior pronotal lobe and explanate lateral pronotal margins. Central scutellar area, suffused areas on wing pads and extreme outer edges of explanate wing pad margins dark brown. Y-suture between abdominal terga 3–4 margined with bright crimson. Areas around abdominal scent gland openings between abdominal terga 3–4, 4–5, and 5–6 quadrate-shaped dark brown, the area surrounding anterior gland opening larger than succeeding ones. A dark mesal spot on terga 7 and broader ones on terga 8 and 9. Abdominal tergum otherwise yellowish but suffused with reddish mesally and with obscure lateral pale maculae. Legs chiefly dull reddish with distal ends of tibiae and second tarsal segments darker. Antennal segments 1, 2 and proximal half of 3 pale yellow, segment 3 distally and all of segment 4 dark reddish brown.

Head large, eyes sessile, set well away from anterolateral pronotal angles. Length of head 0.92, width 1.00, interocular distance 0.72. Pronotum nearly quadrate, only slightly narrowing anteriorly, lateral margins strongly explanate. Length of pronotum 0.84, width 1.12. Length of wing pad 1.24. Length of abdomen 2.28. Fore femora incrassate, each armed below on distal third with a single short spine. Labium attaining anterior margin of metacoxae. Length of labial segments I 0.60, II 0.48, III 0.48, IV 0.36. Length of antennal segments I 0.36, II 0.84, III 0.80, IV 1.08. Total body length 4.40.

The Slater (1964) catalogue lists records of this species from Colorado, Idaho, Illinois, Iowa, Maine, Minnesota, Nebraska, New Hampshire, New York, N. Dakota, S. Dakota, Utah, Alberta, British Columbia, Manitoba, Newfoundland, Ontario, Quebec, and Saskatchewan. Sweet (1964) reported it from Connecticut. We have also examined specimens from Michigan, Wisconsin, Wyoming and Mono Co., California, and one specimen from the Big Bend National Park, Brewster Co., Chisos Mts. Basin, 31 May 1977, M. H. Sweet. The Texas specimen is of the pale morph. As noted, it is intriguing that the two species, *S. insignis* and *S. chisos,* are sympatric in the Chisos Mountains.

Our Mexican locality data are as follows: DURANGO: 14 mi. E Las Boregas, 15.VII. 1952, J. D. Lattin (Slater collection). DURANGO: Los Mimbres, 6.VIII. 1974, E. Barrera and H. Brailovsky (UNAM collection).

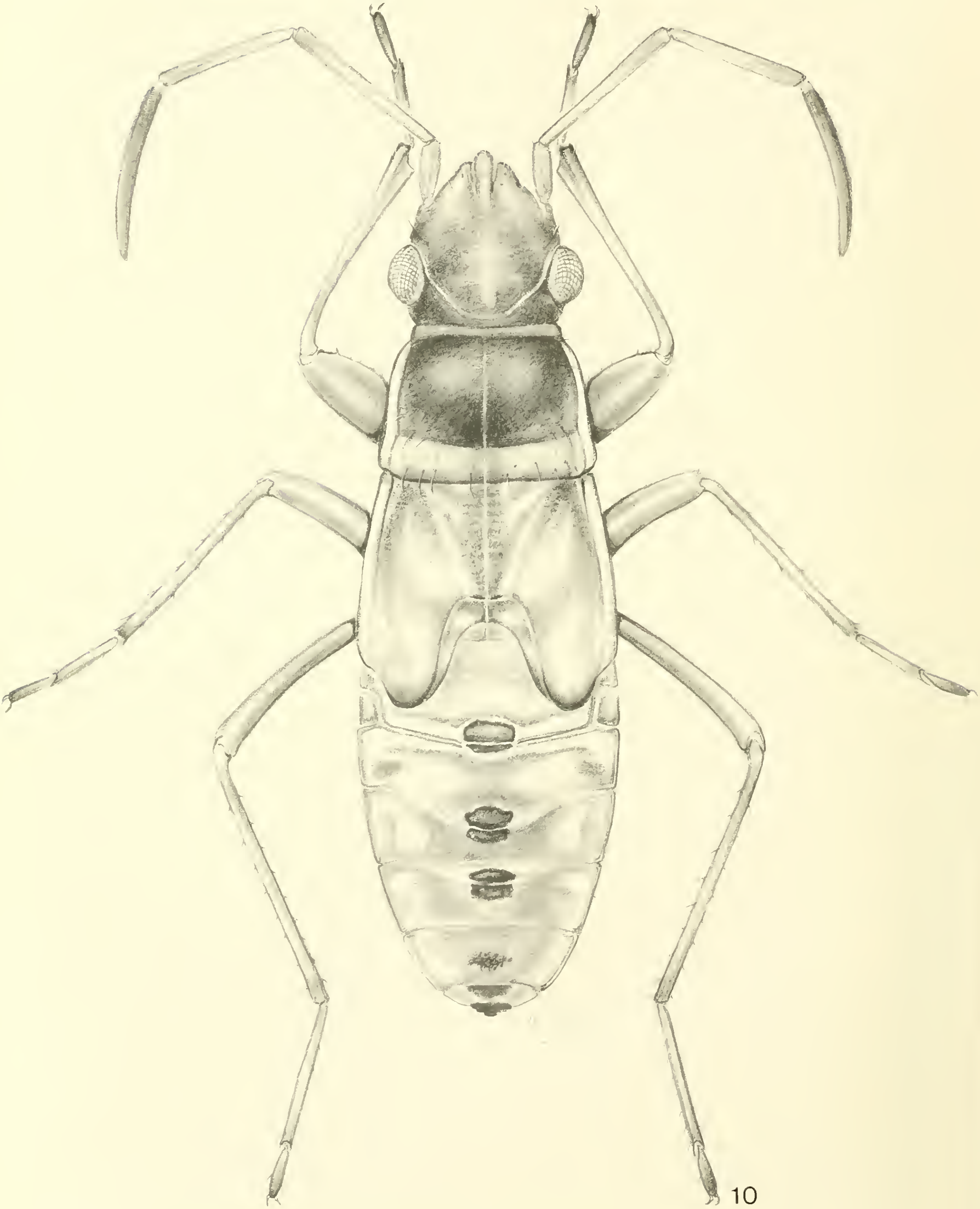


Fig. 10. *Slaterobius insignis* (Uhler) fifth instar nymph, dorsal view.

Ecology and Zoogeography

All species of *Slaterobius* are strikingly myrmecomorphic. The biology of *S. insignis* was studied in detail by Sweet (1964). He noted that the species lives on the ground in hot dry habitats where ants are common and that the movements of the lygaeids greatly enhance the already striking structural mimetic appearance.

Harrington (1980) noted that many specimens with reduced hemelytra also showed a "peculiar distended metapleuron which is very bulbous when viewed from above." Both *S. chisos* (Figs. 7, 8) and *S. nigritus* (Fig. 9) have enormously enlarged anterior metapleura that expand well laterad of the body and wings and enhance the ant mimicry effect. To a lesser extent the expanded metapleura are seen in *S. insignis* and *S. quadristriatus.* What the function of this enlargement may be is unknown, but it is tempting to think that it may be a sound-enhancing area for these stridulating insects or/and an accommodation for especially enlarged scent gland reservoirs.

The distribution of the genus is indeed interesting. The occurrence of two additional species in arid regions of the southwestern U.S. and Mexico strengthens Sweet's (1964) hypothesis that the occurrence of *S. insignis* in northeastern North America is probably due to a range expansion from western North America. Similar to *S. insignis,* both new species live on the ground in dry open natural habitats.

In eastern North America the distribution of *S. insignis* is strictly northern despite its inhabiting hot dry substrates (ground surface temperature reaching 50°C) (Sweet 1964). It barely reaches the highlands of northwestern Connecticut and most eastern records are from northern New York, northern New England and southern Canada. It also occurs in Michigan, Minnesota, Wisconsin, Iowa and Illinois. In the western states it has been reported from Utah, Idaho, Wyoming, the Dakotas, Nebraska, Colorado (see Slater 1964). We have examined material from New Mexico and single specimens from California and Texas. The specimens listed above are the first from Mexico. Such a distribution is unusual, but not unique, in the Lygaeidae. *Kolenetrus plenus* (Distant) appears to have a similar distribution. When the distributions of Mexican Lygaeidae are better known, we anticipate that additional similar distribution patterns will emerge.

It seems most reasonable to hypothesize that *Slaterobius* itself originated in conjunction with the rise of the Madro-Tertiary flora in the rain shadow of the ancestral Sierra Madre de Occidentale (Axelrod 1958). Some members of this flora and its attendant insect fauna spread into the Great Plains. The subsequent spread of *S. insignis* eastward may well be associated with morainic dry conditions developing behind the retreat of the ice sheets (Holloway and Bryant 1985, Delacourt and Delacourt 1985, Gaudreau and Webb 1985). Certainly distributions of this kind do not appear to be attributable to the Mid-Holocene eastern extension of the Prairie Peninsula. The preference (Sweet 1964) of *S. insignis* for the seeds of the grass *Schizachyrium scoparium* (Michx.) Nash, a species of dry open areas, gives additional support to the above hypothesis.

It is unfortunate that so little is known of the distribution of *Slaterobius quadristriatus.* Until recently, this insect was known only from the Pine Barrens of New Jersey (Barber 1911). Blatchley (1926) noted that it was "Beaten from small pines, which were partly scorched from fire." *Slaterobius quadristriatus* appears to be an arboreal species, unlike the other known members of the genus and most Rhyparochrominae. Wheeler (1991), in correcting an erroneous reference to *E. depressus* Barber (Slater and Baranowski 1990), reported collecting "numbers of specimens by beating pine cones in New Jersey." Dr. Wheeler (in litt.) and Dr. Harrington (pers. comm.) informed us that Mr. Jonathan F. Fetter first discovered *S. quadristriatus* in Wisconsin on *P. banksiana* Lamb., feeding on pine seeds in the cones. Fetter thus suggested to Wheeler that he search on Pitch Pine (*P. rigida* Mill.) for *S. quadristriatus.* Wheeler (in litt.) was able to find *S. quadristriatus* in New Jersey but noted that he could locate only one colony, despite his extensive collecting on *P. rigida* throughout its range from Maine to North Carolina in the course of his study of the insect fauna of *P. rigida.* Wheeler and Henry (pers. comm.) were also able to find *P. quadristriatus* on jack pine on the Upper Peninsula of Michigan. Wheeler and Harrington both describe the collecting sites as being open pine barren habitats with sandy soil in which the pine trees were short and broad in sparse stands rather than tall and polelike in dense stands.

A further important point is that the pines from which *S. quadristriatus* was collected (*P. rigida* in New Jersey and *P. banksiana* in Michigan) are both species which retain their cones on the trees for years after maturity and the cones are frequently serotinous, staying closed for years and opening irregularly, often when scorched by fire (Fowells 1965). This may promote the arboreal niche of *S. quadristriatus* by extending seed retention and providing cover for this insect. Unlike other arboreal pine seed-feeding lygaeids, such as *Gastrodes* spp., *Orsillus* spp., and *Eremocoris depressus* Barber, *S. quadristriatus* is not flattened to fit inside cone scales. This perhaps indicates a relatively recent niche shift by *S. quadristriatus* to an arboreal habit, given that the other *Slaterobius* species are ground-living. In this context, the absence of the Holarctic genus *Gastrodes* from the eastern United States is noteworthy, given the presence of 4 of its 9 species in the western United States. (*G. walleyi* Usinger is known from one specimen collected in Quebec.) Similarly, while the other species of Nearctic *Eremocoris* are all ground-living, and most feed on conifer seeds (Sweet 1964, 1977, Sweet unpublished), the eastern *E. depressus* is the only arboreal species (Barber 1928, Slater and Baranowski 1990, Wheeler 1991, pers. comm.).

Harrington and Fetter (pers. comm.) have studied the distribution and life cycle of *P. quadristriatus* in Wisconsin, and found it to be a scarce species on jack pine much as Wheeler (pers. comm.) noted for the insect in Michigan and on pitch pine in the East. To stress its arboreal habit, Harrington further noted that she and Fetter could not find *S. quadristriatus* on the ground, even when the insect was present on the tree above. It may be significant that *P. rigida* and *P. banksiana* are considered to be closely related species within the subgenus *Diploxylon* section *Pinaster* (Fowells 1965), a relationship that may be similarly reflected in a "rare" cerambycid *Xylotrechus schaefferi* Schott which uses cones of these same pine species as hosts (Hoebeke and Huether 1990).

To understand the distribution of *S. quadristriatus,* it is significant that both jack pine and pitch pine thrive in the nutrient-poor sandy soils of barren areas where both species form fire climax communities. During glacial maxima, forests of both jack pine and pitch pine occurred in refugia on the vast coastal plain along the North American Atlantic coast to the east and south of the ice sheet (Delacourt and Delacourt 1985). The biogeographical importance of the glacier together with the dry cold mid-American prairies for geographical isolation is well indicated by the general systematic species separation of the eastern coniferous forest from the western coniferous forest of North America. With the amelioration of climate, the most cool-adapted eastern conifers (*P. banksiana* and *P. resinosa* Ait.) invaded the dry periglacial outwash morainic areas virtually up to the margin of the retreating glaciers, and between 10–8000 B.P., these pines had spread west to occupy the lake areas of Michigan, Wisconsin, and Canada (Holloway and Bryant 1985, Delacourt and Delacourt 1985, Gaudreau and Webb 1985). This pattern may explain well the distribution of *S. quadristriatus.* By the same dry route, utilizing open morainic areas, ground-living cool-adapted western elements, such as *S. insignis,* could move eastward to occupy their present more northern ranges in eastern North America. This cool adaptation of the eastern population, which is shown by its univoltine egg diapause life cycle (Sweet 1964), makes understandable the northern restriction of the distribution of *S. insignis.*

Sweet (1964) noted that 80% of the individuals in the populations of *insignis* that he studied were brachypterous and related this to the relative permanence of the dry morainic habitats preferred by the species in New England. All specimens of the new species described here show a uniform degree of brachyptery, with the membrane reduced to a remnant but with the clavus and corium either not fused, or when fused, the two areas are still distinguishable (Figs. 7, 9). In the Upper Sonoran habitat of *S. chisos,* nearly all the rhyparochromine species are pterygopolymorphic, which attests to the relative permanence of the open woodland to montane grassland biotopes. The open pine barren habitats preferred by *S. quadristriatus* are similarly relatively permanent, compared to the life cycle of the species, allowing the species to persist and evolve pterygopolymorphism. As both Wheeler and Harrington remarked, it is nevertheless astonishing how infrequent *S. quadristriatus* appears to be, as compared to the extent of the apparently favorable habitat. It may be that the human overuse of fire, especially in the last century (Wacker 1979), had greatly attenuated the populations of *S. quadristriatus* because of the insect's relatively poor dispersal abilities. Under normal natural conditions of lower fire frequency, brachyptery may have been advantageous for maintaining populations in open seral stages undergoing succession slowly (Sweet 1964). The "rarity" of the cerambyid *Xylotrechus schaefferi,* noted earlier, may have a similar ecological origin.

Given the above new information, we propose a simple vicariant reconstruction of the phyletic history of *Slaterobius.* After its origin as a Madro-Tertiary event in the western Nearctic, the genus spread east. The Pleistocene cooling and dehydration of the central United States separated the western and eastern populations; the latter evolved into *S. quadristriatus,* which differs uniquely in its apomorphic striped color pattern and in its arboreal habit. The western population differed in having apomorphic upright thick setae and a lateral stripe of silvery hairs on the abdomen, but was plesiomorphic in retaining the ground-living habit. The next vicariant event would have been the separation of eastern populations of the Sierra Madre de Orientale from populations of the Sierra de Occidentale and western North America, the latter of which became the widespread *S. insignis,* the former, the ancestral *chisos* + *nigritus* population. The third vicariant event would have been the separation of the northern populations in the southwest U.S. from the southern populations in the the Sierra de Orientale of Mexico. The former, characterized by an apomorphic glabrous posterior abdomen, became *S. chisos,* and the latter became *S. nigritus.* Finally, cool-adapted northern populations of *S. insignis,* following the dry morainic habitats left by the retreat of the Pleistocene glacier, were able to invade northeastern North America, and are now sympatric with *S. quadristriatus,* which as discussed, had probably invaded the Lake States from the east, following the northward migrating populations of jack pine. This proposed scenerio should be amenable to testing by molecular techniques. Actually, given our relatively poor field collections of these insects, especially in Mexico, the phyletic history of the genus well may be more complex.

ACKNOWLEDGMENTS

We are indebted to Dr. A. G. Wheeler, Jr. (Pennsylvania Dept. of Agriculture) for the loan of specimens of *S. quadristriatus,* for information concerning this species and *Eremocoris depressus,* and for critically reading the manuscript; to Dr. B. J. Harrington (formerly University of Wisconsin) for information about her and Mr. Jonathan Fetter's field work on *S. quadristriatus*; to Mr. Ernesto Barrera (Instituto de Biologia, UNAM), who collected most of the Mexican material, to Mr. Steven Thurston (formerly University of Connecticut) for preparation of the dorsal and lateral view illustrations, and to Ms. Mary Jane Spring (U. of Connecticut) for preparation of the dorsal view of the fifth-instar nymph of *Slaterobius insignis*.

LITERATURE CITED

Axelrod, D. I. 1958. Evolution of the Madro-Tertiary geoflora. Botanical Reviews 24: 433–509.

Barber, H. G. 1911. Descriptions of some new Hemiptera-Heteroptera. Journal of the New York Entomological Society 19: 23–31.

———. 1928. The genus *Eremocoris* in the eastern United States, with a description of a new species and a new variety (Hemiptera—Lygaeidae). Proceedings of the Entomological Society of Washington 30: 59–60.

Blatchley, W. S. 1926. Heteroptera or True Bugs of Eastern North America, with Especial Reference to the Faunas of Indiana and Florida. Nature Publishing Co., Indianapolis, Indiana. 1116 pp.

Fowells, H. A. 1965. Silvics of Forest Trees of the United States. Agriculture Handbook No. 271. Forest Service, United States Department of Agriculture, District of Columbia. 762 pp.

Delacourt, H. R. and P. A. Delacourt. 1985. Quaternary palynology and vegetation history of the southeastern United States, pp. 1–37. *In* Bryant, V. M., Jr. and R. G. Holloway, eds., Pollen Records of Late-Quaternary North American Sediments. American Association of Stratigraphic Palynologists Foundation, Austin, Texas. 426 pp.

Gaudreau, D. C. and T. Webb III. 1985. Late-Quaternary pollen stratigraphy and isocrone maps for the northeastern United States, pp. 245–280. *In* Bryant, V. M., Jr., and R. G. Holloway, eds., Pollen Records of Late-Quaternary North American Sediments. American Association of Stratigraphic Palynologists Foundation, Austin, Texas. 426 pp.

Harrington, B. J. 1980. A generic level revision and cladistic analysis of the Myodochini of the World. (Hemiptera, Lygaeidae, Rhyparochrominae). Bulletin of the American Museum of Natural History 167: 49–116.

Hoebeke, E. R. and J. P. Huether. 1990. Biology and recognition of *Xylotrechus schaefferi* Schott, an enigmatic longhorn in northcentral and eastern North America with a description of the larva (Coleoptera: Cerambycidae). Journal of the New York Entomological Society 98: 442–449.

Holloway, R. G. and V. M. Bryant, Jr. 1985. Late-Quaternary pollen records and vegetation history of the Great Lakes Region: United States and Canada, pp. 295–245. *In* Bryant, V. M., Jr. and R. G. Holloway, eds., Pollen Records of Late-Quaternary North American Sediments. American Association of Stratigraphic Palynologists Foundation, Austin, Texas. 426 pp.

Slater, J. A. 1964. A Catalogue of the Lygaeidae of the World. 2 vols. Storrs, Connecticut. 1669 pp.

Slater, J. A. and R. M. Baranowski. 1990. Lygaeidae of Florida (Hemiptera: Heteroptera). Arthropods of Florida and Neighboring Land Areas. Vol. 14. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, Florida. 211 pp.

Sweet, M. H. 1964. The biology and ecology of the Rhyparochrominae of New England (Heteroptera: Lygaeidae). Pt. I. Entomologia Americana 43: 1–123. Pt. II. Entomologia Americana 44: 1–201.

———. 1977. Elevation of the seed bug *Eremocoris borealis* (Dallas) from synonymy with *E. ferus* (Say) (Hemiptera: Lygaeidae). Entomological News 88: 169–176.

Wacker, P. O. 1979. Human exploitation of the New Jersey Pine Barrens before 1900, pp. 3–23. *In* Forman, R. R. R., ed., Pine Barrens: Ecosystem and Landscape. Academic Press, New York. 601 pp.

Wheeler, A. G., Jr. 1991. Review of *Lygaeidae of Florida* (Hemiptera: Heteroptera) by J. A. Slater and R. M. Baranowski. Florida Entomologist 74: 372–374.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 603–604

NEOTYPE DESIGNATION FOR *ADELPHOCORIS VARIABILIS* (UHLER) (HETEROPTERA, MIRIDAE)

Tomohide Yasunaga[1]

Biological Laboratory, College of General Education, Kyushu University, Ropponmatsu, Fukuoka 810, Japan.

Abstract.—A neotype for *Adelphocoris variabilis* (Uhler) is designated.

Key Words: Insecta, Hemiptera, Heteroptera, Miridae, *Adelphocoris,* neotype designation

Adelphocoris variabilis was described in the genus *Calocoris* by Uhler (1896), based on ten Japanese specimens. Although I revised the Japanese *Adelphocoris* (Yasunaga 1990a, b), I did not examine the holotype of each species. Recently, through the courtesy of Thomas J. Henry (Systematic Entomology Laboratory, USDA, Washington, D.C.), I had an opportunity to examine three syntypes deposited in U.S. National Museum of Natural History(= USNM). (The remaining seven are lost, Henry, pers. comm.) However, they do not correspond to the accepted concept of *Adelphocoris variabilis,* but instead are representative of *Creontiades tricolor* (Scott 1880), *Adelphocoris suturalis* (Jakovlev 1882), and *A. triannulatus* (Stål 1858), respectively. On the other hand, because the original description exactly fits what has been called *A. variabilis,* the specimen representing Uhler's concept is considered to be lost. Thus, I am selecting a neotype from the type locality to maintain Uhler's name.

Adelphocoris variabilis (Uhler)

Calocoris variabilis Uhler, 1896: 267.
Adelphocoris variabilis: Oshanin 1906–1909: 685; Esaki 1950: 259; Carvalho 1959: 23; Miyamoto 1961: 222; Miyamoto 1974: 129; Kerzhner 1978: 41; Kerzhner 1988: 819; Ichita 1988: 135; Yasunaga 1990a: 614; Lee and Kwon 1991: 27.
Adelphocoris suturalis: Linnavuori, 1963: 78 (in part).

Neotype.—♂, Tagokura-dam, Tadami Town, Fukushima Pref., Honshu, Japan, 22. vii. 1987, S. Nomura (USNM).

Acknowledgments

I thank Dr. T. J. Henry for lending the Uhler material and reviewing the manuscript. I also appreciate Dr. S. Miyamoto (Fukuoka City, Japan) and Mr. H. Hasegawa (Hoya City, Tokyo, Japan) for their kind advice, and Dr. S. Nomura (Kyushu University, Japan) for providing the above specimen selected as the neotype.

Literature Cited

Carvalho, J. C. M. 1959. Catalogue of the Miridae of the world. Part IV. Subfamily Mirinae. Arqivos do Museu Nacional, Rio de Janeiro 48: 1–384.

Esaki, T. 1950. Heteroptera, pp. 179–270. *In* Esaki, T., et al., eds., Iconographia Insectorum Japonicorum. Hokuryukan, Tokyo. (In Japanese.)

Ichita, T. 1988. Heteroptera of Aomori Prefecture, Japan. Celastrina (20): 113–145. (In Japanese.)

Kerzhner, I. M. 1978. Heteroptera of Sakhalin and

---

[1] Post Doctoral Fellow of JSPS Fellowships for Japanese Junior Scientists.

South Kurile Isles. Trudy Biologo-Pochvennogo Instituta, Novaja Serija 50(153): 31–57.

———. 1988. Family Miridae. Keys to the insects of the Soviet Far East. Nauka, Leningrad 2: 778–857. (In Russian.)

Lee, C. E. and Y. J. Kwon. 1991. Annotated check list of Hemiptera from Korea. Part III. Cimicomorpha 2: Miridae. Nature and Life, Taegu 21: 23–38.

Linnavuori, R. 1963. Contributions to the Miridae fauna of the Far East III. Annales Entomologici Fennici 29: 73–82.

Miyamoto, S. 1961. Comparative morphology of alimentary organs of Heteroptera, with the phylogenetic consideration. Sieboldia, Fukuoka 2: 197–259.

———. 1974. Miscellaneous notes on the mirid bugs(3). Rostria (23): 120–122. (In Japanese.)

Oshanin, B. 1906–1909. Verzeichnis der Palaearktischen Hemipteren mit besonderer Berücksichtigung ihrer Verteilung im Russischen Reiche. Volume I. Beilage zum, Annuaire Musée Zoologique de l'Académie Impériale des Sciences, St Pétersburg 11–14: 1–1087.

Uhler, P. R. 1896. Summary of the Hemiptera of Japan, presented to the United States National Museum by Professor Mitsukuri. Proceedings of the U.S. National Museum 19: 255–297.

