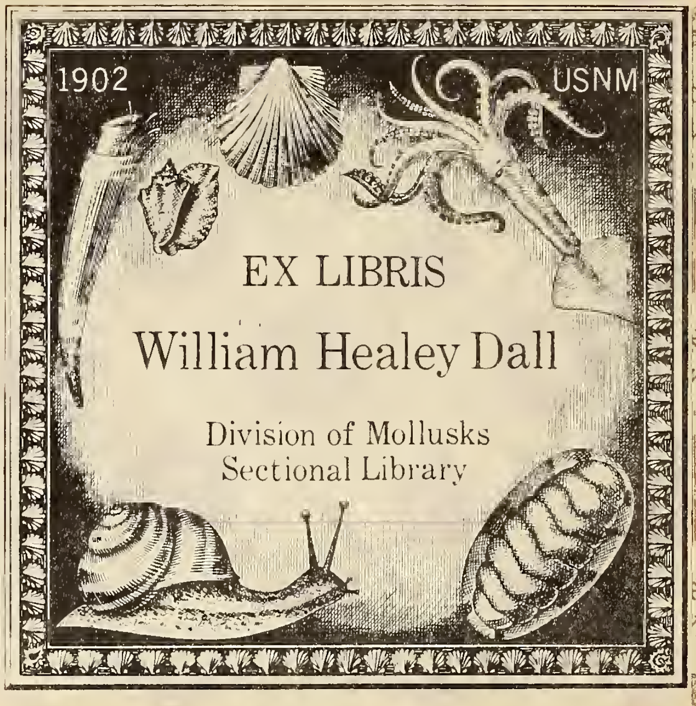
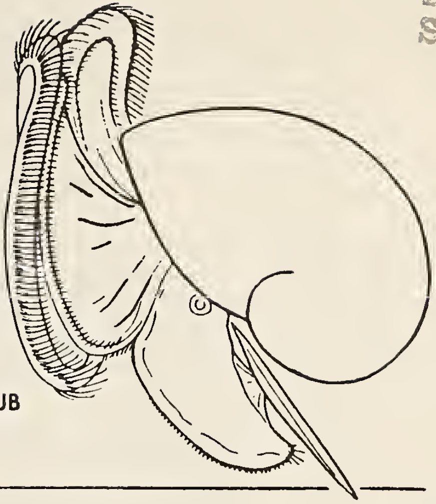


THE VELIGER

A Quarterly published by
NORTHERN CALIFORNIA MALACOZOOLOGICAL CLUB
Berkeley, California



Volume 4

July 1, 1961 to April 1, 1962

Foreword to Volume Four

Practically everything said in the Foreword to the two preceding volumes could be repeated, word for word, except, perhaps, that we must admit that our hopes of a brighter financial picture at the end of this year did not materialize. Of course, we realize that we are to blame for this ourselves, because we have continued experimenting with the format and have added new features. We think that it was worth the effort. Possibly we will be accused of being conceited, but nevertheless we are proud of the growth of The Veliger.

As before, we have enjoyed the wholehearted cooperation of many individuals who have, without exception, gone beyond the call of duty to assist us in our efforts to make this a better journal. The extremely time-consuming job of typing the copy was again performed skillfully by Mrs. Heidi S. Norskog. Mrs. Emily Reid has donated uncounted hours for the excellent art work reproduced in these pages. The letterpress work again was contributed by your editor in his "spare time", and his family deserves recognition for bearing with the absences for many extra hours as well as for patience with the delay caused by this activity in performing the handyman tasks around the house. Also, the special care given to the production by the employees of the Printing Department deserves a word of praise; if we mention just a few by name, it is not to neglect the others who should be included also: Earl Gustafson, Charles Peckham, Louis Rengel, and John Schoen.