Yasunaga, T. 1990a. A revision of the genus *Adelphocoris* Reuter (Heteroptera, Miridae) from Japan, Part I. Japanese Journal of Entomology 58: 606–618.

———. 1990b. A revision of the genus *Adelphocoris* Reuter from Japan, Part II. Japanese Journal of Entomology 58: 725–733.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 605–610

FLEXARIDA CHAOTICA, NEW GENUS AND SPECIES OF LEAFHOPPER (HOMOPTERA: CICADELLIDAE) FROM THE AMERICAN SOUTHWEST

Robert F. Whitcomb and Andrew L. Hicks

Insect Biocontrol Laboratory, Agricultural Research Service, Beltsville Agricultural Research Center, Beltsville, Maryland.

Abstract.—In the course of a recent review of the genus *Flexamia,* a new species was discovered that, although apparently related to *Flexamia* and two other related genera (*Spartopyge* and *Alapus*), could not be assigned to an existing genus. The species has a highly reduced aedeagus with little trace of characters of other flexaminoid genera. Characters of the male plates and female sternum VII suggested that ancestors of this new species, which apparently specializes on *Muhlenbergia arenacea* or closely related grasses in alkaline flats of southern Arizona and New Mexico, diverged from the flexaminoid lineage prior to divergence of *Flexamia.* We name this species ***Flexarida chaotica.***

Key Words: Leafhopper, grasslands, semiarid, Southwest

In the course of a recent review (Whitcomb and Hicks 1988) of the genus *Flexamia,* we encountered several series of an undescribed species which, although clearly allied with the *Flexamia-Spartopyge-Alapus* lineage of deltocephaline leafhoppers, could not be assigned to an existing genus. The species possessed some characters of the genus *Alapus* and of primitive members of *Flexamia,* but was distinctively different from these genera in lacking all characters autapomorphic for them. The new species was autapomorphic in possession of a small, stout, asymmetrical aedeagus with two tiny subapical lateroventral teeth, and an apodeme consisting of two small semicircular structures.

Most specimens from our collections were taken from a single host, *Muhlenbergia arenacea* (Buckl.) Hitchc., although several individuals were collected from the closely related *M. asperifolia* (Nees & Mey.). *M. arenacea* is a frequent inhabitant of highly saline flats of the American Southwest. In addition to specimens collected in our surveys, we discovered two specimens in the National Museum of Natural History (NMNH, Washington, D.C.) taken by E. D. Ball in 1932 from southeastern Arizona.

The new species is characterized not only by its bizarre aeadeagal morphology, which is unlike that of any *Flexamia* species, but by a highly setose pygofer.

Flexarida Whitcomb and Hicks, New Genus

Closely resembling *Flexamia* in general habitus, but with the aedeagus much reduced in size. Head wider than pronotum, crown 1½–2 times longer medially than next to the eye, anterior margin acutely angled. Male pygofer (Fig. 1D) truncate, heavily setose on caudodorsal quarter (Fig. 1F), constricted medially both dorsally and ventrally. Plates (Fig. 1F) large, acute, with uniseriate spine-like setae on outer margin; aedeagus (Fig. 1A) small, stout, shorter than connective. Joint distinct between aedeagus

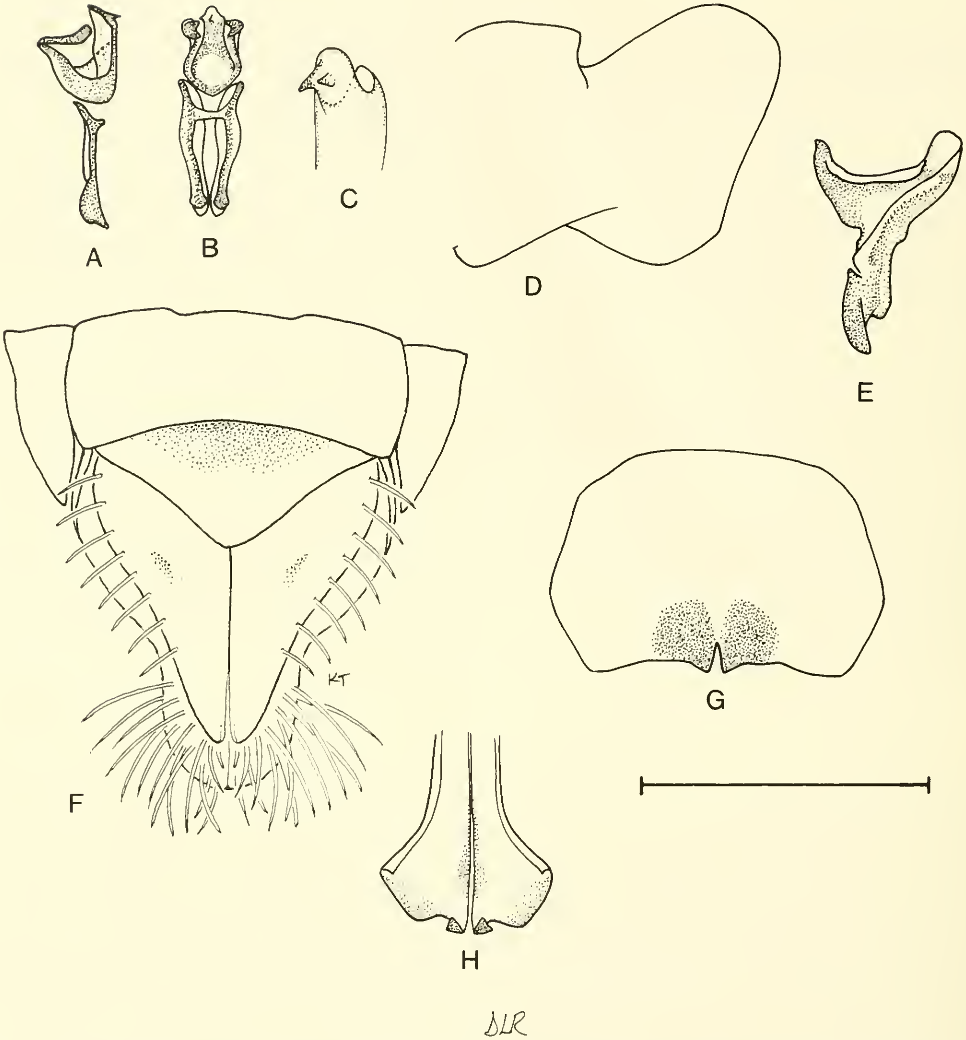


Fig. 1. *Flexarida chaotica.* A. Aedeagus and connective, lateral aspect; B. Aedeagus and connective, ventral aspect; C. Detail of apex of aedeagus; D. Lateral aspect of male pygofer; E. Style, broad aspect; F. Ventral aspect of plates, pygofer and valve of male; G. Female sternum VII; H. Base of first valvulae of ovipositor.

and connective, which together are approximately equal in length to the styles. Apodeme consisting of two small semicircular structures. Female sternum VII (Fig. 1G) with a shallow V-shaped notch at the center of the posterior margin.

Flexarida chaotica Whitcomb and Hicks, New Species

Description.—Length of male 3.6 (3.3–3.9) mm, of female 4.2 (4.0–4.5) mm, head width of male 1.06 mm, of female 1.10 mm. Crown not strongly produced; median length of crown 0.65 × head width and 1.52 × interocular width (male n = 24; female n = 32).

Crown with indistinct dark circular areolet at apex with a black dash between the apex and eyes parallelling angled anterior margin of crown, disc of crown pale brown with ivory stripe along medial line in well-marked specimens. Macropterous to submacropterous with opaque elytra usually equalling or exceeding abdomen, occasionally exposing 0.5 pregenital abdominal segments, two dark brown spots on disc, cells with or without variable amounts of brown outlining, costal cells usually with posterior margins heavily infuscated. Cells usually pale brown, veins white. Face variable, in some specimens almost entirely fuscous, diminishing basally to lighter shades of brown, to strikingly bicolored, with a fuscous band above, subtended with ivory. Abdomen and legs with varying amounts of dark brown pattern, femurs striped, tibia spotted along bases of spines.

Male.—Pygofer (Fig. 1D) with posterior margin truncate, angling from a ventrally produced caudoventral lobe, apex of pygofer exceeding that of anal tube. Plates (Fig. 1F) subacute, divergent apically, slightly shorter than pygofer. Valve triangular. Style apices (Fig. 1E) small, digitately tapered, curved ventrally, with subapical ventral lobe barely attaining plate bases. Aedeagus (Fig. 1A, B) foot-shaped, very small, stout, with two tiny subapical teeth (Fig. 1C) on lateroventral side. Gonopore large, apical, asymmetrical. Connective (Fig. 1A, B) much like those in the *pectinata* group of *Flexamia* (Whitcomb and Hicks, 1988), dorsal keel not present.

Female.—Sternum VII (Fig. 1G) with posterior margin slightly concave, with a notched medial projection, heavily infuscated on either side of notch. Ovipositor with recurved basal processes of first valvula small, dark and triangular (Fig. 1H).

Type material.—*Holotype male:* Arizona, Cochise Co., Dos Cabezas, mile 336, Arizona Route 186, 5 October, 1987, 4100 ft, A. L. Hicks, IPL 002811, on *Muhlenbergia arenacea.* Deposited in NMNH. *Paratypes:* Arizona, Cochise Co., Dos Cabezas, same data as holotype, on *M. arenacea,* 7 males, 13 females, 2 nymphs; Cochise Co., Johnson (Interstate 10 near Johnson Rd Exit, between mi 324 and 325), 5 Oct., 1987, 4100 ft, A. L. Hicks, IPL 002812, on *M. arenacea,* 6 males, 11 females; Arizona, Cochise Co., Cochise, between mile 329 and 330 on Interstate 10, 7 Oct., 1987, 4500 ft, A. L. Hicks and J. E. Lowry, 4500 ft, IPL 002813, 3 males, 5 females; Arizona, Cochise Co., Dos Cabezas, 7 Oct., 1987, A. L. Hicks and J. E. Lowry, 4100 ft, IPL 002814, on *M. arenacea,* 8 males, 7 females; Arizona, Cochise Co., Rucker Canyon, 8 Oct. 1987, A. L. Hicks and J. E. Lowry, 4500 ft, IPL 002815, on *Muhlenbergia arenacea,* 2 males, 2 females; Arizona, Cochise Co., Douglas, Aug. 21, 1932, E. D. Ball, 1 male, 1 female. New Mexico, Chaves Co., Roswell, 20 August 1985, 3900 ft, R. F. Whitcomb, IPL 001929, on *Muhlenbergia arenacea,* 3 males, 5 nymphs; Luna Co., New Mexico Rt 9, mi 66, near Columbus, 6 Sept. 1987, 4500 ft, on *M. asperifolia,* IPL 003496, 1 male, 1 nymph. Deposited in BARC, Beltsville, Maryland; California Academy of Sciences, San Francisco; Canadian National Collection, Ottawa; Monte L. Bean Museum, Brigham Young University, Provo, Utah; Kansas State University, Manhattan; University of Kansas, Snow Museum, Lawrence; Ohio State University, Columbus; and NMNH. Localities are mapped in Fig. 2.

PHYLOGENY OF *FLEXARIDA CHAOTICA*

To assess the phylogenetic position of *F. chaotica,* we determined the placement of the species in the 18 character transformations used to reconstruct *Flexamia* phylogeny (Whitcomb and Hicks 1988). A phylogeny showing the position of *F. chaotica* with respect to *Flexamia* and *Spartopyge* is presented in Fig. 3. Definitive placement of this genus awaits full consideration, on a world basis, of flexaminoid genera in the general context of evolutionary trends in the Deltocephalinae as a whole, or at least in the cluster of grass-inhabiting genera characterized by a Y-type connective that is not fused (or is incompletely fused) with the aedeagus (see scattergram of Oman 1949, p. 110).

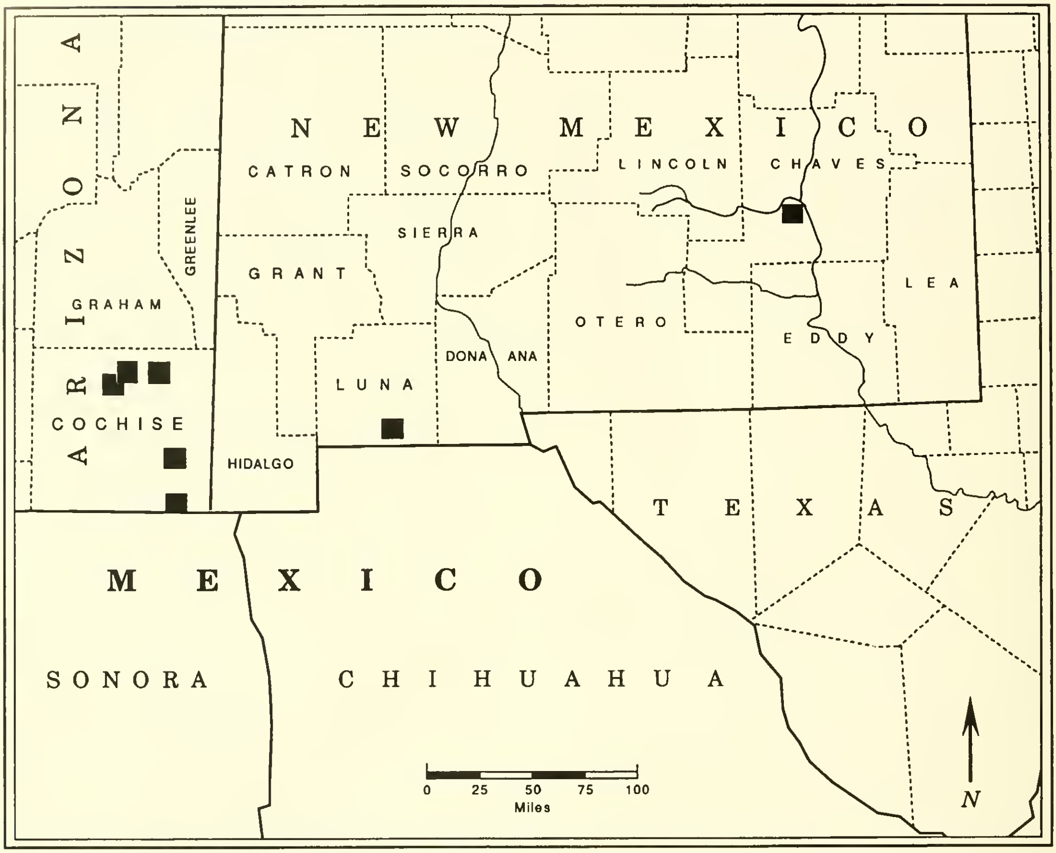


Fig. 2. Collection localities for *Flexarida chaotica*.

Discussion

We have surveyed a number of *Muhlenbergia* species in the Southwest (Whitcomb et al. 1986, 1987, 1988) but have found *F. chaotica* only on *M. arenacea* or the closely related *M. asperifolia.* The lowland habitats of *M. arenacea* are presumably often high in inorganic salts. We regarded the first specimens of *chaotica* that we collected in New Mexico as examples of aberrant genitalic development. However, after several series were taken in southeastern Arizona it became clear that this was not the case. Furthermore, a specimen collected by E. D. Ball in 1932 in southeastern Arizona had identical aedeagal morphology. We therefore believe that the highly unusual genitalia are unlikely to be products of a teratogenic process, but instead represent the normal genitalia of a bizarre, previously undescribed genus and species.

Although the genitalia are clearly not the result of proximate environmental influences, it is possible that saline and/or alkaline habitats have nevertheless influenced the evolution of this species. We are also reminded that the aedeagus of the Four Corners "Anasazi" population of *Flexamia arenicola* Lowry and Blocker are invariably broken (Whitcomb and Hicks 1988). This region of the Colorado Plateau at the intersection of Utah, Colorado, Arizona, and New Mexico (the San Juan Basin) is currently undergoing salinization during an interglacial dry period. Given the aedeagal simplification of other desert cicadellids, for example *Athysanella* (Blocker and Johnson

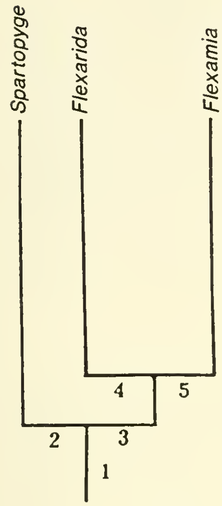


Fig. 3. Tentative phylogeny of North American flexaminoid genera (see Whitcomb and Hicks 1988). We hypothesize an ancestral form (1) with dorsal stripes and a pale face with contrasting black interocular band, relatively wide male plates, a broad aedeagus jointed with the connective, without apical processes but with tiny subapical processes, and an anteapical gonopore on the caudoventral surface. Division of this lineage led (2) to *Spartopyge* and (3) to the *Flexarida-Flexamia* lineage, in which the dorsal aedeagal apodeme plesiomorphically had a pair of appendages directed caudoventrally or caudad. This was modified in *Flexarida* (4) to form an apodeme consisting of two semicircular structures, a condition autapomorphic for the genus. Other autapomorphies defining *Flexarida* are narrow tapered plates, and various characters of the aedeagus, which is short, stout, and asymmetrical, has a pair of lateroventral teeth, and a large apical gonopore. In *Flexamia* (5), the aedeagus is narrow, and plesiomorphically symmetrical; the plates, in more plesiomorphic species, are relatvely wide; and the dorsal apodeme in all species has a pair of appendages directed caudoventrally or caudad.

The PHYSYS matrix data for *Flexarida chaotica,* compatible with those presented for *Flexamia, Alapus,* and *Spartopyge* (Whitcomb and Hicks 1988) are:

```
DISTIN   CHAOT    ASYM   ABSENTP  STRAIT   THICK  1 CHAOTICA
SHORT    UNTAPER  ABSNT  APICALG  APODEXP  APOCH  2 CHAOTICA
CONNAR   BULBPY   CHAPL  UNITOO   ABSTR    CONBLF 3 CHAOTICA
```

where CHAOT, APOCH, and CHAPL are autapomorphic for the genus.

1988, 1990a, b, Hicks and Whitcomb 1991), it seems possible that the stress conditions of drought and salinization may favor aedeagal simplification.

ACKNOWLEDGMENTS

The logistical support and hospitality of Eric Weber and Rosemary J. Smith during extended field studies of ALH in southeastern Arizona made collection and recognition of this taxon possible. The University of Arizona Herbarium was also most helpful, especially Charles T. Mason, Jr., and Charlotte Reeder who identified the grass. H. Derrick Blocker provided insight and encouragement throughout the course of this study. Mapping was greatly assisted by Kathleen McCormick's cartographic expertise. To them, to Lee Marlatt and staff of Bitter Lake National Wildlife Refuge, and to J. Elaine Lowry, who provided field assistance, we express our sincere gratitude.

Illustrations.—We thank Deborah Roney for discussion of artistic representation of morphological structures of the new genus, and for preparation of the figures. We are also indebted to Karen Teramura for Fig. 1F.

LITERATURE CITED

Blocker, H. D. and J. W. Johnson. 1988. Classification of the subgenus *Athysanella,* genus *Athysanella* (Homoptera: Cicadellidae: Deltocephalinae). Great Basin Naturalist Memoirs 12: 18–42.

———. 1990a. Classification of *Athysanella* (*Gladionura*) (Homoptera: Cicadellidae: Deltocephalinae). Journal of the Kansas Entomological Society 63: 9–45.

———. 1990b. Classification of *Athysanella* (*Amphipyga*) (Homoptera: Cicadellidae: Deltocephalinae). Journal of the Kansas Entomological Society 63: 101–132.

Hicks, A. L. and R. F. Whitcomb. 1994. Notes on the leafhopper (Homoptera: Cicadellidae) fauna of southeastern New Mexico, with emphasis on gypsum grasslands and a description of a new species of *Athysanella.* Proceedings of the Entomological Society of Washington. (In press.)

Oman, P. W. 1949. The nearctic leafhoppers (Homoptera: Cicadellidae). A generic classification and check list. Memoirs of the Entomological Society of Washington. Entomological Society of Washington, Washington, D.C.

Whitcomb, R. F. and A. L. Hicks. 1988. Genus *Flexamia*: New species, phylogeny, and ecology. Great Basin Naturalist Memoirs 12: 224–323.

Whitcomb, R. F., A. L. Hicks, D. E. Lynn, K. Allred, and H. D. Blocker. 1987. Geographic variation in host relationships of leafhoppers (Homoptera: Cicadellidae) in North American grasslands, pp. 293–325. *In* Wilson M. R. and L. R. Nault, eds., Proceedings of the 2nd International Workshop on Leafhoppers and Planthoppers of Economic Importance. Commonwealth Institute of Entomology, London.

Whitcomb, R. F., J. Kramer, M. E. Coan, and A. L. Hicks. 1986. Ecology and evolution of leafhopper-grass relationships in North American grasslands. Current Topics in Vector Research 4: 125–182.

Whitcomb, R. F., A. L. Hicks, H. D. Blocker, and J. P. Kramer. 1988. Host specificity: A major mechanism enhancing insect diversity in grasslands. Paper 11.06. *In* Davis, A. and G. Stanford, eds., The Prairie: Roots of Our Culture; Formulation of our Economy. Proceedings of the 10th North American Prairie Conference, Denton, Texas, 1986. Native Prairies Association, Wheatland, Texas.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 611–634

THE NORTH AMERICAN SPECIES OF THE *FORCIPOMYIA (LEPIDOHELEA) BICOLOR* SUBGROUP (DIPTERA: CERATOPOGONIDAE)

WILLIS W. WIRTH AND GUSTAVO R. SPINELLI

(WWW) Cooperating Scientist, Systematic Entomology Laboratory, USDA, and Research Associate, Florida State Collection of Arthropods, 1304 NW 94th St., Gainesville, Florida 32606, U.S.A.; (GRS) Instituto de Limnologia "Dr. Raul A. Ringuelet," Casilla de Correo 712, 1900 La Plata, Argentina.

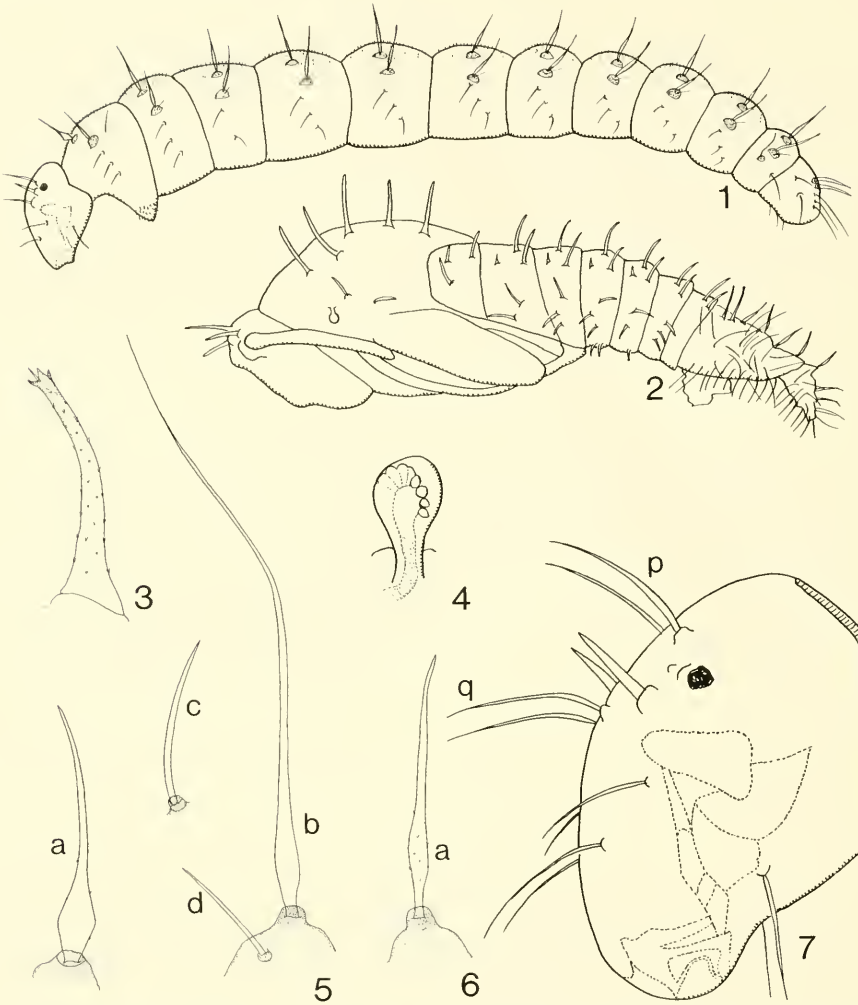
Abstract.—The *bicolor* Subgroup of the genus *Forcipomyia* Meigen, subgenus *Lepidohelea* Kieffer, is represented in the Nearctic Region by nine species. Keys are presented for their identification, and to distinguish them from other groups of the subgenus *Lepidohelea* in North America. The two previously known species, *F. christiansoni* Wirth and Hubert and *F. varipennis* Wirth and Williams, are redescribed and illustrated, as well as the following seven new species: ***acinacis, cochisei, dubiamima, eadsi, edmistoni, usingeri,*** and ***werneri.*** The immature stages of *F. edmistoni* and *F. usingeri* are described and illustrated; they were found under tree bark. *F. christiansoni* was reared from rotting *Opuntia* cacti in California.

Key Words: Ceratopogonidae, *Forcipomyia, Lepidohelea, bicolor* Subgroup, taxonomic revision, Nearctic, *Opuntia* cacti, tree bark

In North America the biting midges of the genus *Forcipomyia* Meigen with banded legs have until now been poorly understood taxonomically. It has been only during the past five years that serious attention has been given to their taxonomy. Coquillett (1905) described the first of these problematical species with banded legs as *Ceratopogon cinctipes* (Coquillett) from Florida. Wirth (1952) identified as *Forcipomyia cinctipes* a common species from California that he reared from under the bark of dead Monterey pines; and is herein described as *F. usingeri* n. sp. This new species is apparently closely related to *F. christiansoni* Wirth and Hubert (1960), which was originally described from *Opuntia* cacti in California. Wirth and Williams (1957) described *F. varipennis* from Bermuda, Texas, Puerto Rico, and Guatemala; the type series is actually a mixture of species—the paratype from Puerto Rico is conspecific with the holotype from Bermuda; the Texas specimens are herein described as *F. eadsi* n. sp., and the identify of the Guatemalan specimens is still doubtful.

All of these species were placed by Wirth (1976) in the subgenus *Forcipomyia* in a group which he named the *Forcipomyia cinctipes* group. In this group he inferentially placed *F. cinctipes,* added *F. pictoni* Macfie which had been described from Trinidad, and two new species from Florida, *F. beckae* Wirth and *F. seminole* Wirth.

Debenham (1987), in a magnificent comprehensive study of the Australian *Forcipomyia,* first brought order into the chaotic state of taxonomy of *Forcipomyia* (s. str.) and the subgenus *Lepidohelea* Kieffer, in which she outlined characters for the reli-



Figs. 1–7. *Forcipomyia usingeri*; 1, 5–7, larva; 2–4, pupa: 1, larva, habitus, side view; 2, pupa, habitus, side view; 3, cuticular process of cephalothorax; 4, respiratory horn; 5, body hairs of prothorax, lettering as in text; 6, *a* hair of remaining body segments; 7, head, side view.

able separation of the two subgenera and for species groups within the subgenus *Lepidohelea.* She included some Australian species in the so-called "*cinctipes* Group," and pointed out that *F. pictoni* really belonged in the subgenus *Forcipomyia,* while *F. beckae* and *F. seminole* belonged to *Lepidohelea.*

Wirth (1990) redescribed *Forcipomyia cinctipes* and transferred it to the subgenus *Schizoforcipomyia* Chan and LeRoux (1971). He pointed out that "The species that Wirth (1952) described and figured as *Forcipomyia cinctipes* from California, including the immature stages, was misdetermined and actually belongs to a group of banded-legged species in the subgenus *Lepidohelea.* Therefore the *cinctipes* Group of Wirth and other authors is a misnomer and must take a new name based on an included species." Following up on his 1990 paper, Wirth (1991a, b) divided the American species of *Lepidohelea* into two groups, based mostly on species that Lutz (1914) and Macfie (1939) had described from Brazil.

In the *annulatipes* group Wirth (1991b) included three species, *annulatipes, brasiliensis,* and *kuanoskeles,* all described by Macfie (1939) from southern Brazil. In the *bicolor* group he included the following Neotropical species: *bicolor* Lutz (1914), *dubia* Macfie (1939), and *lacrimotorii* Macfie (1939), which he redescribed from types, and *squamithorax* Clastrier (1972), *abercrombyi* Macfie (1938), *seminole* Wirth, *varipennis* Wirth and Williams, *winderi* Wirth (1991a), and *flavifemoris* Macfie (1940).

Wirth and Spinelli (1992) have divided the *bicolor* group into two subgroups, the *bicolor* subgroup, and the *seminole* subgroup, the latter including three species, *beckae* Wirth, *seminole* Wirth, and *luteigenua* Wirth and Spinelli. Species of the *seminole* subgroup were distinguished by the color of the hind femur, which is pale except for a narrow dark band just distad of midlength; whereas in the *bicolor* subgroup at least the distal half of the hind femur is dark.

Explanation of the taxonomic characters used can be found in the general papers on Ceratopogonidae by Wirth et al. (1977) and Downes and Wirth (1981), and the revision of the North American *Forcipomyia* (*Euprojoannisia*) by Bystrak and Wirth (1978). Terminology of the larval and pupal chaetotaxy follows the system of Saunders (1924, 1956).

Holotypes and allotypes of the new species are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. Paratypes as available will be deposited in the California Academy of Sciences, San Francisco, Canadian National Insect Collection, Agriculture Canada, Ottawa; Florida State Collection of Arthropods, Gainesville; Natural History Museum, London; and Museum National d'Histoire Naturelle, Paris.

Subgenus *Lepidohelea* Kieffer

Lepidohelea Kieffer, 1917: 364 (as genus). Type-species, *Ceratopogon chrysolophus* Kieffer, by original designation.

Diagnosis (modified from Debenham 1987).

Female.—Body usually with flattened striated scales, especially on legs and wings. Eyes bare. Mouthparts unarmed. Maxillary palpus 4- or 5-segmented, segments 4 and 5 fused in *annulatipes* group; segment 3 slightly to moderately swollen, maximum width at center, there with a small to medium sensory pit. Antenna 15-segmented, segments 4–10 short to vase-shaped, distal five segments slightly more elongate. Legs with complex pattern of pale and dark bands; hind tibia usually with a broad dark band proximally, then a broad pale band, another broad dark band, and broad pale apex; fore and mid tibiae usually with similar bands, but bands often obscure or absent; tarsi dark with joints of segments distinctly pale. Hind tarsal ratio usually about 1.0. Empodium well developed; claws small, simple and gently curved, or sharply bent centrally and sometimes also with a central barb. Wing with pattern of pale and dark scale-like macrotrichia, the dark scales larger on the wing veins, especially dark and prominent over radial cells, anteriorly at midlength of cell R5, and on branches of mediocubital fork. First radial cell closed, second open but short; costal ratio 0.4–0.5. Abdomen usually with well-developed genital sclerotization in form of a transverse arcuate band bearing small spines posteriorly at ends; one or two spermathecae.

Male.—Generally similar to female. Wing paler than in female, but the dark anterior spots and spot on vein CuA2 smaller and more distinct. Hind tibial spur often enlarged and sometimes hook-like; outer claw of fore tarsus sometimes with distinct blunt tooth at midlength ventrally. Genitalia usually prominently bicolored; with prominent pale yellowish areas on sternite 9 and gonocoxites, and gonostyli more or less whitish. Gonostylus variously shaped; straight, sinuous or bent, often with apex distinctly or grossly expanded; short setae often on basal portion, but long setae absent. Aedeagus variable, usually elongate rectangular or conical, often with complex apical processes. Parameres well developed, structure varies with species group.

Pupa.—Typical of *Forcipomyia*; larval exuviae retained on distal abdominal segments. Respiratory horn small, with or without basal heel, with row of spiracular openings around apex and extending down posterior side. Thorax with seven pairs of long cuticular processes, some of which are spinose apically. Abdomen with similar processes and/or smaller spinose tubercles on segments 1–8; large dorsal cuticular processes absent from 1 and 8. Terminal processes long and tapering. Male genital processes dorsal.

Larva.—Head hypognathous; antenna a simple tapered rod; *p* and *q* hairs long, expanded near base but becoming filamentous distally. Prothoracic pseudopod cleft apically, with four small dark spines at apex of each branch. Prothoracic *a* hair various; usually swollen near base and then filamentous, but short and swollen bulbously or vesicle-like in *annulatipes* group. Posterior body segments with *a* hairs rodlike with hastate apex; *b* hairs similar to prothoracic *a* hair but larger and longer, other setae simple. Segment 8 with *a* and *b* hairs all resembling prothoracic *a* hair but larger, the 4 hairs mounted on a common, halfmoon-shaped, chitinized base. Anal pseudopod cleft with each branch bearing 5–6 hooks apically and 3–4 on inner side. Cauda absent.

Larvae of *Lepidohelea* can be distinguished from larvae of the subgenera *Forcipomyia* s. str. and *Schizoforcipomyia* by means of the following key:

1. Head hairs *p* and *q* long and simple, sometimes hastate at tip; body hairs not thickened basally; *a* hairs with distinctly hastate tips; body segment 8 with *a* and *b* hairs variable in shape, but not swollen at base, often with a narrow bridge of chitin between the 4 hairs . . . . Subgenus *Forcipomyia* s. str.

– Head hairs *p* and *q* thickened at base, then becoming filamentous distally; *a* hairs variable; body hairs *b* and *d* thickened basally; body segment 8 with *a* and *b* hairs all resembling prothoracic *a* hair but larger, the 4 hairs mounted on a common halfmoon-shaped sclerotized base 2

2. Body with *a* hairs hastate apically . . . . Subgenus *Schizoforcipomyia*

– Body with *a* hairs swollen at base, at least on prothorax . . . . Subgenus *Lepidohelea*

Key to Species Groups of *Lepidohelea* in North America

1. Palpus with four segments; one spermatheca; gonostylus more or less expanded distally . . . . *annulatipes* Group

– Palpus with five segments; two spermathecae; gonostylus straight or slightly curved, tapering to slender (*bicolor* Group) 2

2. Hind femur pale with narrow dark band just distad of midlength . . . . *seminole* Subgroup

– Hind femur dark, at least on distal half . . . . *bicolor* Subgroup

Forcipomyia (*Lepidohelea*) *bicolor* Subgroup

Diagnosis.—For complete diagnosis see Wirth (1991b). Wing length 0.7–1.5 mm. Palpus 5-segmented. Female with two spermathecae. Female genital sclerotization usually an arcuate transverse ribbon bearing small spines on posterior margin, especially at lateral ends. Male gonostylus not swollen or modified at tip, straight or gently curved. Aedeagus with low basal arch, more or less triangular in outline, and bearing 1–3 inconspicuous longitudinal ridges or sclerotized lines on ventral surface. Parameres usually separated, distal portions simple, long, nearly straight rods usually tapering to filiform tips.

Biology.—Adult habits of the *Forcipomyia bicolor* group are very poorly known. Adults of *F. winderi* Wirth are very numerous in cocoa (*Theobroma cacao* (L.) plantations in Brazil where they are of considerable importance in pollination, along with many other *Forcipomyia* species. Larvae of the two North American species live under bark of dead or dying trees, and one species has been reared from rotting *Opuntia* cacti. The larvae are assumed to feed, like most other terrestrial *Forcipomyia* larvae, on various fungi associated with these habitats.

KEY TO NEARCTIC SPECIES OF THE *FORCIPOMYIA* (*LEPIDOHELEA*) *BICOLOR* SUBGROUP

(primarily for males)

1. Third palpal segment greatly swollen to apex; hind tibial spur straight, nearly ½ length of basitarsus; halter brown; spermathecae subequal; anterior arch of aedeagus poorly sclerotized .... *varipennis* Wirth and Williams

– Third palpal segment swollen at mid-portion, distal ¼ slender; hind tibial spur short (long in *acinacis*, but deeply curved); halter pale or brown; spermathecae unequal; anterior arch of aedeagus well sclerotized 2

2. Male 9th sternite and gonocoxite entirely dark brown 3

– Male 9th sternite and gonocoxite yellowish with dark brown patches 6

3. Gonostylus dark brown; fore and mid legs primarily yellowish; halter brown .... *werneri* new species

– Gonostylus pale (sometimes tip dark); fore and mid legs primarily brown; halter pale or brown 4

4. Antennal segments 11–14 of female short, only slightly longer than proximal segments; proximal ½ of femora pale; mid tibia without subbasal pale ring; spermathecae without pale punctations; halter brown .... *eadsi* new species

– Antennal segments 11–14 of female much longer than proximal segments; proximal ½ of femora brown; mid tibia with subbasal pale ring; spermathecae with small, faint, pale punctations; halter pale 5

5. Mid tibia dark to tip; hind tibial spur of male short, slender, and nearly straight, 0.28–0.32 as long as basitarsus .... *christiansoni* Wirth and Hubert

– Mid tibia with broad apical pale band; hind tibial spur long, stout, and curved, 0.34 as long as basitarsus .... *usingeri* new species

6(2). Large species (wing length 1.38–1.73 mm); proximal flagellar segments of female elongate vasiform or bottle-shaped; legs dark brown, fore and mid tibiae without subbasal pale rings, apex of hind tibia dark; male 9th sternite yellowish, dark brown lateroposteriorly; proximal ⅔ of gonocoxite yellowish, distal ⅓ dark brown .. *dubiamima* new species

– Smaller species (wing length 1.00–1.27 mm); proximal flagellar segments stout with short distal necks; legs brown, fore and mid tibiae with subbasal pale rings, apex of hind tibia pale; male 9th sternite and gonocoxite not as above 7

7. Third palpal segment very slightly swollen in midportion (palpal ratio 3.40); mid femur pale, narrow apex brown; apex of hind femur brown; wing with conspicuous pattern of pale areas; spermathecae with faint pale punctations; male 9th sternite dark brown laterally, pale in middle; distal ⅔ of gonocoxite dark brown on inner side .. *cochisei* new species

– Third palpal segment moderately swollen in mid portion (palpal ratio 2.60–2.70); distal ⅔ of mid femur brown; apex of hind femur pale (variable); wing densely covered with appressed microtrichia; spermathecae without pale punctations; distal ½ of male 9th sternite dark brown; distal ⅓ of gonocoxite pale yellowish on inner side 8

8. Costal ratio 0.37; apex of hind femur dark brown; male hind tibial spur short, slightly curved; male 9th sternite dark brown lateroposteriorly; distal ½ of gonocoxite entirely dark brown .... *pricei* new species

– Costal ratio 0.46–0.49; apex of hind femur pale (variable); male hind tibial spur as above, or unusually long, hook-shaped; distal ½ of male 9th sternite dark brown; distal ⅓ of gonocoxite pale yellowish on inner side ... 9

9. Male hind tibial spur unusually long, hook-shaped .... *acinacis* new species

– Male hind tibial spur short, slightly curved .... *edmistoni* new species

***Forcipomyia* (*Lepidohelea*) *acinacis* Wirth and Spinelli, NEW SPECIES**
(Fig. 57)

Allotype female.—Wing length 1.20 mm; breadth 0.46 mm.

Head: Brown, with numerous strong, erect, bristly brown hairs. Antenna with lengths of flagellar segments in proportion of 23-20-22-22-22-22-22-22-29-29-31-34-40; antennal ratio 0.93; proximal segments moderately long, 11–14 vase-shaped with short distal necks. Palpus with lengths of segments in proportion of 11-17-36-16-16; palpal ratio 2.60; 3rd segment moderately swollen in midportion, with an irregular deep pit opening by a small pore; distal ¼ slender.

Thorax: Dark brown. Scutum and scutellum with numerous, mixed brown and yellowish, bristly, erect setae and narrow, appressed, yellowish scales. Legs brown, with numerous, very long, brown and golden, erect setae, and elongate, broad, striated, brownish scales; femora pale at bases, hind femur also pale at tip; tibiae with subbasal and apical pale bands; hind tibial comb with eight spines, spur short, curved; tarsi brown with narrow segmental pale rings, hind tarsal ratio 0.85. Wing densely covered with appressed dark macrotrichia, a small, inconspicuous, yellowish spot just past end of costa; costal ratio 0.47. Halter slightly infuscated.

Abdomen: Dark brown, with numerous erect brown setae; tergites and pleura also with scattered, semi-appressed, 1-striated, scalelike, brown setae. Genital sclerotization as in *F. edmistoni* (Fig. 51). Spermathecae oval, unequal, measuring 0.095 × 0.062 mm and 0.084 × 0.056 mm.

Holotype male.—Wing length 1.40 mm; breadth 0.41 mm; costal ratio 0.42. Similar to female with usual sexual differences. Wing primarily pale, with macrotrichia concentrated on radial veins and in cells, along anterior margin beyond end of costa, and on vein CuA2. Hind tibial comb (Fig. 57) with nine spines; spur hook-like, unusually long, scaly at base, tip dark. Abdomen with extensive pale yellowish dorsal areas, especially on proximal segments; scales absent.

Genitalia: Similar to those of *F. edmistoni* (Fig. 53). Proximal ½ of 9th sternite yellowish, distal ½ dark brown; gonocoxite yellowish, variably dark brown posteriorly on external side; gonostylus slender, pale, tip slightly darkened. Aedeagus with basal arms directed laterally; main portion triangular, gradually tapering to blunt tip, ventral surface with pair of widely separated, more strongly sclerotized, longitudinal lines. Parameres as usual.

Distribution.—Florida, Maryland, North Carolina, Virginia.

Types.—Holotype male, Maryland, Montgomery Co., Colesville, 13.ix.1977, W. W. Wirth; allotype female, same data except 15.v.1977. Paratypes, 18 males, 16 females, as follows:

FLORIDA: Alachua Co., Gainesville, Oak Crest, 8.iii.1992, WWW, 1 male.

MARYLAND: Same data as types except 9.viii.1975, 1 male; 8.v.1977, 2 males; 15.v.1977, 2 males; 9.vi.1977, 1 male.

NORTH CAROLINA: Macon Co., Highlands, Wightman Cottage, 10.vi.1986, WWW, 5 males. Transylvania Co., Lake Toxaway, 9-20.vii.1989, WWW, 16 females, 17 males.

VIRGINIA: Falls Church, 9.vi.1958, WWW, 1 male; same data except 20.vii.1958, 1 male.

Etymology.—The species name is from the Latin *acinaces* (a scimitar), referring to the large, curved, scimitar-shaped spur on the male hind tibia.

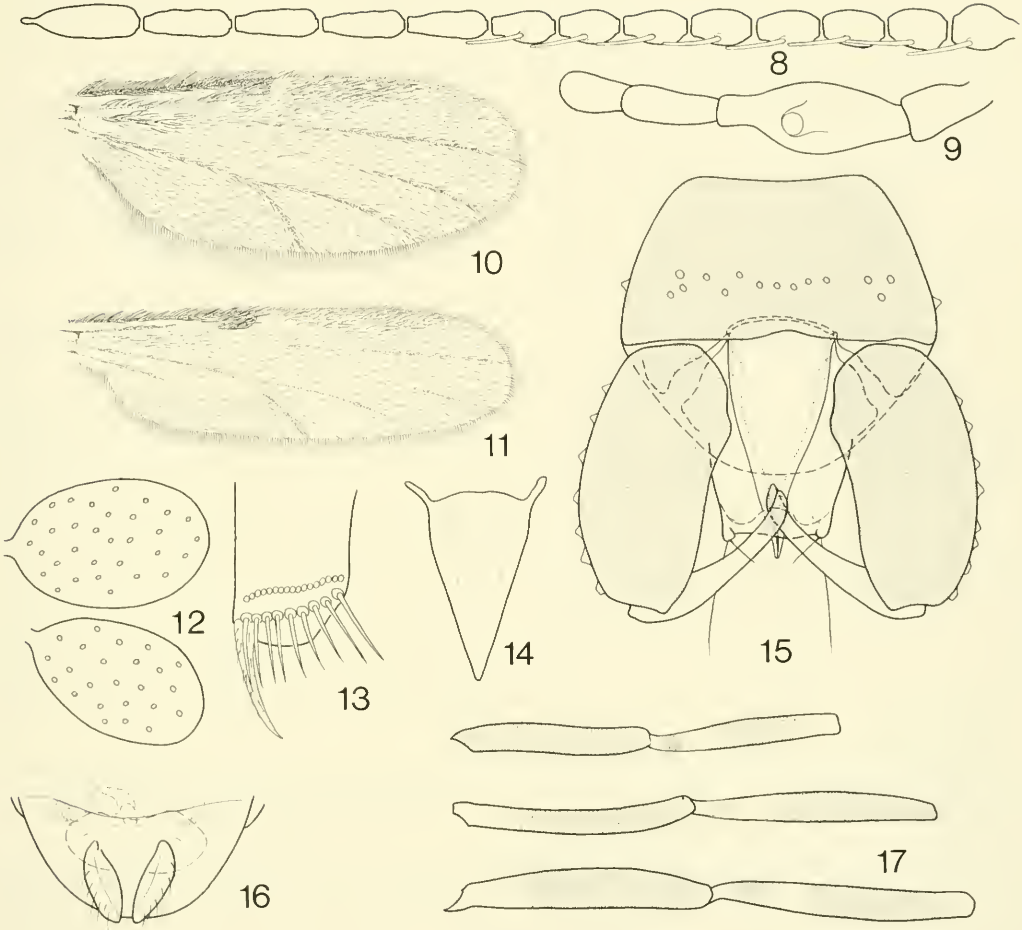
Discussion.—This species is nearly identical to *Forcipomyia edmistoni,* except for the male hind tibial spur which is unusually long and hook-shaped. As in *F. edmistoni,* the dark area on the hind femur is variable in extent, with the pale distal area broad to almost absent. The extent of the distal dark area on the male gonostylus is also variable.

Forcipomyia (*Lepidohelea*) *christiansoni* Wirth and Hubert
(Figs. 8–17)

Forcipomyia christiansoni Wirth and Hubert, 1960: 640 (female, male; California; figs.).

Female.—Wing length 1.27 (1.12–1.35, n = 5) mm; breadth 0.51 (0.43—0.53, n = 5) mm.

Head: Antenna (Fig. 8) with lengths of flagellar segments in proportion of 22-20-



Figs. 8–17. *Forcipomyia christiansoni*; 8–10, 12, 13, 16, 17, female; 11, 14, 15, male: 8, antenna; 9, palpus; 10, 11, wing; 12, spermathecae; 13, hind tibial comb; 14, aedeagus; 15, genitalia, aedeagus omitted; 16, genital sclerotization; 17, femora and tibiae of (top to bottom) fore, mid, and hind legs.

19-19-19-19-19-19-25-25-25-25-35; antennal ratio 0.84 (0.77–0.90, n = 4); proximal segments short, stout, 11–14 vase-shaped with short distal necks. Palpus (Fig. 9) with lengths of segments in proportion of 12-20-41-22-16; palpal ratio 3.00 (n = 3); 3rd segment moderately swollen in mid-portion, with irregular pit opening by small pore; distal ¼ slender.

Thorax: Dark brown. Scutum and scutellum with numerous erect, dark brown, bristly setae and mixed whitish and dark brown appressed scales. Legs (Fig. 17) dark brown; small knee spots yellowish; bases of mid and hind femora pale; tibiae with narrow subbasal pale rings; fore and hind tibiae with moderately broad apical, yellowish rings; mid tibia dark to tip; hind tibial comb with nine spines, spur slender and curved; tarsi with very narrow segmental pale rings; hind tarsal ratio 1.10 (n = 4). Wing (Fig. 10) with dense vestiture of narrow, dark macrotrichia, especially long and blackish along costa; costal ratio 0.44 (0.41–0.46, n = 5). Halter pale.

Abdomen: Dark brown, with numerous erect dark brown setae. Genital sclerotization as in Fig. 16. Spermathecae (Fig. 12) elongate oval, slightly unequal, measuring 0.084 × 0.046 mm and 0.079 × 0.051 mm; surface with faint pale punctations.

Male.—Wing length 1.45 mm; breadth 0.44 mm; costal ratio 0.44. Similar to female with usual sexual differences. Wing (Fig. 11) with brown areas on radial cells, along anterior margin beyond end of costa, and on vein CuA2. Hind tibial spur (Fig. 13) moderately short, nearly straight, 0.28–0.32 as long as basitarsus.

Genitalia (Fig. 15): Ninth sternum and gonocoxite entirely dark brown; gonostylus whitish, narrow apex darkish, slender and slightly curved to sharp point. Aedeagus (Fig. 14) with short oblique basal arms, main portion triangular, tapering distally to a sharp apical point, ventral surface with pair of widely-separated, more heavily sclerotized, longitudinal lines. Parameres as usual.

Distribution.—Arizona, California, Wyoming.

Types.—Holotype female, allotype male, San Dimas Canyon, Los Angeles Co., California, 24-xi.1957, C. P. Christianson and J. P. Fonseca, reared from *Opuntia occidentalis.* Paratypes, 3 males, 8 females, same data.

Specimens examined.—ARIZONA: Brown Canyon, Baboquivari Mts., 4.viii.1961, F. Werner, 1 female, 2 males. Chiricahua Nat. Mon., 1.vi.1967, C. W. Sabrosky, 1 male. Cochise Co., Huachuca Mts., Ramsey Canyon, "Trout Pond," 1770 m, 28.viii.1980, J. H. Epler, 2 males; Cochise Stronghold, Dragoon Mts., 16.vii.1958, C. W. O'Brien, 8 males; same data except 13.viii.1958, 1 female; same data except 21.vii.1961, F. Werner, 1 female. Maricopa Co., Wickenburg, viii.1950, H. K. Gloyd, 1 female. Yavapai Co., Oak Creek Village, 2–5.viii.1982, M. W. Sanderson, 2 females; same data except 13–15.viii.1982, 3 females. Yuma Co., 19 km E Tacna, Mohawk Dunes, 6.iii.1988, R. E. Woodruff, 1 male.

CALIFORNIA: El Dorado Co., Snowline Camp, 13.vii.1948, W. W. Wirth, 1 male. Los Angeles Co., San Dimas Canyon, 24.xi.1957, C. P. Christianson & J. P. Fonseca, 4 females, 2 males (paratypes).

WYOMING: Platte Co., Brown Ranch, 1.vii.1967, M. Griffith, 1 male. Weston Co., 10 km NW Newcastle, 23.vi.1965, R. W. Hodges, 1 female; same data except 18.vii.1965, 6 males; same except 20.vii.1965, 1 female, 2 males.