Perhaps the most striking advance we have made this year was the addition of color plates. This was possible, in part, because of the generosity of certain individuals who contributed toward the cost of the experiment. But the extraordinary detail shown in the reproductions is due solely to the unusual skill and devoted care of Dr. and Mrs. G Dallas Hanna and Mr. Maurice Giles who have produced these plates for us as an accommodation and on an experimental basis. To them we wish to extend a special word of thanks.

One step forward, we think, will be overlooked by most. That step is the reduction in the number of typographical errors that still pass the watchful eye of the editor. This improvement is due entirely to the extreme care given the reading of the copy by Mrs. Jean Cate and to her goes our appreciation. The index has again been under the continued care of Dr. Phyllis Kutsky.

And as before, there are many other persons who have contributed, in one way or another, to the current volume. Among these are the members of the Editorial Board, the Officers and Members of the Northern California Malacozoological Club, as well as many others, too numerous to be listed by name. To all, named and unnamed, go the continued thanks of

Your Editor.

Berkeley, California, April 1, 1962.

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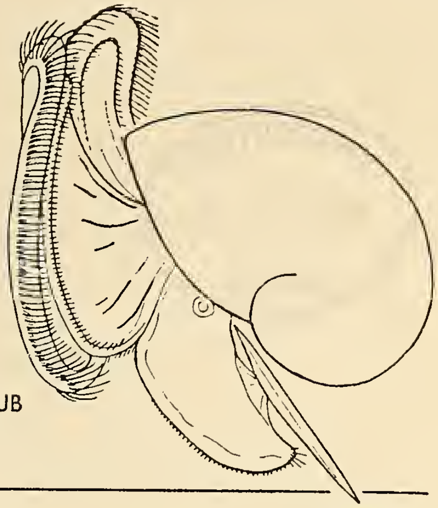
THE VELIGER



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VOLUME 4 JULY 1, 1961 NUMBER 1

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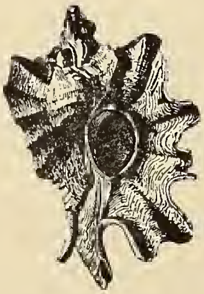


The Genus *Bankia* Gray (Pelecypoda) in the Oligocene of Washington

by

J. Wyatt Durham and Victor A. Zullo

Museum of Paleontology, University of California, Berkeley 4, California

A contribution from the University of California Museum of Paleontology, Berkeley, California

(3 Textfigures)

The family Teredinidae, including the genera Teredo Linnaeus and Bankia Gray, is a diverse and widely distributed group in Recent seas. However, the number of fossil species that have been described are relatively few, even though the genus Teredo is known from deposits as old as Jurassic and the genus Bankia is recorded from deposits of Paleocene age. The teredinids are not uncommon in the fossil record, but their presence is usually indicated only by burrows with calcareous linings in fossil wood, rather than by the shell or pallets. To separate Teredo from Bankia it is necessary to examine the siphonal pallets. These pallets, which seal the aperture of the burrow in case of need, consist of a calcareous stalk and blade and are covered by periostracum. In the genus Bankia the blade of the pallet is composed of a series of nested cones. In comparison the blade of the pallet of Teredo is entire. Previously, the ornamentation and shape of the shell have been used to delimit living and fossil species, but these features have been shown to be environmentally controlled and not constant for a species. More recently (i.e., Clench and Turner, 1946), the character of the periostracum covering the siphonal pallets has been considered significant at the specific level, but the periostracum is not readily preserved, and, consequently, fossil species must be defined on other characters. The morphology of the calcareous parts of the siphonal pallets appears to be of some value in specific determination, but detailed illustrations of this part of the pallet are seldom available, even for Recent species. Therefore, it is with some reservation that the following species is described. However, as this discovery represents, insofar as is known, the only fossil record of the genus Bankia in the eastern Pacific, and as the specimens are not readily comparable with any known species, Recent or fossil, the description of this species appears justified.