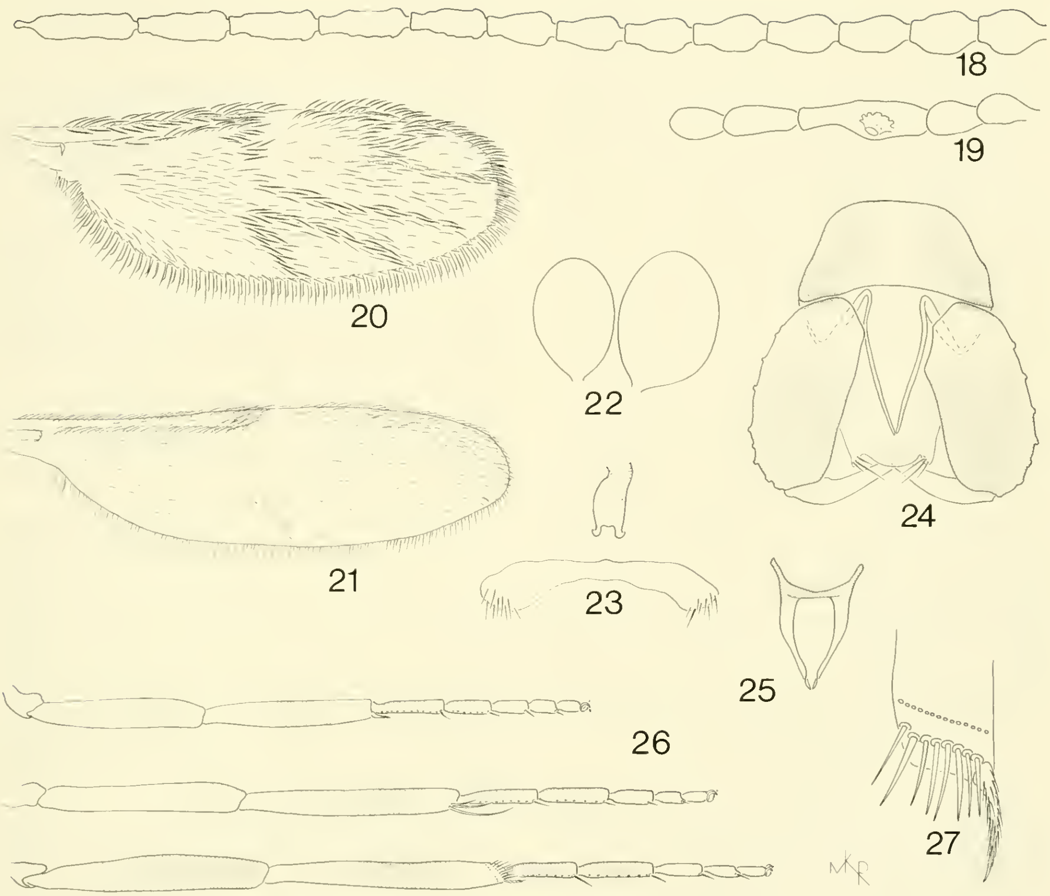
Discussion.—*Forcipomyia usingeri* n. sp. is closely related to *F. christiansoni,* and in fact the two species are almost indistinguishable. The former species can be distinguished by the presence of a well-marked pale band at the apex of the mid tibia, and the spur on the male hind tibia is slightly longer, but stouter and more strongly curved. The two species also occupy different ecological niches; *F. christiansoni* breeds in cacti in desert situations, while *F. usingeri* larvae live under pine bark under cooler and more humid conditions at higher elevations.

Forcipomyia* (*Lepidohelea*) *cochisei
Wirth and Spinelli, New Species
(Figs. 18–27)

Female.—Wing length 1.19 (1.17–1.27, n = 5) mm; breadth 0.44 (0.43–0.48, n = 5) mm.

Head: Dark brown. Antenna (Fig. 18) with lengths of segments in proportion of 20-18-19-20-20-19-18-20-22-25-26-26-35; antennal ratio 0.88 (0.86–0.93, n = 5). Palpus (Fig. 19) with lengths of segments in proportion of 16-18-40-20-17; palpal ratio 3.40 (3.25–3.55, n = 5); 3rd segment slightly swollen in midportion, with irregular, moderately deep pit opening by a small rounded pore; distal ⅓ slender.

Thorax: Dark brown. Scutum and scutellum with numerous erect, dark brown, bristly setae, scales missing in slide-mounted specimens. Legs (Fig. 26) brown, hind leg darkest; bases of fore and hind femora yellowish, mid femur broadly yellowish basally; knees pale; tibiae with subbasal and apical pale rings; hind tibial comb (Fig. 27)



Figs. 18–27. *Forcipomyia cochisei*; 18–20, 22, 23, 26, 27, female; 21, 24, 25, male: 18, antenna; 19, palpus; 20, 21, wing; 22, spermathecae; 23, genital sclerotization; 24, genitalia, aedeagus omitted; 25, aedeagus; 26, femora and tibiae of (top to bottom) fore, mid, and hind legs; 27, hind tibial comb.

with 7–8 spines, spur short; tarsi brown with very narrow segmental pale rings; hind tarsal ratio 1.12 (1.10–1.15, n = 5). Wing with vestiture of narrow macrotrichia, mixed whitish and dark, giving a pattern as illustrated in Fig. 20; costal ratio 0.46 (0.45–0.48, n = 5). Halter pale.

Abdomen: Dark brown, with numerous erect brown setae. Genital sclerotization as in Fig. 23. Spermathecae (Fig. 22) elongate oval, unequal, measuring 0.087 × 0.061 mm, and 0.077 × 0.051 mm.

Holotype male.—Wing length 1.43 mm; breadth 0.46 mm; costal ratio 0.43. Similar to female with usual sexual differences. Wing (Fig. 21) primarily pale, dark macrotrichia restricted to radial veins and cells, along anterior margin beyond end of costa, and on vein CuA2.

Genitalia (Fig. 24): Ninth sternite dark brown laterally, yellowish on midportion; proximal ⅓ of gonocoxite pale yellowish, distal ⅔ dark brown; gonostylus slightly curved, whitish except tip dark. Aedeagus (Fig. 25) stout, basal arms short, lateral margins nearly parallel proximally, abruptly tapering distally to somewhat blunt tip. Parameres as usual.

Distribution.—Arizona, Mexico (Sonora).

Types.—Holotype male, allotype female, Arizona, Cochise Co.,. Cochise Stronghold, Dragoon Mts., 13.viii.1958, C. W. O'Brien. Paratypes, 30 females, 33 males, as follows:

ARIZONA: Same data as types except 16.vii.1958, 3 females, 2 males; same data except 21.vii.1961, F. Werner, 1 female. Brown Canyon, Baboquivari Mts., 8.viii.1953, G. D. Butler, 6 females, 2 males; same data except 4.viii.1961, F. Werner, 1 female, 1 male. Chiricahua Nat. Mon., 1.vi.1967, C. W. Sabrosky, 1 male.

MEXICO: Sonora, 10 mi E Navajoa, 13.viii.1959, Werner & Nutting, 1 male.

Discussion.—This species is very similar to *Forcipomyia edmistoni,* from which it can be distinguished by the slender 3rd palpal segment, pale mid femur, apex of hind femur brown, spermathecae with faint pale punctations, and by the coloration of the male 9th sternite and gonocoxite.

Forcipomyia (*Lepidohelea*) *dubiamima* Wirth and Spinelli, New Species (Figs. 28-37)

Female.—Wing length 1.56 (1.38–1.73) mm; breadth 0.57 (0.51–0.61, n = 5) mm.

Head: Dark brown. Antenna (Fig. 28) with lengths of flagellar segments in proportion of 36-33-35-35-37-34-33-33-40-40-44-46-55; antennal ratio 0.80 (0.74–0.88, n = 5); proximal segments elongated, vasiform, with short distal necks. Palpus (Fig. 29) slender, lengths of segments in proportion of 20-25-50-34-24; palpal ratio 3.30 (3.15–3.45, n = 5); 3rd segment slightly swollen in midportion, pit irregular, shallow, opening by small rounded pore; distal ¼ slender.

Thorax: Dark brown. Scutum and scutellum with numerous erect, dark brown, bristly setae. Legs (Fig. 30) dark brown, knees yellowish; hind tibia with subbasal yellowish ring, fore and hind tibiae with apical yellowish rings; femora and tibiae stout; hind tibial comb (Fig. 35) witih 9–10 spines, spur moderately short, nearly straight; tarsi dark brown, with narrow segmental pale rings; hind tarsal ratio 0.95 (0.85–1.00, n = 5). Wing (Fig. 31) with dense vestiture of narrow appressed macrotrichia (Fig. 32) which are broader and more concentrated on radial veins and in radial cells; costal ratio 0.47 (0.46–0.48, n = 5). Halter knob whitish, stem brown.

Abdomen: Dark brown, with numerous erect brown setae. Genital sclerotization as in Fig. 34, without lateral spines. Spermathecae (Fig. 33) oval globose with short necks; slightly unequal, measuring 0.093 × 0.071 mm, and 0.087 × 0.063 mm.

Holotype male.—Wing length 1.91 mm; breadth 0.48 mm; costal ratio 0.44. Similar to female with usual sexual differences.

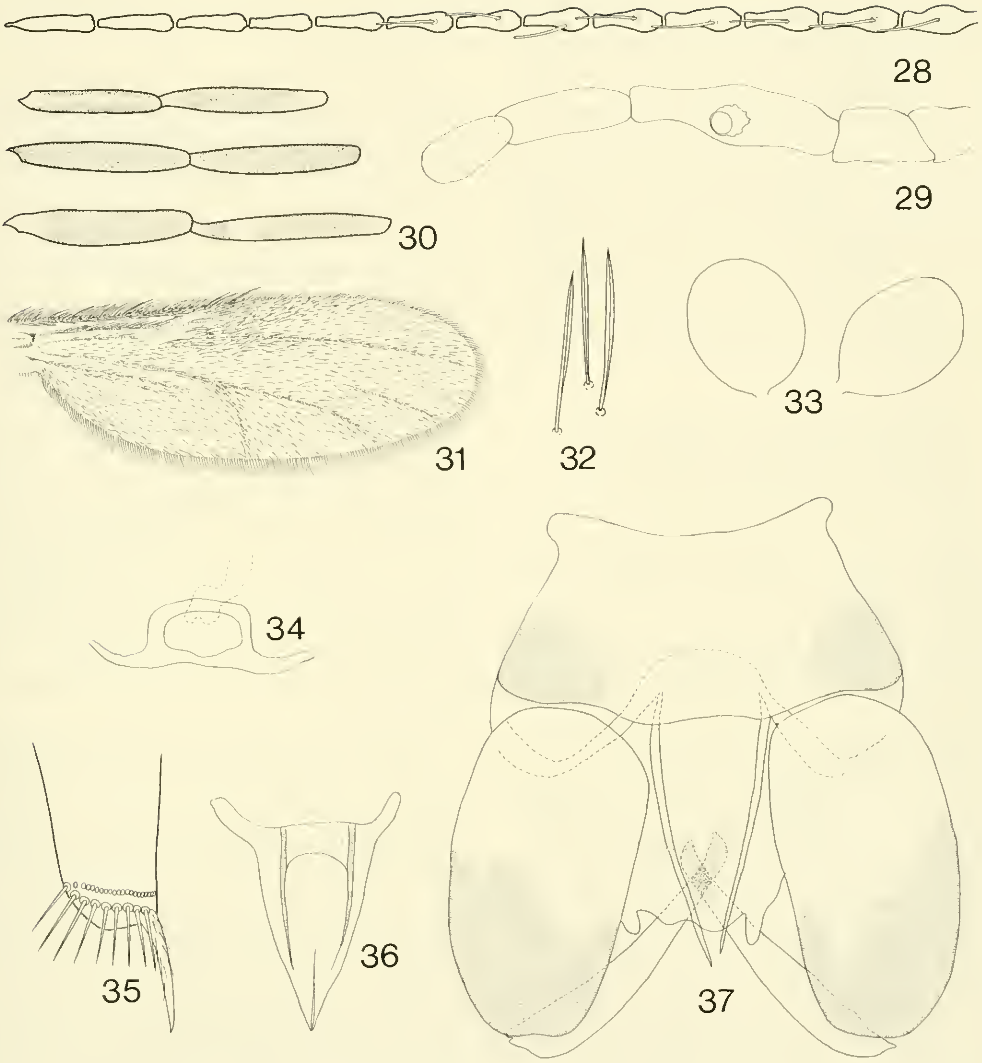
Genitalia (Fig. 37): Ninth sternite yellowish, dark brown lateroposteriorly; proximal ⅔ of gonocoxite yellowish, distal ⅓ dark brown; gonostylus slender, nearly straight, yellowish except tip dark. Aedeagus (Fig. 36) with basal arms moderately developed, main portion triangular, tapering to a sharp distal point, ventral surface with a more heavily sclerotized, distomedian, longitudinal line. Parameres as usual.

Distribution.—Florida, Maryland, North Carolina, Virginia, West Virginia.

Types.—Holotype male, Maryland, Montgomery Co., Colesville, 11.ix.1977, W. W. Wirth; allotype female, same data except 13.ix.1977. Paratypes, 16 females, 18 males, as follows:

FLORIDA: Alachua Co., Austen Carey St. Forest, Hatchet Creek, 13.v.1991, W. W. Wirth, 1 female. Highlands Co., Lake Placid, Archbold Biological Sta., 6.iv.1991, WWW, 6 females. Indian River Co., Vero Beach, Ent. Res. Cntr. iii.1953, (? collector), 1 male.

MARYLAND: Same data as holotype, 1 female, 4 males; same data as allotype, 2 females, 5 males; same data except 18.ix.1977, 2 males; same data except 22.vii.1975, 1 male. Wicomico Co., Salisbury, 13–20.vii.1992, W. L. Grogan, Jr., malaise trap, 1 female.



Figs. 28–37. *Forcipomyia dubiamima*; 28–35, female; 36, 37, male: 28, antenna; 29, palpus; 30, femora and tibiae of (top to bottom) fore, mid, and hind legs; 31, wing; 32, macrotrichia of wing, enlarged; 33, spermathecae; 34, genital sclerotization; 35, hind tibial comb; 36, aedeagus; 37, genitalia, aedeagus omitted.

NORTH CAROLINA: Macon Co., Highlands, Wightman Cottage, 10.vi.1986, WWW, 1 female. Transylvania Co., Lake Toxaway, 9–20.vii.1989, WWW, 2 females, 3 males.

VIRGINIA: Fairfax Co., Falls Church, 5.vii.1958, WWW, 1 male; Falls Church, Holmes Run, 5.ix.1961, WWW, 1 male; same data except 21.ix.1961, 1 female.

WEST VIRGINIA: Hardy Co., Lost River St. Park, 8–14.vii.1963, K. V. Krombein, 1 female.

Discussion.—This large, dark brown species can readily be distinguished from *F. acinacis, F. cochisei,* and *F. edmistoni* by the characters pointed out in the key.

The specific epithet, *dubiamima,* refers to the close similarity of this species to the

Neotropical species, *Forcipomyia dubia* Macfie. The latter species differs in its smaller size, wing length 1.26 mm; legs more slender, normal; hind basitarsus longer (TR 1.10); outer claw of male fore tarsus with blunt ventral tooth at midlength; third palpal segment stouter (PR 2.24); female genital sclerotization with 4–5 short, stout lateral spines; male 9th sternite dark brown on entire lateral margins, gonostylus curved, and aedeagus with lateral margins straight, not convex.

Forcipomyia (*Lepidohelea*) *eadsi* Wirth and Spinelli, New Species (Figs. 38-46)

Forcipomyia varipennis Wirth and Williams, 1957: 8 (misident., in part; Texas paratype).

Female.—Wing length 0.89 (0.82–0.99, n = 5) mm; breadth 0.39 (0.35–0.43, n = 5) mm.

Head: Brown. Antenna (Fig. 38) with lengths of flagellar segments in proportion of 15-12-13-13-13-13-13-13-14-16-16-16-26; antennal ratio 0.82 (0.;80–0.83, n = 5); proximal segments short, stout; 11–14 short, with short distal necks. Palpus (Fig. 40) with lengths of segments in proportion of 11-14-29-12-12; palpal ratio 2.20 (2.00–2.45, n = 5); 3rd segment swollen in midportion, with an irregular, deep pit opening by a small rounded pore; distal ¼ moderately slender.

Thorax: Brown; scutum with dense, appressed, short, brassy scales. Legs (Fig. 45) brown; proximal ½ of femora pale; knees pale; fore and hind tibiae with subbasal pale rings; all tibiae with distal pale rings, broader on fore and hind legs; hind tibial comb (Fig. 41) with nine spines; spur short, nearly straight; tarsi brown, with narrow segmental pale rings; hind tarsal ratio 1.00 (n = 5). Wing pale brown with prominent areas of narrow, dark brown, scalelike macrotrichia more concentrated on radial veins and in radial cells, in cell R5 beyond costa, and on vein CuA2; costal ratio 0.42 (0.40–0.43, n = 5). Halter brown.

Abdomen: Brown. Genital sclerotization as in Fig. 42. Spermathecae (Fig. 43) elongate oval; unequal, measuring 0.068 × 0.046 mm, and 0.056 × 0.044 mm.

Holotype male.—Wing length 1.25 mm; breadth 0.38 mm; costal ratio 0.41. Similar to female with usual sexual differences. Hind tibial spur short, slender, and straight; scaly at base. Wing (Fig. 39) with whitish macrotrichia; dark brown macrotrichia also concentrated on radial cells, in cell R5, and on vein CuA2 as usual in the *bicolor* subgroup.

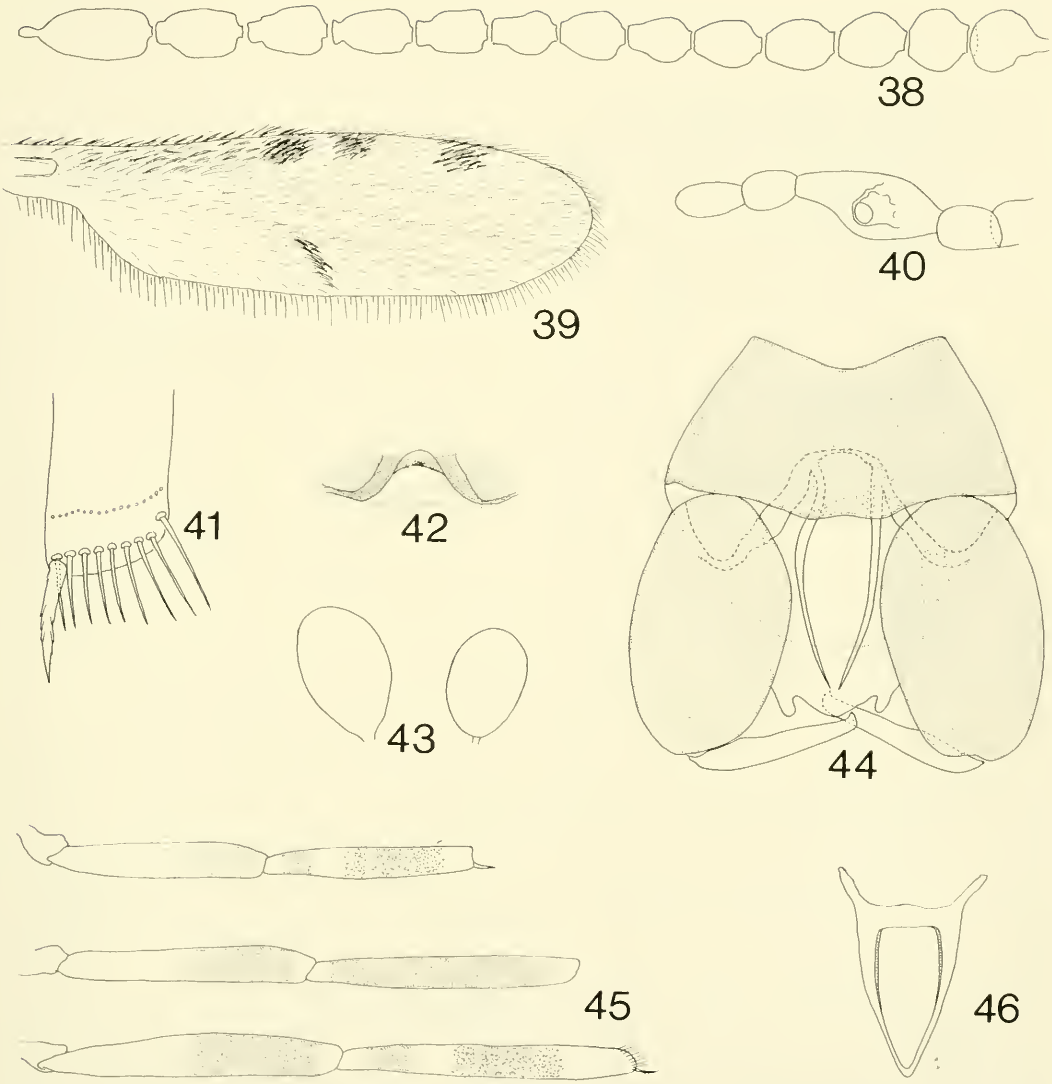
Genitalia (Fig. 44): Ninth sternite and gonocoxite entirely dark brown; gonostylus pale, nearly straight with hooked, pointed apex. Aedeagus (Fig. 46) with slender, strongly sclerotized basal arms; main portion triangular, gradually tapering to narrow, blunt tip. Parameres as usual.

Distribution.—Florida, Mississippi, Texas.

Types.—Holotype male, allotype female, Texas, Cameron Co., ii.1963, R. B. Eads. Paratypes, 40 females, 35 males, as follows:

TEXAS: Same data as types, 2 females, 15 males; same data except v.1963, 10 females, 10 males; same except 2.xi.1962, 1 female; same except 17.ix.1964, 1 male. Cameron Co., Brownsville, 1.x.1951, A. B. Gurney, 1 female (paratype of *F. varipennis*); xi.1963, RBE, 11 females, 6 males; Los Fresnos, 10.ix.1978, B. L. Davis, 1 female. Hildago Co., Weslaco, 15.viii.1963, J. W. Balock, 1 male; same data except 12.ix.1963, 1 male. Kerr Co., Kerrville, 1.iv.1955, W. W. Wirth, 1 female. Starr Co., Rio Grande City, 25.vi.1959, V. H. Lee, 12 females. Val Verde Co., Del Rio, 24.ix.1963, RBE, 1 female.

Other specimens examined (not designated paratypes).—FLORIDA: Alachua Co., Gainesville, Chantilly Acres, 8.v.1967, F. S. Blanton, 1 male; Gainesville, Oak Crest, vi,x,xi.1986, W. W. Wirth, UV light trap, 4 males. Dade Co., Homestead,

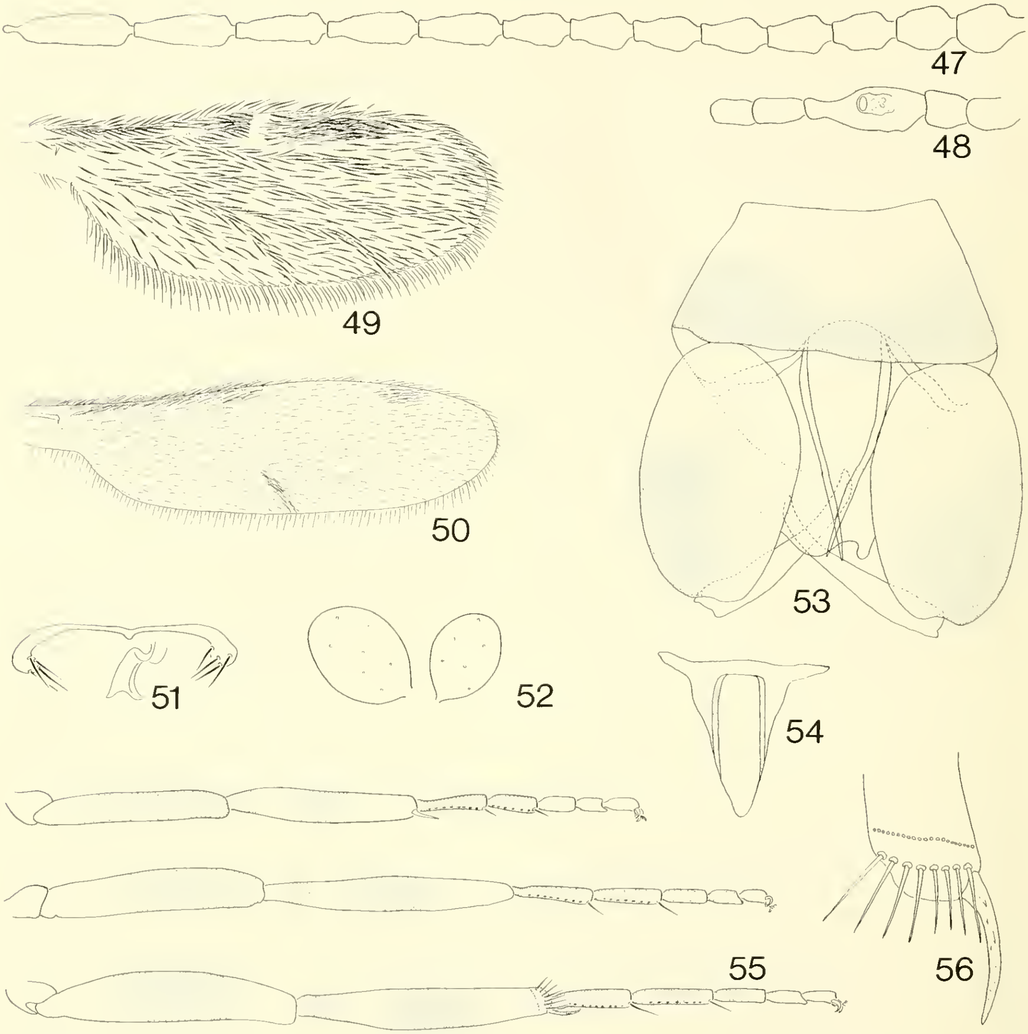


Figs. 38–46. *Forcipomyia eadsi*; 38, 40–43, 45, female; 39, 44, 46, male: 38, antenna; 39, wing; 40, palpus; 41, hind tibial comb; 42, genital sclerotization; 43, spermathecae; 44, genitalia, aedeagus omitted; 45, femora and tibia of (top to bottom) fore, mid, and hind legs; 46, aedeagus.

17.x.1984, R. Woodruff & L. Stange, 1 female, 1 male. Hardee Co., Ona, vii.1970, E. Irons, 2 males. Highlands Co., Lake Placid, Archbold Biol. Sta., iv,ix.1989, ix.1990, 1.iv.1991, WWW, UV light trap, 3 females, 14 males. Indian River Co., Vero Beach, iii.1959, Ent. Res. Ctr. light trap, 1 male. Jackson Co., Florida Caverns St. Park, 26.v.1973, WWW, UV light trap, 1 male. Liberty Co., Torreya St. Park, 15.iv.1957, 7.iv.1958, FSB, 2 males. Orange Co., Maitland, Lake Hope, 25.viii.1986, UV light trap, 1 male.

MISSISSIPPI: Washington Co., vi.1962, R. H. Roberts, 1 male.

Discussion.—This species is dedicated to



Figs. 47–56. *Forcipomyia edmistoni*; 47–49, 51, 52, 55, female; 50, 53–54, 56, male: 47, antenna; 48, palpus; 49, 50, wing; 51, genital sclerotization; 52, spermathecae; 53, genitalia, aedeagus omitted; 54, aedeagus; 55, fore, mid, and hind legs (top to bottom); 56, hind tibial comb.

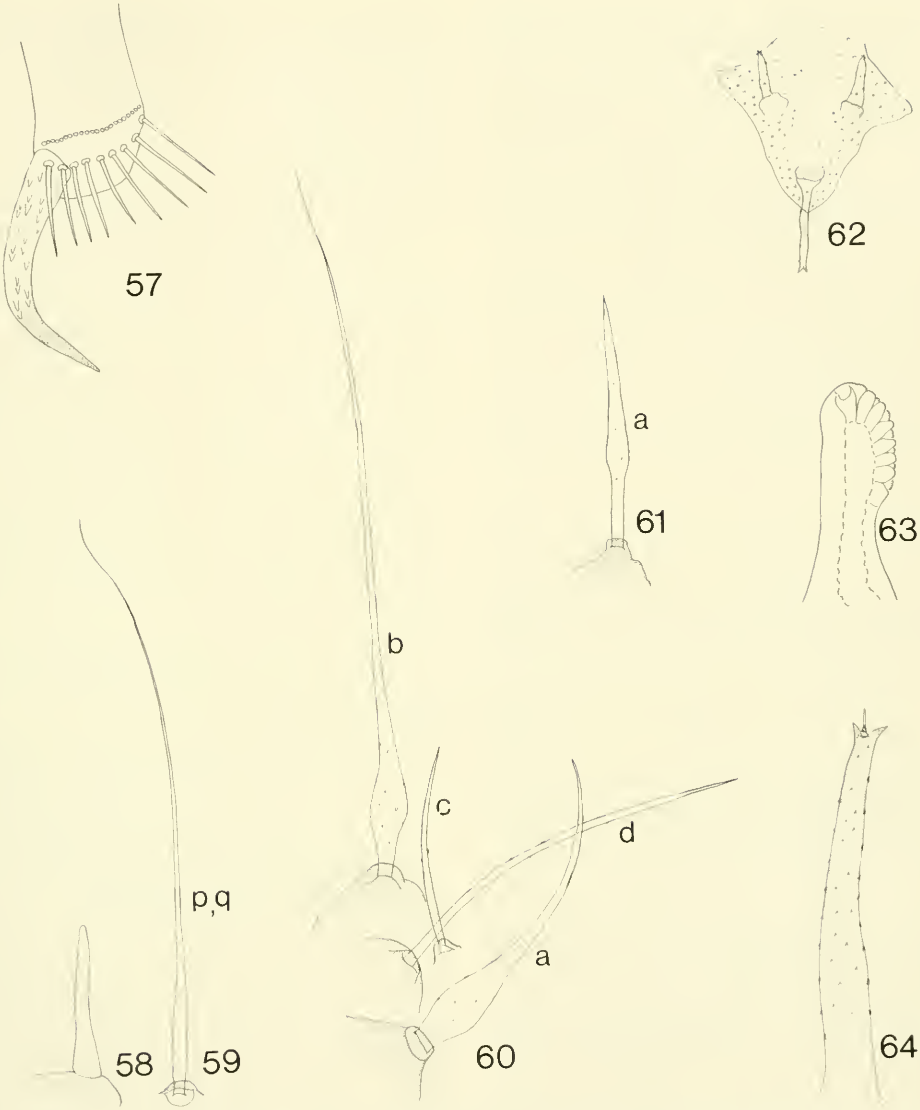
Richard B. Eads of the Texas Department of Health in recognition of his continued interest in the collection and study of Texas biting midges.

Forcipomyia eadsi is a small species, readily distinguished from related congeners except *F. varipennis* by the short flagellar segments 11–14, which are but slightly longer than the proximal segments; in *varipennis* the third palpal segment is swollen to the tip.

Forcipomyia (*Lepidohelea*) *edmistoni* Wirth and Spinelli, New Species (Figs. 47-56, 58-64)

Female.—Wing length 1.09 (1.00–1.17, n = 5) mm; breadth 0.43 (0.39–0.46, n = 5) mm.

Head: Dark brown; with numerous erect, bristly setae. Antenna (Fig. 47) with lengths of flagellar segments in proportion of 21-19-18-18-18-18-18-18-24-25-27-29-39;



Figs. 57–64. 57, *Forcipomyia acinacis*; 58–64, *F. edmistoni*; 57, male hind tibial comb; 58–61, larva; 62–64, pupa: 58, antenna; 59, head hair *p* (*q* hair similar); 60, body hairs of prothorax; 61, *a* hair of remaining body segments; 62, operculum; 63, respiratory horn; 64, cuticular process of cephalothorax.

antennal ratio 0.94 (0.88–0.97, n = 5); proximal segments short, 11–14 elongated, vase-shaped with short distal necks. Palpus (Fig. 48) with lengths of segments in proportion of 13-15-33-15-13; palpal ratio 2.70 (2.60–2.80, n = 5); 3rd segment moderately swollen in midportion, with a deep irregular pit opening by a small pore; distal ¼ slender.

Thorax: Dark brown. Scutum and scutellum with numerous, mixed brown and yellowish, bristly setae. Legs (Fig. 55) brown; with numerous, very long, brown and yellowish, erect, bristly setae, and elongate, appressed, brownish scales; femora pale at bases, hind femur also pale at apex (variable); tibiae with subbasal and apical pale bands; hind tibial comb with eight spines, spur moderately short, slightly curved; tarsi brown with narrow segmental pale rings; hind tarsal ratio 1.00 (n = 5). Wing (Fig. 49) densely covered with appressed macrotrichia; a small, inconspicuous, yellowish spot just past end of costa; costal ratio 0.48 (0.46–0.49, n = 5). Halter lightly infuscated.

Abdomen: Dark brown, with numerous erect brown setae; tergites and pleura also with abundant, appressed, brown, 1-striated scales. Genital sclerotization as in Fig. 51. Spermathecae (Fig. 52) oval; unequal, measuring 0.086 × 0.058 mm and 0.068 × 0.053 mm, surface with minute, faint, hyaline punctations.

Holotype male.—Wing length 1.40 mm; breadth 0.38 mm; costal ratio 0.44. Similar to female with usual sexual differences. Hind tibial spur (Fig. 56) moderately long, slightly curved. Wing (Fig. 50) primarily pale, with macrotrichia concentrated on radial veins and in radial cells, along anterior margin beyond end of costa, and on vein CuA2. Abdomen extensively yellowish dorsally, the brownish apicolateral spots becoming more extensive on posterior segments; scales absent.

Genitalia (Fig. 53): Proximal ½ of 9th sternite yellowish, distal ½ dark brown; gonocoxite yellowish, dark brown distally on external side; gonostylus slender, pale, tip slightly darkened. Aedeagus (Fig. 54) with basal arms directed laterally; main portion triangular, gradually tapering to bluntly pointed tip, ventral surface with a pair of widely spaced, more heavily sclerotized, longitudinal lines. Parameres as usual.

Larva.—Length 2.40 mm. Color yellowish, including head capsule, which becomes conspicuously blackish toward oral margin; conical prominences at bases of dorsal body setae modetately brownish pigmented. Chaetotaxy:

Head: Antenna (Fig. 58) stout, pale, tip blunt. Setae *p* and *q* (Fig. 59) pale, large, slighty swollen at base, gradually tapering to filiform tips.

Prothorax (Fig. 60): *a* seta pale, greatly swollen at base, then gradually tapering to pointed tip, surface lightly spiculate; *b* seta like *a,* but twice as long and with filiform tip; *c* pale, stout, tip pointed; *d* like *c,* but twice as long.

Remaining segments: As in prothorax except for *a,* which is petiolate (Fig. 61).

Pupa.—Length 2.60 mm. Color of exuviae pale yellowish. Respiratory horn (Fig. 63) short, dark brown, with 8–10 distolateral spiracular openings located on the external side. Operculum (Fig. 62) rhomboidal, surface covered by rounded tubercles (scattered in midportion); anterior tubercle long, bearing fine spicules, apex divided in two or three sharp points; *am* tubercles stouter. Thoracic and abdominal tubercles (Fig. 64) resembling anterior tubercle of operculum, with an additional pale, pointed spine at apex.

Distribution.—Florida, Maryland, New York, North Carolina, South Carolina, Virginia, West Virginia.

Types.—Holotype male, allotype female, Maryland, Prince Georges Co., Patuxent Res. Ctr., 28.vii.1979, J. Edmiston (collected as pupae under bark of dead tree near river, reared in lab). Paratypes, 25 females, 43 males, 2 larvae, as follows:

FLORIDA: Alachua Co., Gainesville, Oak Crest, many dates, W. W. Wirth, 10 females, 18 males; Gainesville, Doyle Conner Bldg., 12.v.1990, WWW, 1 male. Highlands Co., Lake Placid, Archbold Biological Sta., 13–19.iv.1989, WWW, 2 males; same data except 8.ix.1989, 1 male; same except 1.v.1991, 1 male. Jefferson Co., Monticello,, v.1969, W. H. Whitcomb, 2 females. Levy Co., Yankeetown, 29.iii.1982, A. Wilkening, 1 male.

MARYLAND: Same data as types, 2 females, 6 females, 2 larvae. Garrett Co., Bittinger 4-H Camp, 5.v.1960, WWW, 4 females. Montgomery Co., Colesville, many dates, WWW, 9 males; Fairland, 12.v.1959, A. A. Hubert, 1 female.

NEW YORK: Cattarauguas Co., Allegany St. Park, 28.v–3.vi.1963, WWW, reared from larvae under bark of maple stump in flood plain of Allegany River, 1 female, with pupal exuviae. Essex Co., Newcomb, Lake Harris, 19.viii.1972, L. Knutson, 1 female.

NORTH CAROLINA: Macon Co., Highlands, Wightman Cottage, 5.vii.1987, WWW, 1 female, 1 male; Highlands, vii.1965, P. M. Marsh, 1 female.

SOUTH CAROLINA: Georgetown Co., Hobcaw House, viii.1972, L. Henry, 1 female.

VIRGINIA: Fairfax Co., Falls Church, Holmes Run, 17.x.1960, WWW, 2 males; same data except 3.x.1961, 1 female.

WEST VIRGINIA: Hardy Co., Lost River St. Park, 10.vii.1977, WWW, 1 male.

Discussion.—This species is named for James Edmiston, former graduate student at the University of Maryland, College Park, in recognition of his interest in the collection and study of biting midges.

Forcipomyia edmistoni is very similar to *F. acinacis* and *F. cochisei.* Characters for separating the three species are found in the key and in the discussions under the two related species.

Forcipomyia* (*Lepidohelea*) *pricei
Wirth and Spinelli, New Species
(Figs. 65–72)

Allotype female.—Wing length 1.06 mm; breadth 0.40 mm.

Head: Dark brown. Antenna (Fig. 65) with lengths of flagellar segments in proportion of 12-11-13-14-13-12-12-13-16-17-18-17-24; antennal ratio 0.92; proximal segments stout with short distal necks, 11–14 vase-shaped with short distal necks. Palpus (Fig. 66) with lengths of segments in proportion of 10-12-27-14-11; palpal ratio 2.70; 3rd segment swollen in midportion, with irregular deep pit opening by a small, round pore; distal ¼ slender.

Thorax: Dark brown. Legs dark brown, hind leg darker; knees pale; tibiae with subbasal pale rings; hind tibial comb (Fig. 67) with 8 spines, spur moderately short. Tarsi dark brown with very narrow segmental pale rings; hind tarsal ratio 0.78. Wing (Fig. 68) with dense vestiture of narrow appressed macrotrichia, which are broader and more concentrated on radial veins and in radial cells; costal ratio 0.37. Halter knob whitish, stem brown.

Abdomen: Dark brown, with numerous erect brown setae. Genital sclerotization as in Fig. 69. Spermathecae (Fig. 70) ovoid with short necks; unequal, measuring 0.076 × 0.045 mm and 0.061 × 0.041 mm.

Holotype male.—Wing length 1.02 mm; breadth 0.30 mm; costal ratio 0.38. Similar to female with usual sexual differences.

Genitalia (Fig. 71): Ninth sternite yellowish, dark brown lateroposteriorly; proximal ½ of gonocoxite yellowish, distal 1.2 dark brown; gonostylus nearly straight, pale with dark pointed apex. Aedeagus (Fig. 72) with basal arms well developed, main portion triangular, coming to a sharp distal point, ventral surface with a more heavily sclerotized, distomedian, longitudinal line. Parameres as usual.

Distribution.—Texas.

Types.—Holotype male, Texas, Sonora, ix.1954, D. A. Price; allotype female, same data except ix.1953. Paratype male, same data as holotype; paratype female, same data except 8.xi.1053.

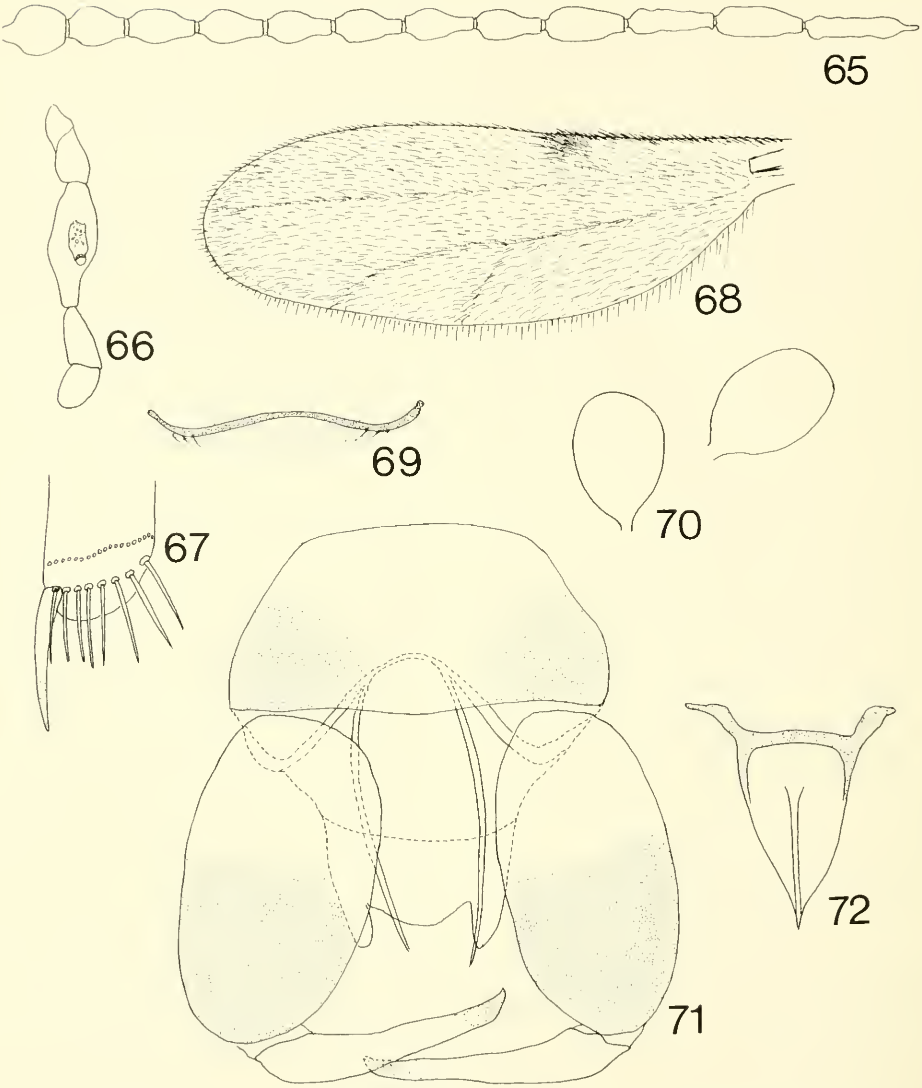
Discussion.—This species is named for the collector, Dr. David A. Price, veterinarian at the Sonora Experiment Station of Texas A & M University. It is very similar to *F. acinacis* and *F. edmistoni*; characters to separate it from these two species are given in the key.

Forcipomyia* (*Lepidohelea*) *usingeri
Wirth and Spinelli, New Species
(Figs. 1–7, 73–81)

Forcipomyia cinctipes (Coquillett); Wirth, 1952: 128 (in part, California specimens).

Female.—Wing length 1.25 (1.03–1.38, n = 5) mm; breadth 0.49 (0.42–0.53, n = 5) mm.

Head: Dark brown. Antenna (Fig. 73) with lengths of flagellar segments in proportion of 22-18-18-18-20-20-20-20-26-26-26-26-

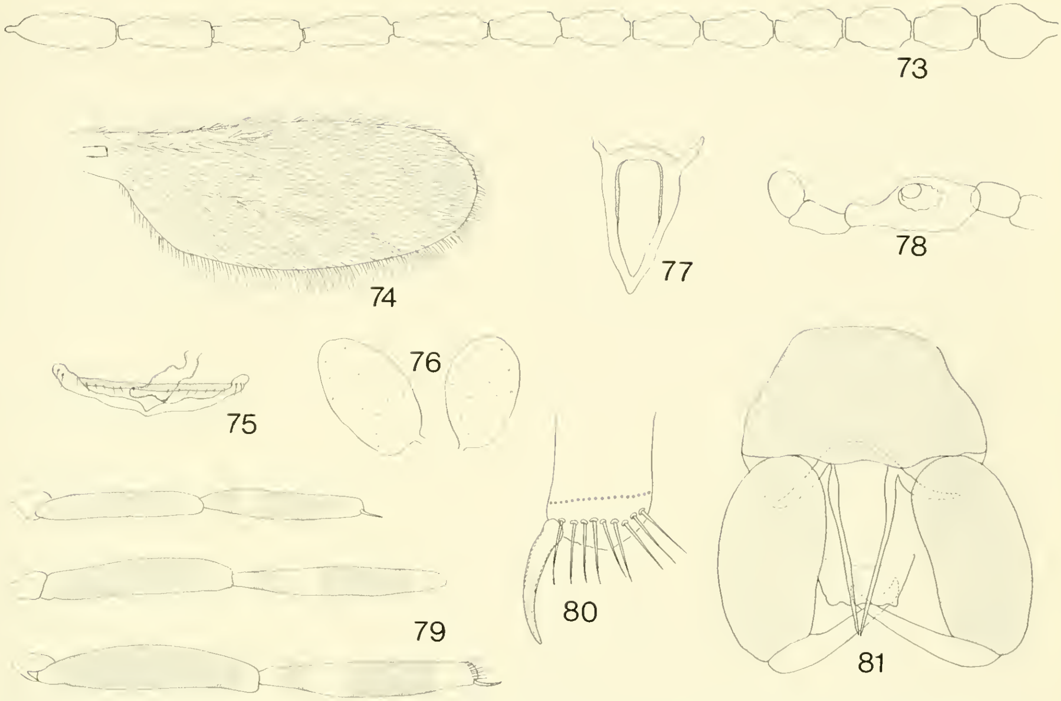


Figs. 65–72. *Forcipomyia pricei*; 65–70, female; 71, 72, male: 65, antenna; 66, palpus; 67, hind tibial comb; 68, wing; 69, genital sclerotization; 70, spermathecae; 71, genitalia, aedeagus omitted; 72, aedeagus.

32; antennal ratio 0.89 (0.84–0.92, n = 5); proximal segments stout with short distal necks, 11–14 vase-shaped with short distal necks. Palpus (Fig. 78) with lengths of segments in proportion of 10-13-40-15-14; palpal ratio 2.90 (2.70–3.10, n = 4); 3rd segment swollen in midportion, with irregular deep pit opening by a round pore; distal ¼ slender.

Thorax: Dark brown. Scutum and scutellum with numerous dark bristly setae. Legs (Fig. 79) dark brown; narrow bases of femora slightly paler; knees pale; tibiae with subbasal and apical pale rings; hind tibial comb with nine spines, spur stout, curved; tarsi brown witih narrow segmental pale rings; hind tarsal ratio 1.15 (1.05–1.20, n = 5). Wing (Fig. 74) densely covered with dark brown macrotrichia, a small pale spot past radius and costa; costal ratio 0.46 (0.44–0.48, n = 5). Halter pale.

Abdomen: Dark brown, with numerous



Figs. 73–81. *Forcipomyia usingeri*; 73–76, 78, 79, female; 77, 80, 81, male: 73, antenna; 74, wing; 75, genital sclerotization; 76, spermathecae; 77, aedeagus; 78, palpus; 79, femora and tibiae of (top to bottom) fore, mid, and hind legs; 80, hind tibial comb; 81, genitalia, aedeagus omitted.

erect brown setae. Genital sclerotization as in Fig. 75. Spermathecae (Fig. 76) oval with short slender necks; unequal, measuring 0.084 × 0.051 and 0.069 × 0.048 mm, surface with very small, faint, pale punctations.

Holotype male.—Wing length 1.48 mm; breadth 0.49 mm; costal ratio 0.48. Similar to female with usual sexual differences. Hind tibial spur (Fig. 80) stout, curved, 0.34 as long as basitarsus. Wing primarily pale, macrotrichia more concentrated on radial veins and in radial cells, along anterior margin beyond end of costa, and on vein CuA2.

Genitalia (Fig. 81): Ninth sternite and gonocoxite entirely dark brown; gonostylus entirely whitish, slender with curved, pointed tip. Aedeagus (Fig. 77) with slender, strongly sclerotized basal arms; main portion stout, triangular, gradually tapering to pointed tip. Parameres as usual.

Larva (Fig. 1).—Length 3.70 mm. Color pale brownish, head capsule conspicuously blackish toward oral margin; conical prominences at bases of dorsal body hairs dark brown. Antenna stout, pale, tip blunt. Chaetotaxy:

Head (Fig. 7): Setae *p* and *q* pale, large, slightly swollen at base, tip filiform.

Prothorax (Fig. 5): Seta *a* pale, swollen at base, gradually tapering to pointed tip; *b* pale, twice as long as *a,* very slightly swollen at base, tip filiform; *c* pale, stout, curved, tip pointed; *d* pale, nearly straight, arising from same tubercle as *b,* nearly as long as *c,* tip pointed.

Remaining segments (Fig. 6): As on prothorax except for *a,* which is short-petiolate and slender.

Pupa (Fig. 2).—Length 2.55 mm. Color of exuviae brown. Respiratory horn (Fig. 4) short, bulbous at apex, with eight apicolateral spiracular openings. Thoracic and abdominal tubercles in form of dark brown elongate processes (Fig. 3), surface with fine spicules; apex divided in three sharp points, with an additional pale, pointed spine.

Distribution.—Arizona, California, Washington.

Types.—Holotype male, California, Alameda Co., Berkeley Hills, T. Thatcher, no date; allotype female, same data except x.1947, W. W. Wirth, under pine bark. Paratypes, 16 females, 21 males, as follows:

ARIZONA: Cochise Co., Chiricahua Nat. Mon., 1.vi.1967, C. W. Sabrosky, 3 males; Portal, Southwest Res. Sta., 23..v.1967, CWS, 1 female, 1 male; same data except 4.vi.1967, 1 female, 1 male.

CALIFORNIA: Same data as allotype, 2 females, 2 males. Modoc Co., Cedar Pass, Warner Mts., 1800 m, 8.viii.1965, (? collector), 1 female. Napa Co., Howell Mtn., 390 m, 5–8.vi.1978, H. B. Leech, 10 females, 12 males. Plumas Co., Meadow Valley, 22.viii.1961, R. Hall & E. Jessen, 1 male.