Several shells and pallets of this new species of Bankia were collected from the middle Oligocene Lincoln formation near Porter, Washington. The specimens are preserved in unfilled burrows in a fragment of wood (Morus ?) embedded in a concretion about 160 mm. long and 90 mm. wide. Most of the material is coated to varying degrees with calcite, but the details of one pallet are exceptionally well preserved (text fig. 1). This new species is described as follows:

Family TEREDINIDAE Latreille, 1825

Genus *Bankia* Gray, 1840

Bankia lincolnensis Durham & Zullo, spec. nov.

(Figures 1, 2, and 3)

Description: Shell similar to that of other species of the genus Bankia, equivalve, strongly convex, gaping widely anteriorly; exterior of shell not visible; interior of shell covered with thin coating of calcite; lobe a little more than one-third length of anterior margin of disc; auricle placed centrally on posterior margin of disc, not produced posteriorly; apophysis flattened dorsoventrally, extending ventrally beyond center of shell; pallets consisting of series of closely-spaced cones; calcareous part of each cone funnel-shaped, semi-circular in cross-section, with inner margin higher than outer margin; inner margin nearly straight; outer margin slightly concave on either side of low, median convexity; lateral edges of calcareous part of each cone produced into long, narrow, vertically extended "awns"; stalk of pallet long, length about five times width of proximal cone, circular in outline.

Dimensions: Holotype UCMP no. 34'672; length of burrow 56 mm.; maximum width of burrow 6 mm.; width of distal cone of pallet 2 mm. Paratype UCMP no. 34'675; height of shell 5 mm.; length of shell 5 mm.

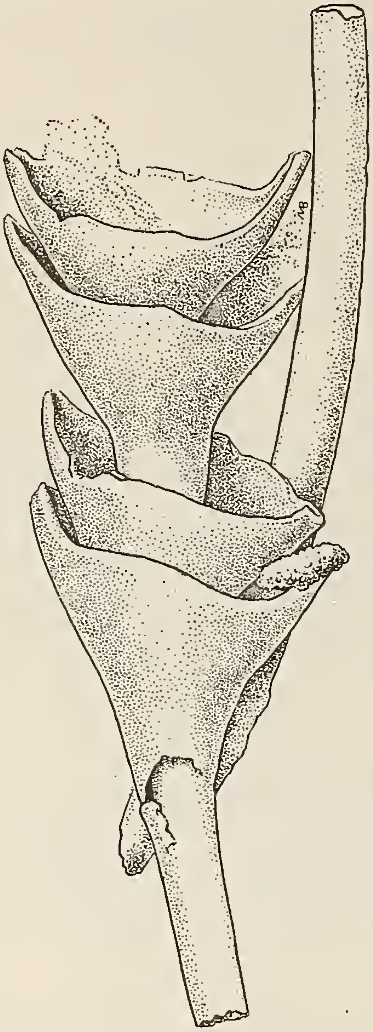


Fig. 1. *Bankia lincolnensis* Durham & Zullo, spec. nov.
Holotype, UCMP no. 34672, x 9.6
outer view of incomplete pallet (secondary deposits of calcite only partially indicated).

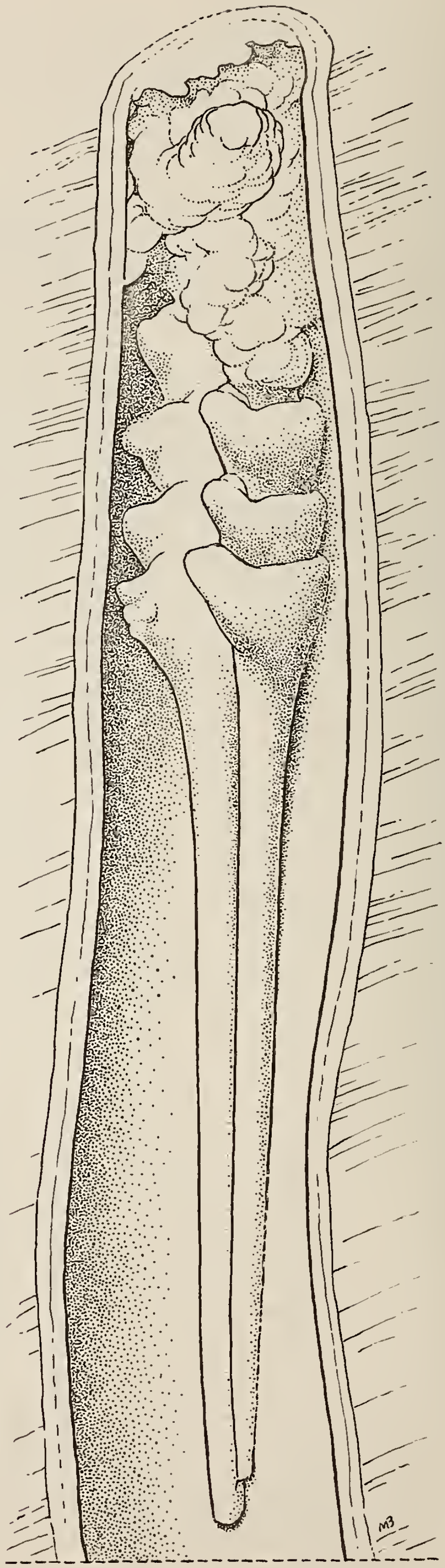


Fig. 2. *Bankia lincolnensis* Durham & Zullo, spec. nov.
Paratype, UCMP no. 34673, x 19.2
paired pallets heavily coated with secondary deposits.

Holotype: University of California, Museum of Paleontology no. 34'672.

Paratypes: University of California, Museum of Paleontology nos. 34'673, 34'674, 34'675.

The specific name "lincolnensis" is derived from the Lincoln formation in which the specimens occurred.

Occurrence: University of California, Museum of Paleontology locality A-8724, middle Oligocene Lincoln formation, "type Porter" locality. Southeast quarter of the northeast quarter of Section 28, T. 17 N., R. 5 W. Twenty-foot stratigraphic interval along cliffs on northeast side of State Highway 9 for a distance of one-half mile immediately southeast of Porter Creek.

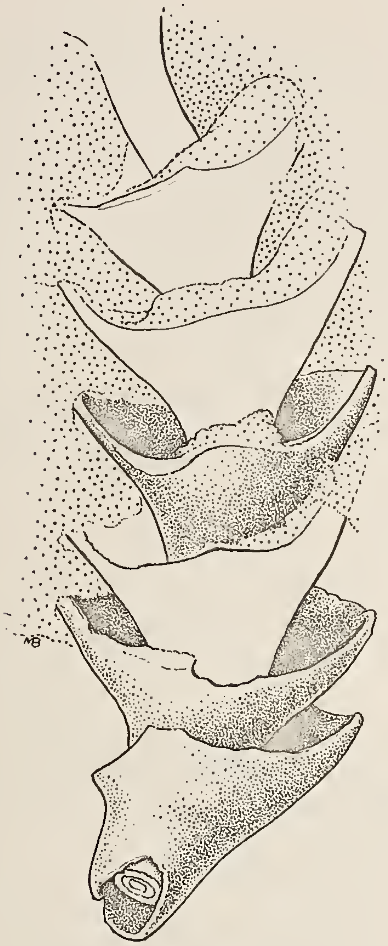


Fig. 3. *Bankia lincolnensis* Durham & Zullo, spec. nov. Paratype, UCMP no. 34674, x 9.6 outer view of series of cones partially embedded in matrix.