WASHINGTON: Kitsap Co., Bremerton, 17.ii.1975, M. Deyrup, 1 female, 1 male.

Discussion.—This species is named in honor of Robert L. Usinger, Professor of Entomology at the University of California, Berkeley, who directed the senior author's graduate research on biting midges and inspired him and dozens of other students and other workers in systematic entomology. Professor Usinger's death from cancer at an early age was a tragic loss to the field of entomology worldwide.

Forcipomyia usingeri is nearly identical with *F. christiansoni*;, the characters separating the two species are given in the key and in the discussion under *F. christiansoni.*

Forcipomyia (*Lepidohelea*) *varipennis*
Wirth and Williams
(Figs. 82–91)

Forcipomyia varipennis Wirth and Williams, 1957: 8 (female; Bermuda, Puerto Rico, Guatemala (misident.), Texas (misident.).

Female.—Wing length 0.74 (0.67–0.81, n = 2) mm.

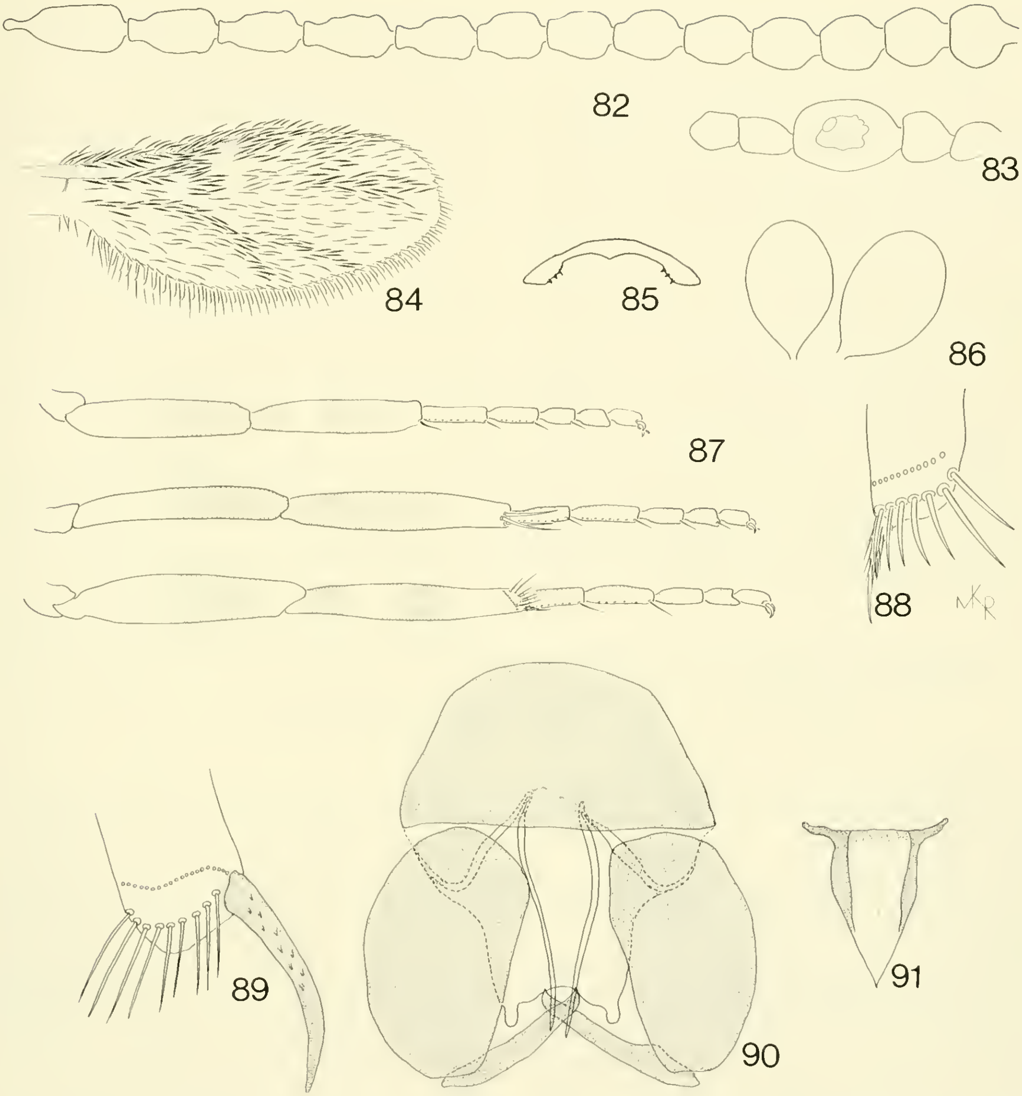
Head: Brown. Antenna (Fig. 82) with lengths of flagellar segments in proportion of 13-12-12-12-12-12-12-12-15-18-18-18-23; antennal ratio 0.93 (0.91–0.95, n = 2); proximal segments short, slightly tapering distally, 11–14 short with short distal necks. Palpus (Fig. 83) with lengths of segments in proportion of 10-10-20-10-10; palpal ratio 1.60 (1.50–1.70); 3rd segment greatly swollen to tip, with large deep sensory pit opening by a smaller pore.

Thorax: Dark brown, scutum and scutellum with numerous long, mixed brown and golden, upright setae, and appressed, yellowish scales. Legs (Fig. 87) brown; femora pale at bases, knees pale; fore and hind tibiae with narrow subbasal and broader subapical brown bands, the latter subequal in width to the yellowish band on each side; mid tibia brown except at extreme base and apex; hind tibial comb (Fig. 88) with 6–7 spines, spur slender, almost ½ length of basitarsus, slightly curved, pigmented distally, scaly at base; tarsi brown with narrow segmental yellowish bands; hind tarsal ratio 1.00 (n = 2). Wing (Fig. 84) with abundant long, striated, blackish scale-like macrotrichia; with small, yellowish anterior spot past end of costa and irregular, diffuse, paler areas on distal and posterior portions; cosal ratio 0.41. Halter brown.

Abdomen: Dark brown, with numerous dark brown hairs and slender scales. Genital sclerotization as in Fig. 85. Spermathecae (Fig. 86) elongate oval; subequal, each measuring 0.055 × 0.035 mm.

Holotype male.—Wing length 1.14 mm; breadth 0.36 mm; costal ratio 0.43. Similar to female with usual sexual differences; hind tibial comb (Fig. 89) with nine spines; spur very long and curved distally.

Genitalia (Fig. 90): Ninth sternite dark brown, slightly paler anteriorly; gonocoxite and gonostylus entirely dark brown (gonostylus paler in the specimens from Vero Beach). Aedeagus (Fig. 91) with nearly horizontal basal arms; main portion triangular, lateral sides subparallel anteriorly, coming



Figs. 82–91. *Forcipomyia varipennis*; 82–88, female; 89–91, male: 82, antenna; 83, palpus; 84, wing; 85, genital sclerotization; 86, spermathecae; 87, fore, mid, and hind legs (top to bottom); 88, 89, hind tibial comb; 90. genitalia, aedeagus omitted; 91, aedeagus.

to a sharp distal point, ventral surface with a more heavily sclerotized, medial longitudinal line. Parameres as usual, but anterior arch poorly sclerotized.

Distribution.—Bermuda, Florida, Puerto Rico.

Type.—Holotype female, Bermuda, Warwick Pond, 4.vii.1955, R. W. Williams, recovery cage.

Specimens examined.—FLORIDA: Alachua Co., Austen Carey St. Forest, Hatchet Creek, 13.v.1991, W. W. Wirth, malaise trap, 5 females, 3 males. Dade Co., Orchid Jungle, v–vi.1969, R. M. Baranowski, UV light trap, 1 female. Indian River Co., Vero Beach, vii.x.1958, Ent. Res. Ctr. light trap, 1 female, 1 male.

PUERTO RICO: El Verde Barrio Rio

Grande, no date, G. E. Drewery, sticky trap, 1 female, 1 male.

Discussion.—*Forcipomyia varipennis* is readily distinguished from the remaining Nearctic congeners by the peculiar stout 3rd palpal segment which is greatly swollen to its apex, by the unusually long hind tibial spur, by the brown halter (also *F. eadsi* and *F. werneri* have brown halteres), and by the subequal spermathecae. *Forcipomyia eadsi* also has short antennal segments without a distinct break between 10 and 11, but differs from *F. varipennis* in the shape of the third palpal segment which is slender distally.

The medians of the numerical values of the female were obtained from the specimen from Puerto Rico here examined and from the values given for the holotype by Wirth and Williams (1957).

Forcipomyia (*Lepidohelea*) *werneri*
Wirth and Spinelli, New Species
(Figs. 92–100)

Female.—Wing length 0.83 (0.77–0.94, n = 5) mm; breadth 0.34 (0.31–0.36, n = 5) mm.

Head (Fig. 83): Brown. Antenna (Fig. 92) with lengths of flagellar segments in proportion of 15-13-14-15-15-15-15-15-16-17-17-17-24; antennal ratio 0.78 (0.74–0.82, n = 5); proximal segments short, 11-14 vase-shaped with short distal necks. Palpus (Fig. 93) with lengths of segments in proportion of 10-13-27-14-11; palpal ratio 2.65 (2.50–2.70, n = 5); 3rd segment slightly swollen in midportion, with irregular shallow pit opening by a small pore; distal ¼ moderately slender.

Thorax: Brown. Legs (Fig. 99) brown, hind legs darker; fore and mid femora and proximal ½ of hind femur pale; knees pale; tibiae with subbasal and apical pale rings; hind tibial comb (Fig. 100) with seven spines, spur slender and curved; tarsi pale yellowish, tarsomeres 1–2 of hind leg slightly darker; hind tarsal ratio 1.15 (1.10–1.20, n = 5). Wing apparently densely covered by macrotrichia, but many macrotrichia missing in the material studied; costal ratio 0.42 (0.41–0.43, n = 5). Halter brown.

Abdomen: Brown, with numerous erect brown setae. Genital sclerotization as in Fig. 95. Spermathecae (Fig. 96) elongate oval; slightly unequal, measuring 0.074 × 0.046 mm and 0.068 × 0.030 mm.

Holotype male.—Wing length 0.94 mm; breadth 0.31 mm; costal ratio 0.42. Similar to female with usual sexual differences. Wing with macrotrichia more concentrated on radial veins and in radial cells, along anterior margin beyond end of costa, and on vein CuA2.

Genitalia (Fig. 98): Ninth sternite dark brown, slightly paler anteromesad; gonocoxite entirely dark brown; gonostylus dark brown, slightly paler at base. Aedeagus (Fig. 97) stout, basal arms and lateral margins strongly sclerotized, main portion triangular, tapering to pointed tip; ventral surface with more highly sclerotized median line. Parameres as usual.

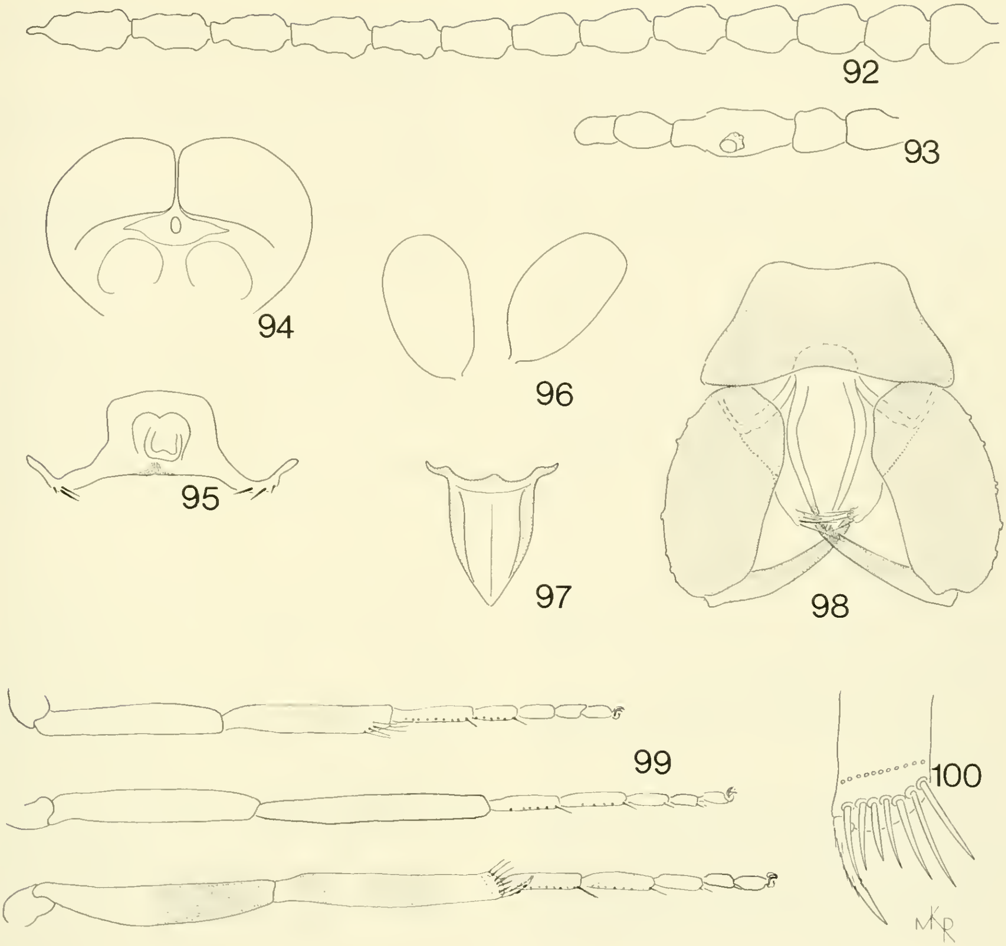
Distribution.—Mexico (Baja California, Sonora).

Types.—Holotype male, allotype female, Mexico, Sonora, 8 km W Alamos, 14.viii.1959, Werner & Nutting, light trap. Paratypes, 23 females, 27 males, as follows:

MEXICO: Baja California, 10 km SW Santiago, 30.viii.1989, Radford & Werner, 1 female, 1 male; 25 mi NW Penjamo, 29.viii.1959, Radford & Werner, 2 females. Sonora, same data as types, 15 females, 16 males; Hermosillo, 12.viii.1959, Werner & Nutting, 1 male; 16 km E Navajoa, 13.viii.1959, Werner & Nutting, 5 females, 9 males.

Discussion.—This species is dedicated to Floyd Werner of Arizona State University in appreciation of his long and continued interest in the collection and study of biting midges of the desert southwest.

Forcipomyia werneri can be distinguished from its Nearctic congeners (except *F. varipennis*) by its brown halter. It differs from *F. varipennis* in the slender 3rd palpal segment and shorter hind tibial spur, and from *F. eadsi* by the dark brown gonocoxite.



Figs. 92–100. *Forcipomyia werneri*; 92–96, 99, 100, female; 97, 98, male: 92, antenna; 93, palpus; 94, eye separation; 95, genital sclerotization; 96, spermathecae; 97, aedeagus; 98, genitalia, aedeagus omitted; 99, fore, mid and hind legs (top to bottom); 100, hind tibial comb.

ACKNOWLEDGMENTS

Financial support for this publication by Mars Incorporated, Effem Services Inc., Information Services International Division, Mt. Olive, NJ, is gratefully acknowledged. GRS is indebted to Ellis C. Greiner of the Department of Infectious Diseases, College of Veterinary Medicine, University of Florida, Gainesville, for providing research facilities. WWW is grateful to Harold A. Denmark and Richard D. Gaskella of the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, for providing research facilities at the Florida State Collection of Arthropods. We acknowledge with thanks the assistance of Molly K. Ryan of the Smithsonian Institution with illustrations of several species.

LITERATURE CITED

Bystrak, P. G. and W. W. Wirth. 1978. The North American species of *Forcipomyia*, subgenus *Euprojoannisia* (Diptera: Ceratopogonidae). United States Department of Agriculture Technical Bulletin 1591: 1–51.

Chan, K. L. and E. J. LeRoux. 1971. A new subgenus and species of midge (Diptera: Ceratopogonidae) from Singapore. Canadian Entomologist 103: 271–276.

Clastrier, J. 1972. *Forcipomyia* (*F.*) *squamithorax* n. sp. de la Guyane francaise [Dipt. Ceratopogonidae]. Bulletin de la Societe Entomologique de France 77: 170–176.

Coquillett, D. W. 1905. New nematocerous Diptera from North America. Journal of the New York Entomological Society 13: 56–69.

Debenham, M. L. 1987. The biting midge genus *Forcipomyia* (Diptera: Ceratopogonidae) in the Australasian Region (exclusive of New Zealand) III. The subgenera *Forcipomyia*, s. s., and *Lepidohelea*. Invertebrate Taxonomy 1: 631–684.

Downes, J. A. and W. W. Wirth. 1981. Ceratopogonidae, pp. 393–421. *In* McAlpine, J. F., et al., eds., Manual of Nearctic Diptera, Vol. 1. Agriculture Canada Mongraph No. 27, 674 pp.

Kieffer, J. J. 1917. Chironomides d'Amerique conserves au Musee national hongrois de Budapest. Annales Historico-Naturales Musei Nationalis Hungarici, Budapest 15: 292–364.

Lutz, A. 1914. Contribuicao para o conhecimento das Ceratopogoninas do Brazil. Memorias do Instituto Oswaldo Cruz 6: 81–98, 2 plates.

Macfie, J. W. S. 1938. Notes on Ceratopogonidae (Diptera). Proceedings of the Royal Entomological Society of London (B) 7: 157–219.

———. 1939. A report on a collection of Brazilian Ceratopogonidae (Dipt.). Revista de Entomologia 10: 137–219.

———. 1940. A report on a collection of Ceratopogonidae (Diptera) from British Guiana. Entomologists' Monthly Magazine 76: 23–32.

Saunders, L. G. 1924. On the life history and the anatomy of the early stages of *Forcipomyia* (Diptera, Nemat., Ceratopogoninae). Parasitology 16: 164–213, 3 plates.

———. 1956. A revision of the genus *Forcipomyia* based on characters of all stages (Diptera, Ceratopogonidae). Canadian Journal of Zoology 34: 657–705.

Wirth, W. W. 1952. The Heleidae of California. University of California Publications in Entomology 9: 95–266.

———. 1976. *Forcipomyia pictoni* Macfie and descriptions of two new related species from Florida (Diptera: Ceratopogonidae). The Florida Entomologist 59: 77–84.

———. 1980. Biting midges of the subgenus *Schizoforcipomyia* of *Forcipomyia* in North America (Diptera: Ceratopogonidae). The Florida Entomologist 73: 649–655.

———. 1991a. New and little-known species of *Forcipomyia* (Diptera: Ceratopogonidae) associated with cocoa pollination in Brazil. Proceedings of the Entomological Society of Washington 93: 163–175.

———. 1991b. *Forcipomyia bicolor* and related species of the subgenus *Lepidohelea* in Brazil (Diptera: Ceratopogonidae). The Florida Entomologist 74: 507–517.

Wirth, W. W. and A. A. Hubert. 1960. Ceratopogonidae (Diptera) reared from cacti, with a review of the *copiosus* group of *Culicoides*. Annals of the Entomological Society of America 53: 639–658.

Wirth, W. W., N. C. Ratanaworabhan, and D. H. Messersmith. 1977. Natural History of Plummers Island, Maryland XXII. Biting midges (Diptera: Ceratopogonidae). 1. Introduction and key to genera. Proceedings of the Biological Society of Washington 90: 615–647.

Wirth, W. W., and G. R. Spinelli. 1992. The immature stages of *Forcipomyia seminole* Wirth and a related new Neotropical species (Diptera: Ceratopogonidae). The Florida Entomologist 75: 349–356.

Wirth, W. W. and R. W. Williams. 1957. The biting midges of the Bermuda Islands, with descriptions of five new species (Diptera, Heleidae). Proceedings of the Entomological Society of Washington 58: 5–14.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 635–638

NAPEMYIA WEBB, A NEW SYNONYM OF *DIALYSIS* WALKER (DIPTERA: XYLOPHAGIDAE)

NORMAN E. WOODLEY

Systematic Entomology Laboratory, PSI, USDA, % National Museum of Natural History, NHB 168, Washington, D.C. 20560.

Abstract.—*Napemyia* Webb is synonymized with *Dialysis* Walker based on reexamination of the unique holotype of the type species, *N. illinoensis,* and the characters Webb used to define the genus. The phylogenetics of *Dialysis* is briefly discussed. *Dialysis illinoensis* (Webb), n. comb., is regarded as a valid species.

Key Words: Diptera, Xylophagidae, new synonymy, new combination

Webb (1983) described the genus *Napemyia* from a single specimen of a new species, *N. illinoensis,* collected in Vermilion County, Illinois. No additional material has been collected. The obvious close resemblance of the figures in the original description and the description itself to known species of *Dialysis* Walker led Nagatomi (1987: 719) to state: "the genus *Napemyia* may be a synonym of *Dialysis,* because the distinguishing characters are slight."

I recently examined the unique holotype male of *Napemyia illinoensis,* and concluded that *Napemyia* is a synonym of *Dialysis.* The holotype is preserved in alcohol in several pieces. The main parts are in a small vial within the storage vial, and the genitalia in a small microvial. During this study I also examined all Nearctic species of *Dialysis,* and *D. iwatai* Nagatomi from Japan. The rest of this paper presents the argumentation for this synonymy.

REEXAMINATION OF DIAGNOSTIC CHARACTERS

In the diagnostic paragraph above the formal original generic description, Webb (1983: 822) listed 5 characters as differing from *Dialysis,* implying that the opposite character state occurs in *Dialysis.* These follow here with a critique of their validity:

1) Elongate parafacial setae.—The facial region of *Dialysis* is deeply concave, such that the parafacials recede into the facial cavity. In all species the upper parafacials are pilose, especially noticeable just below the antennae. Some species, such as *D. dispar* Bigot, have pilosity in this region as long and dense as that found in *N. illinoensis.* In most species of *Dialysis,* the lower parafacial areas near the mouthparts are bare, while they are sparsely haired in *N. illinoensis.* However, I have seen some specimens of *D. dispar* that have this area haired virtually identical to the condition found in *N. illinoensis.* This character is without value in defining *Napemyia.*

2) Ventral plate of male proctiger narrowly emarginate posteriorly.—The ventral plate of the proctiger, the 11th abdominal sternite, is quite small in *Dialysis,* ventral to the cerci, and weakly sclerotized. In nearly all species of *Dialysis* I have examined there is some indication of a posteromedial emargination on this sclerite. In some species it is small and indistinct (e.g. *D. iwatai*), in others the entire median line is weakly sclerotized and the sternite appears almost

divided (e.g. *D. lauta* (Loew)). Only in *D. aldrichi* Williston is the posterior margin virtually entire. In a specimen of *D. rufithorax* (Say) that I examined, the 11th sternite is virtually as illustrated by Webb for *N. illinoensis* (Webb 1983: fig. 4). Unfortunately I could not reevaluate the character state in *Napemyia,* as I could not find this structure among the parts of the holotype.

3) Gonocoxites in ventral view with no open areas.—Most species of *Dialysis* as well as some other xylophagid genera (*Coenomyia* Latreille, *Odontosabula* Matsumura, *Arthropeas* Loew, and *Anacanthaspis* Röder; see figures in Nagatomi and Saigusa 1970) have vaguely defined unsclerotized areas medially on the ventral surface of the gonocoxites (referred to as "basistyles" by Webb). However, Webb himself states that *D. kesseli* Hardy has no such "open areas," and figures the species thusly (Webb 1978: fig. 4). Nagatomi (1992) noted this statement, and regarded the loss of this membranous area in *D. kesseli* and *N. illinoensis* as a secondary reduction, since he considered the membranous patch to be a synapomorphy of the genera listed above. A paratype male of *D. kesseli* (USNM) shows the presence of a more poorly sclerotized medial area as in other species of *Dialysis.* After light staining of the genitalia of the holotype of *N. illinoensis* with chlorazol black, a small medial "open area" is evident. In excessively cleared specimens the contrast between the median open area and surrounding sclerotization becomes increasingly difficult to detect, apparently the reason why it was sometimes overlooked by Webb. It is clear that this character cannot be considered definitive of *Napemyia.*

4) Penis valves present.—Webb implies that *Dialysis* does not have structures he calls penis valves. These structures are actually aedeagal in origin, being part of the apical portion of the aedeagus (B. J. Sinclair, pers. comm.). However, Webb (1978: 409), in his generic description of *Dialysis,* states "aedeagus terminates posteriorly in two narrow, reduced penis valves." In all species that I have examined these structures are present, some being virtually identical to those found in the genitalia of the holotype of *N. illinoensis.*

5) Thyridium lacking.—The "thyridium" found in *Dialysis* is a small, diffuse area around the first branch of the medial vein, which constitutes the most proximal angle of the discal cell. It appears whitish in color due to less pigmentation than the surrounding wing membrane, and sometimes extends proximally along vein M towards the base of the wing. It is variable in extent at the individual level, sometimes being absent in some specimens of a given species. I have noted its absence in individuals of *D. aldrichi, D. elongata* (Say), and *D. rufithorax.* This feature is especially less evident to absent in teneral specimens of *Dialysis.* The holotype of *N. illinoensis* seems to be at least slightly teneral, since the wing veins are lightly colored and the wings have an overall light, milky appearance. It is therefore conceivable that additional specimens may reveal the presence of a "thyridium" in some individuals of *N. illinoensis.* Given the individual variation to which this feature is subject, its value as generically definitive of *Napemyia* is dubious.