Discussion: The pallets were compared with those of 1) the Recent eastern Pacific species Bankia setacea (Tryon) and B. zeteki Bartsch; 2) the Recent western Atlantic species (after Clench and Turner, 1946) B. gouldi Bartsch, B. caribbea Clench and Turner, B. katherinae Clench and Turner, B. destructa Clench and Turner, B. fimbriatula Moll and Roch, B. fosteri Clench and Turner, and B. cieba Clench and Turner; 3) the Recent western Pacific species B. australis Calman and B. debenhami Iredale, and the New Zealand Oligocene species B. turneri Powell and Bartrum; and 4) the European fossils figured by Moll (1942, pl. 24).

The vertically projected "awns" developed on the calcareous part of the cone of the pallet serve to distinguish Bankia lincolnensis from the above mentioned species. Bankia lincolnensis most closely resembles species of the subgenus Neobankia Bartsch in the character of the pallets.

Teredid borings have been reported (as Teredo sp.) from both Cretaceous and Tertiary formations on the Pacific Coast of North America including the following: Cretaceous, Santa Ana Mountains, Southern California (Packard, 1916, p. 147); Paleocene, Martinez formation, California (Dickerson, 1911, p. 173; 1914a, pp. 73, 78, 82, 86, 101; 1914b, p. 295); Paleocene, Meganos formation, California (Clark and Woodford, 1927, p. 103); late Eocene, Tejon formation, California (Dickerson, 1916); late Eocene, Cowlitz formation, Washington (Weaver, 1916, p. 24); Oligocene, San Lorenzo formation, California (Clark, 1918, p. 162); middle Oligocene, "Porter", Washington (Van Winkle, 1918, p. 77); middle Oligocene, Vancouver Island, British Columbia (Merriam, 1896, p. 104); early Miocene, Vaqueros formation, California (Loel and Corey, 1932, p. 234); early Miocene, Sooke formation, Vancouver Island, British Columbia (Clark and Arnold, 1923, p. 156); late Miocene, "Santa Margarita" formation, California (Nomland, 1917, p. 302). Personal observation indicates that fossil teredinids are more common on the Pacific Coast than is indicated by the records listed above, but they have largely been ignored.

Literature Cited

Clark, B. L.

1918. The San Lorenzo series of middle California. Univ. Calif. Publ. Bull. Dept. Geol., vol. 11, pp. 45-234, textfigs. 1-4, pls. 3-24.

Clark, B. L., & R. Arnold

1923. Fauna of the Sook Formation, Vancouver Island. Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 14, pp. 123-234, pls. 15-42.

Clark, B. L., & A. O. Woodford

1927. The geology and paleontology of the type section of the Meganos formation (lower middle Eocene) of California. Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 17, pp. 63-142, pls. 14-22, 1 map.

Clench, W. J., & R. D. Turner

1946. The genus Bankia in the western Atlantic. Johnsonia, vol. 2, no. 19, pp. 1-28, pls. 1-16.

Dickerson, R. E.

1911. The stratigraphic and faunal relations of the Martinez formation to the Chico and Tejon north of Mount Diablo. Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 171-177.

——, ——

1914a. Fauna of the Martinez Eocene of California. Univ. Calif. Publ. Bull. Dept. Geol., vol. 8, pp. 61-180, pls. 6-18.

——, ——

1914b. The Martinez Eocene and associated formations at Rock Creek on the western border of the Mohave Desert area. Univ. Calif. Publ. Bull. Dept. Geol., vol. 8, pp. 289-298, textfig. 1.

——, ——

1916. Stratigraphy and fauna of the Tejon Eocene of California. Univ. Calif. Publ. Bull. Dept. Geol., vol. 9, pp. 363-524, pls. 36-46.

Loel, W., & W. H. Corey

1932. The Vaqueros formation, lower Miocene of California. 1. Paleontology. Univ. Calif. Publ. Dept. Geol. Sci., vol. 22, pp. 31-410, pls. 4-65, 2 maps.

Merriam, J. C.
1896. Note on two Tertiary faunas from the rocks of the southern coast of Vancouver Island. Univ. Calif. Bull. Dept. Geol., vol. 2, pp. 101-108.
Moll, F.
1942. Die fossilen Terediniden und ihre Beziehung zu den rezenten Arten. Paleontographica, Bd. 94, Abt. A, Lief. 3-6, pp. 134-153, pls. 24-26.
Nomland, J. O.
1917. Fauna of the Santa Margarita beds in the north Coalinga region of California. Univ. Calif. Publ. Bull. Dept. Geol., vol. 10, pp. 293-326, textfigs. 1-2, pls. 14-20.
Packard, E. L.
1916. Faunal studies in the Cretaceous of the Santa Ana Mountains of Southern California. Univ. Calif. Publ. Bull. Dept. Geol., vol. 9, pp. 137-159, 1 map.
Van Winkle, K. E. H.
1918. Paleontology of the Oligocene of the Chehalis Valley, Washington. Univ. Washington Publ. Geol., vol. 1, pp. 69-97, pls. 6-7.
Weaver, C. E.
1916. Tertiary faunal horizons of western Washington. Univ. Washington Publ. Geol., vol. 1, pp. 1-67, pls. 1-5.

A New *Vexillum* (Mitridae) from the Philippine Islands

by

JEAN M. CATE

Conchological Club of Southern California, Los Angeles 7, California

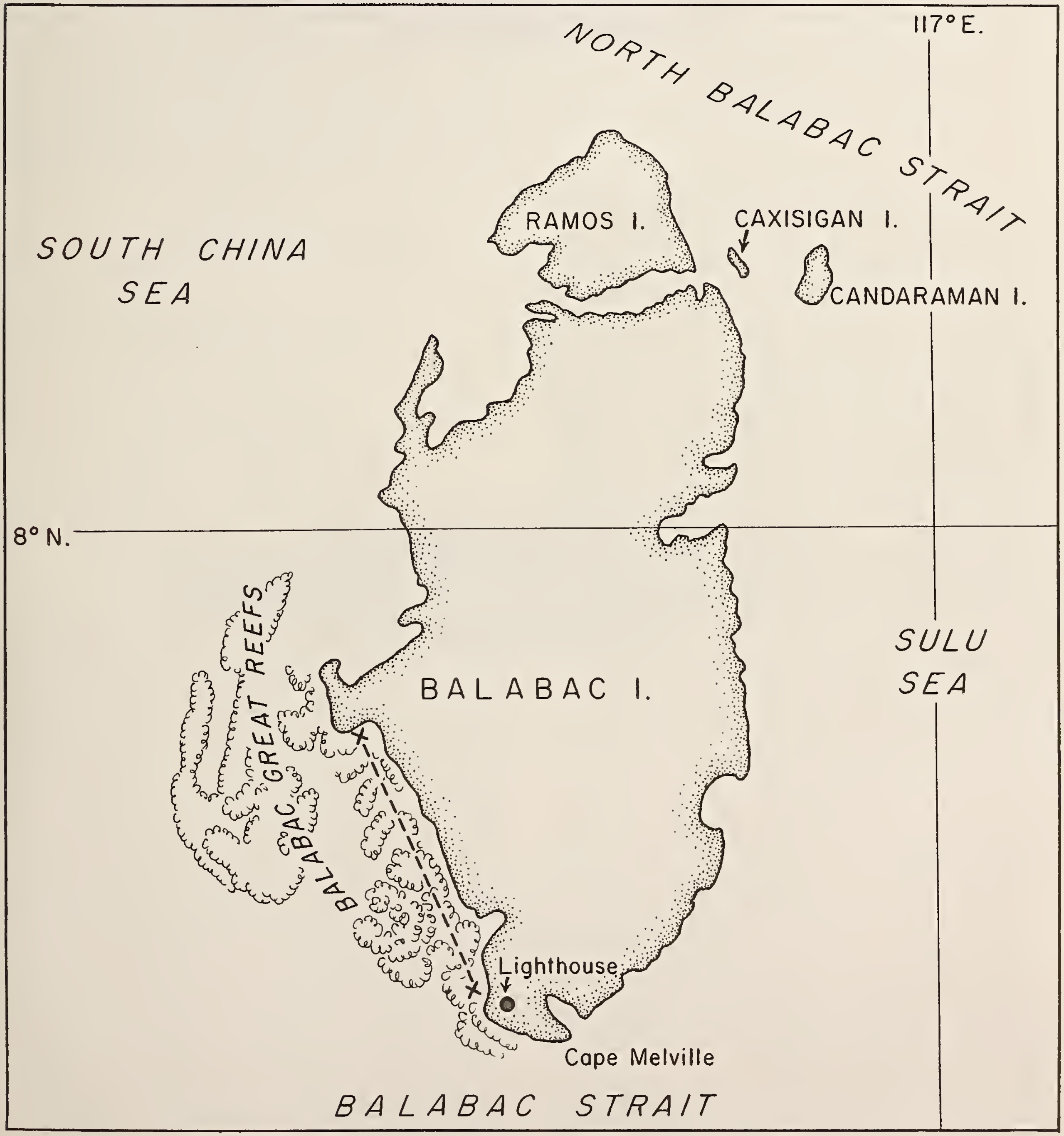
(Plates 1 and 2 and one Textfigure)