PHYLOGENETIC CONSIDERATIONS

Webb (1978: fig. 1) presented a "phylogenetic diagram" for the Nearctic species of *Dialysis,* for which in the text (page 405) he stated: "This cladistic diagram contains the least number of convergent origins of the apomorphic alternatives." The apomorphic character states were displayed on the figured tree. I put these into character matrix form (9 taxa, 13 characters). I did not reevaluate any of the characters or the polarities determined by Webb, but added a hypothetical taxon with all character states coded as plesiomorphic to root the trees to be generated. The character state matrix is presented in Fig. 1 (character states for *Napemyia* are included in the figure but were not included in this analysis). The matrix was analyzed using Hennig86 (Farris 1988), which produced 18 equally parsimonious trees (length = 25, ci = 52, ri = 61) by the implicit enumeration algorithm. Webb's figured tree was then derived utilizing the "Dos Equis" feature of Hennig86 by moving branches until the topology was obtained. This tree was diagnosed and found to have a length of 27 steps (ci = 48, ri = 54). Thus, the tree published by Webb was 2 steps longer than the actual shortest trees based on his data.

I hoped that the characters used by Webb in analyzing *Dialysis* could be scored for *Napemyia.* However, I found it difficult to differentiate between the alternatives for some of Webb's characters (numbers 4, 6, 7, 10; see list in 1978: 405–406) when viewing actual specimens. Furthermore, some of the character states do not appear to be discrete, such as "hind coxa stramineous to testaceous." Two preliminary analyses in which an attempt was made to score *Napemyia* (character states are shown in the bottom line of the character matrix in Fig. 1; character 10 was coded two different ways) from the original description yielded 20 and 21 equally parsimonious trees. In both analyses *Napemyia* was nested well within *Dialysis* in all trees, and in each analysis was the sister group to *D. fasciventris* (Loew) in 18 trees. While I put little value on these phylogenetic results, they do indicate the close similarity of *Napemyia* to some species of *Dialysis.*

Definition of *Dialysis*

Within the family Xylophagidae (genera listed in Woodley 1989) *Dialysis* is easily characterized by the autapomorphic form of the antennal flagellum. The flagellomeres are largely fused and compressed basally to form a very short, compact base of one flagellomere, smaller in diameter than the pedicel, slightly conical in shape. This is occasionally followed by evidence of a very short second flagellomere that is not completely fused with the first; this is the case on the right antenna of the holotype of *N. illinoensis,* less apparent on the left. This basal complex is followed by the apical flagellomere which is in the form of a very slender, elongate style, very slightly expanded just before the apex, then tapered to a fine, sharp apex. This apical flagellomere is more than twice as long as the rest of the antenna. Most other xylophagids have a simple flagellum composed of 8 flagellomeres, sometimes tapered apically but not fused. This is the plesiomorphic state for the Brachycera (Woodley 1989). The only exception to this in the family is *Rachicerus* Walker and two closely related genera (*Gymnorhachicerus* Frey and *Paleorachicerus* Nagatomi) that have an apomorphic condition with supernumerary flagellomeres, often pectinate. As *Napemyia* has antennal morphology identical to that of *Dialysis,* this synapomorphy is additional evidence for the synonymy of the two names.

	Character number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
outgroup	0	0	0	0	0	0	0	0	0	0	0	0	0
aldrichi	0	1	1	1	0	0	0	0	0	0	0	0	0
dispar	0	0	1	1	0	1	0	0	1	0	0	0	0
elongata	1	1	1	0	0	0	0	0	0	0	0	1	0
fasciventris	0	1	1	0	0	0	0	0	1	1	1	1	0
lauta	0	1	1	1	0	0	0	1	1	1	0	0	0
kesseli	0	0	0	0	1	1	1	1	1	0	0	1	0
mentata	0	1	1	0	0	1	1	1	0	1	0	1	0
rufithorax	0	1	1	1	0	1	1	1	0	1	1	1	1
reparta	0	1	1	1	0	1	1	1	1	1	1	1	0
Napemyia	0	1	0	0	0	0	0	0	1	2 (?)	1	1	1

Fig. 1. Character state matrix for *Dialysis,* derived from phylogenetic tree presented by Webb (1978: fig. 1). Bottom line is character state information from original description of *Napemyia* (Webb 1983). Character 10 was coded as state "2" and "?" (unknown) in two different analyses.

Conclusions

It is abundantly clear, especially from reexamination of the purportedly diagnostic characters, that *Napemyia* Webb is a synonym of *Dialysis* Walker (NEW SYNONYMY). *Dialysis illinoensis* (Webb) (NEW

COMBINATION) can at present be considered a distinct species. It is possible that the holotype is an aberrant specimen of a previously described species of *Dialysis*, but final disposition requires additional material.

Acknowledgments

I thank Donald W. Webb and Kathleen R. Methven of the Illinois Natural History Survey for arranging the loan of the holotype of *Napemyia illinoensis*. I also thank Brian Brown of the Natural History Museum of Los Angeles County, Wayne Mathis of the Smithsonian Institution, and A. L. Norrbom and R. W. Poole of the Systematic Entomology Laboratory for reviewing the manuscript.

Literature Cited

Farris, J. S. 1988. Hennig86, Version 1.5. Port Jefferson Station, New York.

Nagatomi, A. 1987. Taxonomic notes on Coenomyiidae (Insecta: Diptera). Zoological Science 4: 711–720.

———. 1992. Notes on the phylogeny of various taxa of the Orthorrhaphous Brachycera (Insecta: Diptera). Zoological Science 9: 843–857.

Nagatomi, A. and T. Saigusa. 1970. The Coenomyiidae of Japan (Diptera). Memoirs of the Faculty of Agriculture, Kagoshima University 7: 257–292.

Webb, D. W. 1978. A revision of the Nearctic genus *Dialysis* (Diptera: Rhagionidae). Journal of the Kansas Entomological Society 51: 405–431.

———. 1983. A new genus and species of Nearctic coenomyiid (Diptera: Coenomyiidae). Proceedings of the Entomological Society of Washington 85: 822–825.

Woodley, N. E. 1989. Phylogeny and classification of the "Orthorrhaphous" Brachycera [Chapter] 115, pp. 1371–1395. *In* Manual of Nearctic Diptera, Volume 3. Research Branch, Agriculture Canada Monograph 32: vi; 1333–1581.

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, p. 639

NOTE

The Star-nosed Mole, *Condylura cristata,* A New Host for *Leptinus orientamericanus* (Coleoptera: Leptinidae) in Virginia

Leptinus orientamericanus Peck, 1982 is the only species among the 3 Nearctic species in the genus *Leptinus* to occur east of the Mississippi River in the United States. It is known from 17 states south of New England (Peck. 1982. Canadian Journal of Zoology 60: 1517–1527). The short-tail shrew, *Blarina brevicauda,* and the eastern mole, *Scalopus aquaticus,* are the first and second most documented hosts. Other hosts include the shrews *Sorex fumeus* and *Sorex frontalis* (lapsus for *Sorex fontinalis*?), the mole *Parascalops breweri,* and rarely the rodents *Peromyscus leucopus, Peromyscus maniculatus, Microtus pennsylvanicus, Pitymys pinetorum,* and *Clethrionomys gapperi* (Peck 1982. op cit.) Previous records from Virginia include "mole fur"—Culpeper County, "on mole"—Montgomery County, and *Scalopus aquaticus*—no other data.

On 24 October 1987, a male star-nosed mole, *Condylura cristata* (Linnaeus 1758) was captured by hand from under a board in a streamside meadow along Back Creek in Highland County, Virginia at an elevation of 1220 m. Ten *L. orientamericanus,* 2M and 8F, were brushed out of the pelage. *Condylura cristata* is a new host and Highland County a new locality for *L. orientamericanus.* Specimens have been mounted on slides in Canada balsam and are retained as accession number M-Ccr-1-87 in the collections at Northern Virginia Community College.

A survey of shrews and moles for leptinids was conducted in 7 states in eastern United States. Counties where animals infested with *Leptinus orientamericanus* were collected are listed in parentheses. Among mole species 1 out of 2 *Condylura cristata* in VA (Highland County), 0 out of 1 *Parascalops breweri* in WV, and 1 out of 9 *Scalopus aquaticus* in VA (Fairfax County), were infested. *Blarina brevicauda* was the most commonly infested host with a prevalence of 11.9% of 135 examined. The mean intensity was low, with an average of 1.6 beetles per infested shrew. Four of 57 short-tail shrews in VA (Highland, King George, Tazewell Counties), 6 out of 47 in WV (Pendleton, Pocahontas, Randolph Counties), 3 out of 13 in PA (Allegheny County), 2 out of 7 in GA (Towns County), 1 out of 7 in TN (Carter County), 0 out of 2 in NC, and 0 out of 1 in NJ were infested. Other species of shrews examined were negative for leptinids: *Cryptotis parva,* 19 (VA); *Sorex fumeus,* 1 (VA), 4 (WV); *Sorex cinereus,* 13 (VA), 5 (WV), 2 (GA); *Sorex dispar* 2 (WV), 1 (TN); *Sorex longirostris,* 10 (VA); and *Sorex palustris,* 1 (MD).

None of the rodents we have examined has been infested with leptinids. Of the 93 rodent nests we have examined with the use of the Berlese funnel, only 2 have yielded 3 *L. orientamericanus.* One of these was from Pocahontas County WV (1 male) and the other with 2 males from Culpeper County VA. We believe rodents are either minor or accidental hosts.

With the addition of *Condylura cristata,* species of all 5 genera of moles in North America are known as hosts of leptinids, and all 3 species of moles which occur in eastern United States are now known as hosts of *Leptinus orientamericanus.*

Ralph P. Eckerlin and Harry F. Painter, *Natural Sciences Division, Northern Virginia Community College, Annandale, Virginia 22003.*

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 640–641

NOTE

A Note on the Host Specificity of the Mirid *Slaterocoris pallipes* (Knight)

This note describes laboratory experiments undertaken to confirm the host range of *Slaterocoris pallipes* (Knight) which was identified as a potential biological control agent for the weed *Baccharis halimifolia* L. (Asteraceae: Astereae) in Australia.

The Nearctic genus *Slaterocoris* Wagner contains 46 species (Knight 1970. Iowa State Journal of Science 45: 233–267). From the little host information available (Kelton 1968. Canadian Entomologist 100: 1121–1137; Knight 1970), *Slaterocoris* spp. appear to be almost exclusively confined to the Asteraceae with most species using only one plant genus.

Slaterocoris pallipes is a univoltine specialist species of *B. halimifolia,* occurring from New York in the north to as far south as North Carolina (Wheeler 1981. Proceedings of the Entomological Society of Washington 83: 520–523). I have more recently (30th June 1983) collected it near Gainesville, Florida, and this is a new state record. Wheeler (1981) also described the life stages of the insect and indicated that the egg is the overwintering stage.

Thirty two plant species (Table 1) were selected in an experiment conducted at the North American Field Station during the summer of 1984 to confirm the known host range of this insect. Most were representatives of Asteraceae, particularly Astereae. Two replications of each species were used. Twelve potted plants (of 12 species but including *B. halimifolia*) were randomly placed within each 53 × 69 × 84 cm gauzed cage. Wooden planks were placed above the pots so that the foliage and stems of the plants protruded through small holes in these planks. Six cages were so prepared in a shade house so that each plant species was exposed twice, except for *B. halimifolia* (6 exposures) and *B. neglecta* (4 exposures).

Quantities of *S. pallipes* were collected from *B. halimifolia* at either Williamsburg, Virginia, or Toms River, New Jersey, and sent to Temple, Texas. During the 3–5 days in transit, the insects were given access to bouquets of foliage.

Immediately upon arrival in Temple, approximately fifty insects (including both adults and nymphs) were introduced into each cage by scattering them over the wooden planks. It was intended to use oviposition, feeding, and counts of the insect as criteria for evaluating its host specificity. Approximately every second day the insects seen on each plant were counted. After the insects had died, the cages were dismantled. The amount of feeding damage was assessed and the stems dissected to count any eggs deposited.

Approximately 56% of all insect sitings were on *B. halimifolia* with *B. neglecta* accounting for an additional 25%. The other 30 plant species therefore accounted for less than 19%, and no one plant species appeared to be particularly favored. All *B. halimifolia* and *B. neglecta* plants showed signs of severe attack and there was little difference between these two species. The feeding damage was as described and illustrated by Wheeler (1981) with leaves, particularly young growth, turning chlorotic and being spotted with black excrement. No other plant showed signs of attack by *S. pallipes.* Oviposition did not occur on any plant, including the two *Baccharis* spp.

Slaterocoris pallipes was imported into quarantine facilities at the Alan Fletcher Research Station, Brisbane, in 1985. Although the insect successfully oviposited in potted *B. halimifolia* plants in this facility, nymphs failed to emerge the next year. A second importation was made in 1986 with similar results. Because *S. pallipes* could not be successfully reared in the laboratory, it was rejected as a biocontrol agent and no further work on it was undertaken.

Table 1. Plant species against which *S. pallipes* was tested.

AMARANTHACEAE: *Gomphrena globosa* L.
APOCYNACEAE: *Vinca minor* L.
ASTERACEAE: Tribe Astereae: *Aster noviae-angliae* L., *Baccharis halimifolia* L., *Baccharis neglecta* Britt., *Callistephus chinensis* (L.) Nees, *Chrysothamnus nauseosis* (Pall.) Britt., *Conyza canadensis* L., *Dimorphotheca aurantiaca* Hort., *Gymnosperma glutinosum* (Spreng.) Less, *Haplopappus* sp., *Solidago altissima* L.; tribe Heliantheae: *Dahlia pinnata* Cav., *Gaillardia pulchella* Foug., *Helianthus anuus* L., *Iva frutescens* L., *Parthenium hysterophorus* L., *Xanthium strumarium* L. (sensu lato), *Zinnia elegans* Jacq.; tribe Tageteae: *Tagetes lucida* Cav.; tribe Cynareae: *Carthamus tintoris* L., *Cynaria scolymus* L.; tribe Eupatorieae: *Ageratum houstonianum* Mill.; tribe Cichorieae: *Lactuca sativa* L.; tribe Anthemidae: *Chrysanthemum maximum* Raymond.
CARYOPHYLLACEAE: *Dianthus* sp.
FABACEAE: *Vicia faba* L.
LAMIACEAE: *Salvia splendens* Sellow.
MALVACEAE: *Gossypium hirsutum* L.
POACEAE: *Zea mays* L.
SOLANACEAE: *Lycopersicon esculentum* L.
VERBENACEAE: *Lantana camara* L., *Verbena* sp.

Acknowledgments.—T. J. Henry (Systematic Entomology Laboratory, USDA, Washington D.C.) and A. G. Wheeler Jr. (Bureau of Plant Industry, Pennylvania Department of Agriculture, Harrisburg) kindly provided expert identifications and other useful information assisting this study.

W. A. Palmer, *North American Field Station, Queensland Department of Lands, 2801 Arrowhead Circle, Temple, Texas 76502.*

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 642–643

NOTE

Observations of Extrafloral Nectar Feeding by Predaceous and Fungivorous Mites

The value of predaceous mites as agents for reducing the populations of plant-feeding mites is significant (McMurtry et al. 1970. Hilgardia 42: 331–390). Many plants have evolved ways to attract and maintain these important predators. Leaves of some plants being attacked by spider mites release volatile chemicals to attract predatory mites and help them locate prey (Dicke and Sabelis. 1988. Netherlands Journal of Zoology 38: 148–165). Other plants employ leaf domatia as a means of enhancing the presence and abundance of predaceous mites and fungivorous mites. Leaf domatia are hair tufts, pits or pockets located at the leaf vein junctions of many plants that act as shelters and nursery sites for these beneficial mites (Pemberton and Turner. 1989. American Journal of Botany 76: 105–112; O'Dowd and Willson. 1989. Biological Journal of the Linnean Society 37: 191–236). Leaves bearing leaf domatia have been found to have more predaceous mites than leaves that do not have leaf domatia (Walter and O'Dowd. 1992. Environmental Entomology 21: 478–484).

Extrafloral nectaries are sugar secreting glands (found primarily on leaves) which have been shown by many studies to promote a food for protection mutualism between plants and ants (Beattie. 1985. The Evolutionary Ecology of Ant-Plant Mutualisms. Cambridge University Press, Cambridge). This note is the first report of extrafloral nectar feeding by predaceous and fungivorous mites.

On July 27, 1990, three red-colored mites of the genus *Anystis* (Anystidae) were observed to feed on the extrafloral nectaries of *Prunus sargentii* Rehder growing in Seoul, South Korea. The nectaries involved were on the leaf petioles of sucker growth at the tree base. Two mites ran rapidly over the surfaces of several leaves, then stopped at the extrafloral nectaries to feed. The third mite was feeding at a gland when first noticed and, after about ten seconds of feeding, it also began to run. Later in the season (October 23), two other *Anystis* mites were seen feeding at the extrafloral nectaries on the petiole-blade junctions on some young leaves of sapling *Populus tomentiglandulosa* T. Lee, also growing in Seoul. These mites behaved in a similar manner to those observed on *P. sargentii,* running rapidly over the leaf surfaces, stopping for a period of feeding, and then running again. The time spent feeding is estimated to have been 15 seconds or less at each gland. Usually only one of the large, paired glands was fed upon. The observations were facilitated by the large size (2–3 mm) and red color of these mites, and the prominently placed, large nectaries of the poplar and cherry. Since the mites were immature and not identifiable to species, it is unknown whether they belong to one or more *Anystis* species.

On August 10, 1990, while observing extrafloral nectaries on a *Paulownia tomentosa* (Thunb.) Steud. (Scrophulariaceae) leaf (from a tree growing in Seoul), under the dissecting microscope, I noticed many *Czenspinskia sp.* (Oud.) (Winterschmidtiidae) feeding at the glands. The extrafloral nectaries of *P. tomentosa* leaves are tiny spherical cups, about 1 mm in diameter, located along and upon the bases of the veins on the upper surface and between the major vein junctions on the lower surface. The nectar feeding mites stood on their hind legs on the leaf surface adjacent to the gland and leaned against the lip of the rim of the gland with their forelegs, enabling their heads and mouth parts to reach the nectar within the cup. The mites fed either alone or in groups of up to four individuals at a single gland. This feeding was observed only at the nectaries located on the bottom surface of the leaf. A total of about 20 mites were observed engaged in this nectar feeding during an hour's observation. During this time the mites moved between glands, walking up and over empty glands and stopping to feed at the glands with nectar.

On September 9, 1992, I observed a *P. tomentosa* leaf which had many *Czenspinskia* walking around and on top of empty nectaries. From an adjacent tree I found a leaf with many actively secreting nectaries but no *Czenspinskia.* I placed the undersides of these two leaves together, set them on a lab bench and pressed them together with a heavy book. After one hour, I examined the leaf with active nectaries and noted that large numbers of the *Czenspinskia* had transferred to this leaf and were feeding at many of the nectaries. Most of the mites were feeding at the glands, frequently in groups of three to five per gland.

The value of extrafloral nectar to these mites is probably primarily as an energy source, but it could have additional nutritional value since most extrafloral nectars contain many amino acids (Baker et al. 1978. Botanical Gazette 139: 322–332). Since most extrafloral nectaries function on young growth and usually cease secretion after leaves reach their full size and harden, the availability of extrafloral nectar to the mites would be mainly in the spring. The extrafloral nectaries of *P. tomentosa* are an exception to this generality because they often continue to function in older leaves. Plants growing under irrigation or in areas with rainy summers, such as Korea, have enough moisture for new growth of foliage in the summer and autumn, making the period of nectar availability much longer (Pemberton. 1990. Korean Journal of Ecology 13: 251–266). Extrafloral nectar is probably particularly valuable during the absence of prey and may serve to maintain these predatory and fungus eating mites on the plants or in the habitat until prey becomes available.

In addition to ants, many other predaceous and parasitic arthropods are frequent visitors to extrafloral nectaries, including parasitic Hymenoptera (Hespenheide. 1985. Ecological Entomology 10: 191–204) and coccinellid beetles (Pemberton and Vandenburg. 1993. Proceedings of the Entomological Society of Washington 95: 131–151). These insects might also cause reductions in the insect herbivores attacking plants that bear the glands. Research is needed to determine the frequency of extrafloral nectar feeding by beneficial mites, and what its significance may be for both the mites and the plants. Extrafloral nectar feeding by predaceous mites could prove to be of considerable importance in pest management. Many economic plants, such as cotton and stonefruits (*Prunus* spp.), bear extrafloral nectaries, and predaceous mites are increasingly important biological control agents.

I thank R. L. Smiley (Systematic Entomology Laboratory, USDA-ARS, Beltsville, MD) for identifying the *Anystis*; H. A. Denmark (Florida Division of Plant Industry, Gainesville) for identifying the *Czenspinkia*; G. W. Krantz (Department of Entomology, Oregon State University) and J. A. McMurtry (Department of Entomology, University of California, Riverside) for reviewing an earlier version of this note.

Robert W. Pemberton, *Asian Parasite Laboratory, United States Department of Agriculture, Agricultural Research Service (Seoul, Korea), % American Embassy, Unit #15550, APO AP 96205-0001, U.S.A.*

Book Reviews

Flycatcher. Memoirs of an Amateur Entomologist. K. A. Spencer. 1991. SPB Academic Publishing, The Hague, The Netherlands. xiv + 414 pp. $105.00 (clothbound).

This autobiography is an awfully good read. If you do not know K. A. Spencer, the name "flycatcher" in the title might seem frivolous, but the book is as serious as he is; rather the title places emphasis on his long obsession with the Agromyzidae, the dipterous family of leafminers on which he became the world's leading expert.

K. A. Spencer, now in his 76th year, has lived an interesting life. Early on he became a linguist, which was an excellent foundation for all his future endeavors and opened many doors to him. He writes about his early years, of his education and travels through pre-World War II Europe, his seven years with the British army spanning World War II and beyond, his meeting and friendship with Hering, the German agromyzid specialist who was responsible for introducing Spencer to work on leafminers, and his career in the printing industry, which eventually allowed him the leisure to pursue full-time collecting and publishing on agromyzids.

Spencer has been to 53 countries, and his impressions of the places he has seen and people he has met during these travels are fascinating. Some of his experiences you don't want to have, such as car trouble on bad hairpin turns in isolated places or a mugging in Colombia. But Spencer is pretty imperturbable, just so he gets his tea on time in the morning. One of his most visited "exotic" countries was the USA, which always seemed to have been a great adventure for him. If he met you, you may be mentioned in this book. And if situations are not quite the way you remember them, well, it's his book so he can call the shots as he sees them.

The book flows well when one gets the habit of skipping over the lists of his catches. Spencer's fixation first on insects and then agromyzids is amazing. In post World War II Yugoslavia, he steps over a man just killed by snipers to collect a butterfly. Later, in some exotic country, he enjoys a preprandial walk and, as he writes, a good dinner. He gives us a list of the agromyzid mines he collected on his walk, which should interest possibly five people in the world, but leaves us to wonder what he ate.

The book has several photographs of scenes and people, especially of agromyzid workers. There is a three-part index: to natural history, localities, and people, at least for first mention.

Raymond J. Gagné, *Systematic Entomology Laboratory, PSI, Agricultural Research Service, USDA, % U.S. National Museum NHB 168, Washington, D.C. 20560.*

The Biology of Mosquitoes. Volume 1. Development, Nutrition, and Reproduction. A. N. Clements. 1992. Chapman & Hall, New York, New York, USA. 509 pp. $99.50 (hardcover).

In 1963, *The Physiology of Mosquitoes* was published as Volume 17 of the Zoology Division of the International Series of Monographs on Pure and Applied Biology. This book, by A. N. Clements, was for years a standard reference on physiology and biology of mosquitoes. Nearly 30 years later, Clements has rewritten and expanded his book. The change of title is a recognition that the original text covered more than just physiology, and this rewritten volume again treats a broad range of mosquito biology topics.

The Biology of Mosquitoes will appear as a two-volume set, and Volume 2, *Behaviour and Sensory Reception,* is in preparation. The original volume consisted of 16 chapters. The first nine chapters have been expanded, and new chapters added, to total 23 chapters in Volume 1 of the new publication. The remaining seven chapters of the old book will be treated in the upcoming second volume. Whereas the old text was 393 pages in length, the first volume of this new rewrite contains over 500 pages; the size of the pages in the new volume is larger, and their margins smaller, than in the old volume. The review of literature is thorough and current. The old volume contained about 850 references, but this first volume contains over 1500. There are many references to papers published in 1991, and at least one published in 1992. These expansions of text length and reference citations reflect the increase in information on mosquito biology in the past 30 years.

The sequence of chapters in the new volume somewhat parallels the old book. The book begins with a short introduction to the life cycle of and disease transmission by mosquitoes. There follows a chapter on genetics, covering karyotypes, linkage maps, sex determination, and infection by rickettsiae.

Some of the chapters from the old book have been divided into two or more new chapters. The old chapter on the mosquito egg has been divided into two chapters: "“Embryology" and "The Egg Shell," including morphology, water relations, and hatching. The old chapter on larval nutrition, excretion, and respiration also has been split into two chapters: "Larval Feeding," covering food sources, morphology of feeding structures, feeding mechanisms, particle capture, and feeding rates and "Larval Nutrition, Excretion, and Respiration." The old chapter on growth and metamorphosis has been split into two chapters ("Growth and Development" and "Metamorphosis"), that on adult feeding has been divided into three chapters ("Adult Food and Feeding Mechanisms," "The Adult Salivary Glands and Their Secretions," and "The Structure of the Adult Alimentary Canal"), that on adult nutrition and metabolism into three chapters ("Adult Digestion," "Adult Energy Metabolism," and "Adult Diuresis, Excretion, and Defaecation"), and the old chapter on reproduction has been divided into seven chapters in the new volume ("Structure of the Gonads and Gonoducts," "Spermatogenesis and the Structure of Spermatozoa," "Oogenesis," "Vitellogenesis," "Hormonal Regulation of Ovarian Development in Anautogenous Mosquitoes," "Nutrition and Fertility of Anautogenous Mosquitoes," and "Autogeny"). Each of these newly divided chapters has been expanded and rewritten.

The "Circulatory System" chapter has been expanded to include information on hemolymph and immune responses. The chapter on "Osmotic and Ionic Regulation" has been expanded and several new figures have been added. There is also a new chapter on the "Endocrine System and Hormones."

Some of the new chapters, however, are

very short, and it perhaps would have been better to combine some of them. For example, the chapter on "Structure of the Gonads and Gonoducts" is only five pages long, and the following chapter on "Spermatogenesis and the Structure of Spermatozoa" is only six pages long. Similarly, "Structure of the Adult Alimentary Canal" is nine pages long.

I noticed no glaring typographic errors. The text is well-illuminated by numerous photomicrographs, line drawings, tables, and graphs. The quality of the illustrations is high and the addition of photomicrographs improves this volume over the old text. The writing style is easy to read and understand, and Clements has made an effort to write in such a manner that will "satisfy the specialist" while being "comprehensible to any informed biologist." Indeed, while the emphasis of the book is on physiology, there is something here for just about everyone working in biology. My only complaint is that the new volume does not include an author index, as did the old book. However, species and subject indices are present. This first volume is an excellent review of mosquito biology and a welcome addition to any library. The second volume is eagerly awaited by all working with mosquitoes.

Lawrence J. Hribar, *Florida Medical Entomology Laboratory, University of Florida, 200 Ninth Street SE, Vero Beach, Florida 32962.*

The Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, Volumes 3 and 4, Hexapoda. F. M. Carpenter. The Geological Society of America, Boulder, Colorado. 1992. 655 pp. Available from: The Geological Society of America, P.O. Box 9140, Boulder, Colorado 80301. $87.50 (2 volume set, clothbound).

This two-volume set is, according to the author's preface, the culmination of 30 years of assembling, compiling, and distilling the extensive literature on fossil hexapods. What entomologist worth his salt has not had his imagination fired at the thought of the giant Meganeuridae with a wing span in some species approaching 70 cm or some of the other fabulous insects of bygone ages? Now for the first time since Handlirsch's *Die fossilen Insekten* (1906–1908), we have available an exhaustive treatment of the extensive diversity of insects found through geological time. While technically the volumes treat the superclass Hexapoda, only 4 pages deal with the Collembola, Protura, and Diplura, the remainder being devoted to the insects.

The preparation of such a work is surely a daunting prospect, considering the extensive literature on the subject in Russian and to a lesser extent Chinese. The literature is stated to be covered through the year 1983. I did note a few later references in the bibliography.

The format of the book conforms to the previous volumes in the series. The main text is presented in phylogenetic order, following the classification proposed by Manton in 1969. There is a short description of each suprafamilial taxon followed by a few general comments (this being more extensive for the taxon Insecta). For each family there is a very short diagnosis, followed by a list of included genera known from the fossil record. Each generic entry contains the reference of the original description, additional references if they exist, a few diagnostic characters for genera described as fossils, the geological period(s) from which fossils are known, the country of origin, and figure legends with references to their sources.

The figures are an important aspect of this work. They are derived largely from original literature with appropriate documentation. However, they have been extensively relabeled in a uniform format throughout the volumes. They are well presented without clutter, and are superbly reproduced. These are supplemented by some of Professor Carpenter's fine original photographs of several spectacular fossils, primarily of the larger, extinct orders such as Palaeodictyoptera. These photos show that some ancient insects had strikingly patterned wings and were perhaps quite colorful. There are two summary figures (Fig. 9 and Table 2) which present graphically the geological time span occupied by each order and family treated in the volumes.

Two ancillary features should prove useful, especially to non-taxonomists who have occasion to use these volumes. The editorial preface gives a brief summary of some rules of zoological nomenclature as they pertain to the entries in the *Treatise,* and also explains some of the conventions and abbreviations used. Secondly, on pages 526–528 there is a small glossary of "somewhat more than a hundred" entomological terms, as well as a couple of references to sources that contain much more extensive glossaries.

The real measure of the endurance of a work such as this is its completeness. I spot checked a number of Diptera fossil references in an attempt to discover any omissions. The only one I discovered is probably a compilation error rather than an oversight. The taxa described by Cobben (1971; Hemiptera, Saldidae), Cook (1971; Diptera, Scatopsidae), and James (1971; Diptera, Stratiomyidae) were omitted from the main text. These papers were, however, cited in the bibliography. They appeared together in Volume 63 of the *University of California Publications in Entomology* dealing with Chiapas amber, and other papers in the volume were properly included in the text. Certainly in a monograph compiling 5188 recognized genera of fossil Hexapoda (p. 504), there must be other omissions, but from my checking, I think they are minimal. I noted only one typographical error; on page 428 the asilid generic name "*Nicodes*" should read *Nicocles.*

Physically, the volumes are pleasing and appear to be durable. They are fully cloth bound, not housed in flimsy, paper-covered boards that are increasingly being marketed on expensive academic books. The paper quality is high, the typography is pleasant, and the printing well executed. I noted no lightly printed pages or poorly reproduced figures. Considering the exorbitant prices asked for many scholarly books these days, I think these volumes are an unexcelled bargain.

These volumes are clearly an indispensible tool for anyone interested in fossil insects, be they paleontologists, entomologists, or others attracted to the subject. They are likely to become venerable research tools, unlikely to be supplanted for decades, if ever. Both the author and the editorial staff can be justifiably proud of a superb production.

Norman E. Woodley, *Systematic Entomology Laboratory, PSI-ARS-USDA, % National Museum of Natural History NHB 168, Washington, D.C. 20560.*

PROC. ENTOMOL. SOC. WASH.
95(4), 1993, pp. 649–654

SOCIETY MEETINGS

981st Regular Meeting—January 7, 1993

The 981st Regular Meeting of the Entomological Society of Washington was called to order by President Russell D. Stewart in the Naturalists' Center of the Natural History Building at 8:00 pm on January 7, 1993. Twenty members and fifteen guests were present. Minutes of the December meeting were read by Program Chairman Chris Dietrich and approved as read.

President Stewart called for annual reports from officers. President Stewart read the names of four applicants for membership: Peter Bilbey, Newton, New Jersey; Brian V. Brown, Los Angeles County Museum, Los Angeles, California; Dan A. Polhemus, Bishop Museum, Honolulu, Hawaii; Robert L. Zuparko, Berkeley, California. He also recognized Dr. Karl Krombein as the new Honorary Member of our society.

President Stewart called for notes or exhibits. Nathan Schiff exhibited specimens of brachypterous scorpionflies (*Boreus brumalis* Feld.) collected in pitfall traps.

Chris Dietrich, Program Chairman, introduced the speaker for the evening, Dr. Wayne Lord, Federal Bureau of Investigation, Quantico, Virginia, whose talk was entitled "Forensic Entomology: The Use of Insects in the Investigation of Violent Crimes." Forensic entomology is the study of patterns of human decomposition with insects as decomposers. This occupation also requires the understanding of the ecology of other decomposers such as bacteria, fungi, other invertebrates, and vertebrates. Dr. Lord described three major patterns of human decomposition. If insects gain access to human tissue it undergoes putrefaction. This process begins when immune processes cease to function, bacteria multiply, and produce gases that attract insects. If the decomposers have no access to human tissue, then study of the environmental conditions becomes important. In a dry environment human tissue is mummified; in a wet environment, tissue is saponified. There are physical, chemical, and climatic barriers that affect decomposers. Physical barriers are usually cultural practices that exclude insect decomposers. Chemical barriers include embalming to prevent decomposition by insects. Climatic barriers include bodies preserved in cold water, snow, or ice.

Saponification of human tissue occurs when fat tissues interact with the wet environment and form a casing called an adipocere. It then becomes important to study the organisms on the surface of the casing. Aquatic plants and invertebrates go through a successional process that gives clues about how long the tissue has been in a particular aquatic habitat. In the marine environment, space is the limiting environmental factor and it becomes most important to study the container of the tissue for coral, algae, barnacles, worms, and molluscs. Mummification is a process by which tissues dehydrate and are well preserved and offers information about the cause of death.

Forensic entomologists examine and study the differential growth rates and community dynamics of insects and other invertebrates that colonize human remains to determine time of death and movement of remains from one place to another. Recently, toxological assays of insects determine the presence of drugs. Blood meals can provide information about the assailants identity as illustrated in a recent paper entitled "Extraction and characterization of human DNA from crab louse blood meals." Since carrion is a patchy, rare resource, insects, such as flies, callophorids, sarcophagids, and, to a lesser extent, muscids, are the first to get to crime scenes and have rapid life cycles. For example, a callophorid life cycle includes 3 larval instars and a puparium. After 72 hours insects are more reliable in estimating the post mortem interval. Tests such as liver mortis, pooling blood, rigor mortis, and body temperature become inaccurate. The age of offspring helps estimate time of death. In addition, since bodies are often moved from one place to another, the insect species may help determine the origin of the body.

Insects first colonize body parts that have been traumatized first, and secondarily, natural body openings. In bodies without trauma, callophorids, with spongy mouthparts, are the first to colonize normal orifices. Since it is necessary to locate the oldest individuals in order to determine time of death and since larvae leave the host to pupate, there is a need to investigate the surrounding environment such as soil, drains, carpets, boxes, under newspapers, bedding material, and piles of laundry.

Our visitors were introduced and the meeting was adjourned at 9:30 pm. President Stewart stated that volunteers are needed to provide refreshments for future meetings. Refreshments for this meeting were provided by Russ Stewart.

M. Alma Solis, *Recording Secretary*

982nd Regular Meeting—February 4, 1993

The 982nd Regular Meeting of the Entomological Society of Washington was called to order by President Russell D. Stewart in the Naturalists' Center of the Natural History Building at 8:00 pm on February 4, 1993. Twenty-one members and three guests were present. Minutes of the January meeting were read by Recording Secretary M. Alma Solis and approved as read.

President Stewart called for reports from officers. Membership Chairman, Ralph Eckerlin, read the names of five applicants for membership: David E. Bowles, Converse, Texas; Fernand Daussin, Clifton, Virginia; Steven L. Keffer, Northern Virginia Community College, Annandale, Virginia; Varuni Mallampalli, Department of Entomology, University of Maryland, College Park, Maryland; D. R. Oliver, CLBRR, Ottawa, Canada.

President Stewart called for notes, exhibitions, or announcements from the members. Bill Bickley announced the death of Harold H. Shepard, a former member of the Society, on January 3, 1993. Manya Stoetzal brought a book she acquired in China entitled *Iconography of Forest Insects in Hunan China* (1992) edited by P. Jianwen and L. Yougiao (ISBN 7-5357-1068-9). She also presented a short travelogue of her recent visit to Beijing, China, for the International Congress of Entomology. Ralph Eckerlin announced the meeting of the Helminthological Society.

President Stewart introduced the speaker for the evening, Dr. Wayne N. Mathis, Department of Entomology, Smithsonian Institution, and Past President of the Society, whose talk was entitled "Shore-Fly Systematics (Diptera: Ephydridae)." Dr. Mathis catalogs, classifies, and conducts systematic research on the world's fauna of this family of 1800 species. He presented an overview of the family, including a "phylogeny" and "key" to previous workers on the family. Dr. Mathis inherited one of the world's largest collections of shore flies, amassed by Willis W. Wirth, a former USDA dipterist at the Smithsonian Institution. Dr. Mathis has produced phylogenetic classifications at all taxonomic levels, but especially at the tribal (i.e. Hecamedini) and generic level (i.e. *Hecamede*) and is presently working on the tribe Gymnomyzini. Tadeusz Zatwarnicki and he are producing a catalog of the shore flies of the world that includes a rearrangement of the tribes within the subfamilies.

Dr. Mathis provided slides of the many diverse habitats of shore flies throughout the world and described some of the more unusual feeding habits. Shore flies occur at high (15,000 ft., Nepal) and low (the Dead Sea) elevations, usually associated with aquatic or semiaquatic habitats. Many species are osmotically tolerant of aquatic conditions with a high saline or alkaline content, such as Great Salt Lake or the effluent of geysers in Yellowstone National Park. Shore flies are more species rich in undisturbed habitats, but are frequently more abundant in harsh environments, such as saline or alkaline lakes or highly polluted habitats. Coastal marine habitats are also exploited, sometimes where wave action directly abrades the coast, although quieter embayments have greater diversity. Oases in deserts have a concentrated and often diverse fauna.

Among the unusual, sometimes bizarre life cycles and behaviors that Dr. Mathis described is the collaborative research that Dr. Amnon Freidberg and he have undertaken on the genus *Rhyncopsilopa,* which is a predator by way of proctophily on ants of the genus *Crematogaster.* This behavior was first reported by Farquharson who noted the ant/fly association in Nigeria. Species of *Gastrops* are predators on frog eggs that are laid in foam nests, especially by leptodactylid frogs. Species of *Discomyza* demonstrate diverse feeding habits. Some are predators on snails, others feed on concentrated organic matter associated with highly polluted habitats. *Hydrellia* is an economically important genus, with the larvae feeding as miners in cereal crops, such as rice. Dr. Mathis concluded his talk with an historical review of the classification of the family.

Visitors were introduced and President Stewart adjourned the meeting at 9:15 pm. Refreshments were provided by Marty Condon.

M. Alma Solis, *Recording Secretary*

983rd Regular Meeting—March 4, 1993

The 983rd Regular Meeting of the Entomological Society of Washington was called to order by President Russell D. Stewart in the Naturalists' Center of the Natural History Building at 8:00 pm on March 4, 1993. Nine members and two guests were present. Minutes of the February meeting were read by Recording Secretary M. Alma Solis and approved as read.

President Stewart called for reports from officers. Membership Chairman, Ralph Eckerlin reported no new members during this month. President Elect Paul Spangler announced that the banquet this year is scheduled for June 3rd in the Associates Court at the National Museum of Natural History. The price will be $22.00 per person with a Cash Bar from 6–7:30 pm. He asked for suggestions for speakers and volunteers for ticket sales. President Stewart also asked for volunteers to bring refreshments for the next meeting.

Program Chairman, Chris Dietrich, introduced the speaker for the evening, Dr. Michael Pogue, Department of Entomology, Smithsonian Institution, whose talk was entitled "Using an Expert System to Compare Cicada Faunas in Two Southeastern Peruvian Rainforest Sites." There are six families of Cicadoidea in the world, four in the neotropics, and two are represented in Peru. Dr. Pogue described the various collecting methods for the cicadas in Tambopata and Pakitza, Peru. Cicadas can be collected at night lights and tahiti torches on paths since they fly 60–100 ft. in the canopy. Some of the smaller species can also be collected in malaise traps and in the fogging samples. Also, he has been working with material collected in the two areas by Terry Erwin and John Heppner during various years. Dr. Pogue brought several drawers of pinned Peruvian cicada specimens for perusal. In addition, Dr. Pogue has even had time to collect over 1000 species of nocturnal Lepidoptera with black lights.

Dr. Pogue is developing a computerized taxonomic identifications system for the cicadas using "Toolbook," a MacIntosh Program. Illustrations are scanned into "Paintbrush" and modified; morphological structures are photographed with a video program; 35 mm slides of the adults are scanned with a slide scanner; descriptions and keys are developed using DELTA. He has also used the data to conduct biodiversity analyses of species richness and species acumulation, and site comparisons.

Visitors were introduced and President Stewart adjourned the meeting at 9:00 pm. Tasty refreshments were provided by Phyllis and Paul Spangler.

M. Alma Solis, *Recording Secretary*

984th Regular Meeting—April 1, 1993

The 984th Regular Meeting of the Entomological Society of Washington was called to order by President Russell D. Stewart in the Naturalist Center, National Museum of Natural History at 8:00 pm on April 1, 1993. Twelve members and five visitors were present. Minutes of the April meeting were read by the Program Chairman Chris Dietrich and approved as read.

President Stewart called for reports from officers. Ralph Eckerlin, Membership Chairman, reported one new member, Conrad C. Labandeira, Department of Paleobiology, Smithsonian Institution. He also distributed membership applications for new members.

President Stewart announced that the May meeting would be held at the Log Lodge, Beltsville, Maryland, and Manya Stoetzal volunteered to bring refreshments.

President Stewart called for notes or exhibits. Manya Stoetzal showed slides and described the biology of two phylloxerans she collected in Japan: the female of *Aphanostigma ulmifoliae* Aoki on *Ulmus davidiana* var. *japonica* from Napporo, and *Moritziella cataneivora* Miyazaki on *Castanea crenata* from Iwama.

Chris Dietrich, Program Chairman, introduced the speaker for the evening, Dr. Gordon R. Pratt, Department of Entomology and Applied Ecology, University of Delaware, Newark, whose talk was entitled "Sympatric Divergence in a Western Butterfly Genus: *Euphilotes*." Dr. Pratt pointed out that examples of sympatric speciation are rare in butterflies. But *Euphilotes* has major characteristics that are common to species with known sympatric speciation. They are univoltine, specifically feed on flowers and seeds, and are highly synchronized with characteristics of the host plant, *Eriogonum* (Polygonaceae) or wild buckwheat. His study included a morphological and allozyme study of the species to develop a genetic distance tree. He also collected larvae in order to ascertain the exact host plant. Larval morphology is modified by the association with ants and selective pressure by parasites. Pupal diapause is correlated to flower blooming and, more importantly, climatic variables. He found *Euphilotes* diverged sympatrically based primarily on climatic effects.

Our visitors were introduced and the meeting was adjourned at 9:30 pm by President Stewart. After the meeting refreshments were provided by Carl Harlin.

M. Alma Solis, *Recording Secretary*

985th Regular Meeting—May 6, 1993

The 985th Regular Meeting of the Entomological Society of Washington was called to order by President Russell D. Stewart in the Log Lodge, Beltsville, Maryland, at 8:00 pm on May 6, 1993. Sixteen members and eight visitors were present. Minutes of the April meeting were read by the Recording Secretary M. Alma Solis and approved as read.

President Stewart called for reports from officers. Ralph Eckerlin, Membership Chairman, reported two new members, Peter P. Korch, Barnesboro, Pennsylvania and James L. Krysan, Rockville, Maryland. President Elect Paul Spangler announced the banquet to be held June 3rd and tickets were available.

President Stewart called for announcements, notes, or exhibits. Jeffery Stibick announced that the Chesapeake Chapter of ARPE was active and open to all entomologists in the area. Nathan Schiff brought a specimen of *Xiphydria maculata* Say collected at Blandy Experimental Farm, a sawfly that usually attacks live maple trees, is rare in collections, and doesn't often fly into malaise traps. John H. Fales reported two butterflies that were the first spring records: the rare Carolina Satyr (*Hermeuptychia sosybius* (F.)) was found at Indian Head, Charles County, Maryland, on June 7–8, 1992 and the Cloudless Sulphur (*Phoebus sennae eubule* (L.)) was found at Plum Point, Calvert County, Maryland, May 21, 1992. A specimen of the rare dimorphic female of this species was seen closely on August 28. The Monarch Butterfly (*Danaus plexippus* (L.)) was scarce in southern Maryland in 1992. A female with a short left forewing (49 mm) and a normal right wing (59 mm) was exhibited. R. J. Gagné showed color slides of burgeoning flower buds of *Rhododendron nudiflorum,* a deciduous native azalea, found in Beltsville on April 30, 1993 and infested by larvae of a gall midge (Diptera: Cecidomyiidae) that is probably a new species. He had been collecting a known bud gallmaker to send to a colleague in Italy for spermatogenesis research and accidentally noticed the previously unrecorded flower damage. Flower heads each contained up to 75 larvae that crawled freely among the developing flowers. The larvae when noticed were full grown and already beginning to crawl out of the heads to drop to the ground, where they will remain until they pupate next spring. Larvae deposited on damp peat moss in the laboratory immediately burrowed into the substrate and formed coccoons. Within several days after the initial discovery, the infested flowers had succumbed to secondary bacterial or fungus decay and did not develop further. Fully developed flowers were subsequently very sparse in the woods where the gall midges were found.

Chris Dietrich, Program Chairman introduced the speaker for the evening, Dr. F. Christian Thompson, Systematic Entomology Laboratory, USDA, whose talk was entitled "The Biodiversity Scene, Where Are We and Where Are We Going, An Update for Entomological Systematics." Dr. Thompson defined biodiversity as a property of life unique to all levels of organization, from genes to ecosystems. As an entomologist he sees diversity in terms of flies, so he had a simultaneous slide show of flies. He discussed the significance of biodiversity as being essential for the welfare of man and the world. He cited recent books (e.g. E. O. Wilson), articles (e.g. Quentin Wheeler), and presentations (e.g. Tom Eisner) by various entomologists on biodiversity. The politics of biodiversity was expressed as "competing agendae" from the viewpoints of conservation, science, ecology, systematics, and competition for limited monetary resources. At the national level there are bills being proposed in Congress to conduct biodiversity studies such as The National Biological Diversity Conservation and Environment Research Act and the creation of the U.S. National Biological Survey. At the international level global change and sustainable development are important aspects of biodiversity, but the legislative and monetary realities emerging from governments and international agencies still remains to be seen.

This concern for exploring the earth's biodiversity means opportunities for entomologists because arthropods are the most diverse group of organisms known and a keystone taxon. For ecologists the Sustainable Biosphere Initiative and "Genes to Ecosystems" report to IUBS (Internationl Union of Biological Sciences) has established a scientific agenda and set priorities. The effort on the part of systematists has begun with Systematics Agenda 2000: Integrating Biological Diversity and Societal Needs. The scientific agenda for systematists consists of enumeration or estimation and the selection of sites and taxa. The methods and criteria for such studies are hotbeds of controversy. For example, should biodiversity of a site be measured in terms of ecological gradients or amount of endemism or speciation? It is the opinion of many that systematists should select a few sites to concentrate their resources and money and there should be an All Taxa Biodiversity Inventory (ATBI). Finally, he pointed out that everyone can participate in some form or another in the study of biodiversity in various forms and scales such as biodiversity studies in the state of Maryland (Maryland Insect Survey), in handbooks, and in peoples' gardens. There was a lively question and answer period and discussion afterwards.

Our visitors were introduced and the meeting was adjourned at 10:45 pm. After the meeting refreshments were provided by Manya Stoetzal.

M. Alma Solis, *Recording Secretary*

986th Regular Meeting—June 3, 1993

The 986th Regular Meeting was held at a banquet with the Maryland Entomological Society at the Associates Court at the National Museum of Natural History, 10th & Constitution, Washington, D.C. Over eighty people attended. M. Alma Solis was Mistress of Ceremonies. The speaker for the evening was Dr. Dale Habeck, Dept. of Entomology and Nematology, University of Florida who spoke on "Entomophily Expressed Philatelically & Deltiologically." The banquet was adjourned at 9:45.

M. Alma Solis, *Recording Secretary*

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld. 124 pp. 1959	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld. 35 pp. 1960	3.00
Both papers on cynipid galls	6.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver. 25 pp. 1951	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney. 15 pp. 1976	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal. 35 pp. 1977	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal. 61 pp. 1979	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff. 85 pp. 1990	10.00

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
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00

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.

CONTENTS

(*Continued from front cover*)

YASUNAGA, TOMOHIDE—Neotype designation for *Adelphocoris variabilis* (Uhler) (Heteroptera, Miridae) 603

WHITCOMB, ROBERT F. and ANDREW L. HICKS—*Flexarida chaotica,* new genus and species of leafhopper (Homoptera: Cicadellidae) from the American Southwest 605

WIRTH, WILLIS W. and GUSTAVO R. SPINELLI—The North American species of the *Forcipomyia* (*Lepidohelea*) *bicolor* subgroup (Diptera: Ceratopogonidae) 611

WOODLEY, NORMAN E.—*Napemyia* Webb, a new synonym of *Dialysis* Walker (Diptera: Xylophagidae) 635

NOTES

ECKERLIN, RALPH P. and HARRY F. PAINTER—The star-nosed mole, *Condylura cristata,* a new host for *Leptinus orientamericanus* (Coleoptera: Leptinidae) in Virginia 639

PALMER, W. A.—A note on the host specificity of the mirid *Slaterocoris pallipes* (Knight) .. 640

PEMBERTON, ROBERT W.—Observations of extrafloral nectar feeding by predaceous and fungivorous mites 642

BOOK REVIEWS

GAGNÉ, RAYMOND J.—*Flycatcher. Memoirs of an Amateur Entomologist* 644

HRIBAR, LAWRENCE J.—*The Biology of Mosquitoes, Volume 1. Development, Nutrition, and Reproduction* 645

WOODLEY, NORMAN E.—*The Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, Volumes 3 and 4, Hexapoda* 647

SOCIETY MEETINGS 649

TABLE OF CONTENTS, VOLUME 95 655