About a year ago I received a shipment of Mitra species from various parts of the Philippine Archipelago; among these was a specimen from Balabac Island labelled Vexillum regina (Sowerby, 1825) which aroused my curiosity because its color seemed to differ from that of other specimens I had seen. Further investigation brought out that there were several additional differences between this specimen and the typical V. regina: first, it was not sharply shouldered; further, the surface sculpture was far less coarse than in Sowerby's original figure of V. regina, and the color pattern was arranged in a different manner. In the course of working out a solution as to what this species might be, additional problems arose involving other closely related species; these, however, will be dealt with in a subsequent paper.

A careful search through all the known monographs and many other papers on Mitridae failed to turn up anything resembling the Balabac species. It therefore seemed likely that this was an undescribed taxon, but as nearly 100 years had passed since the last comprehensive monograph had been compiled for the family Mitridae, this was not an adequate basis for describing a new species. Consequently, in addition to perusal of all available literature, as thorough a search as possible was made among many of the larger museums and private collections to make certain that this species was indeed new and hitherto undescribed. This search turned up two specimens, also labelled Vexillum regina (Sowerby, 1825), which match my specimen fairly closely; both are from private collections and were collected in the southern Philippines.

Wherever it was not possible to visit collections personally, Ektachrome color transparencies of the dorsal and ventral aspects ($\frac{2}{3}$ actual size) were submitted for comparison with other collections; without exception these transparencies were returned promptly and with a notation to the effect that nothing similar existed in that particular collection. Most of the responses stated that it superficially resembled Vexillum regina (Sowerby, 1825). Regrettably, due to a change in personnel taking place at the time of this search, the Mollusca Section of the British Museum (Natural History) was not able to compare the photographs with the specimens in its collection; it is felt, however, that the remaining institutional and private collections which participated represent a good cross-section of the material available in this Vexillum complex. For the prompt and courteous response so willingly given in all instances, I wish to express my gratitude to the following persons and institutions cooperating: Dr. William J. Clench and Dr. Ruth D. Turner, Museum of Comparative Zoology, Harvard University; Dr. Alan Solem, Chicago Natural History Museum; Mr. William Old, Jr., New York Museum of Natural History; Dr. Myra Keen, Stanford University; Dr. Leo G. Hertlein, California Academy of Sciences; Dr. Joseph Rosewater, U. S. National Museum; Dr. Robert Robertson, Academy of Natural Sciences of Philadelphia; Mr. and Mrs. E. P. Chace, San Diego Museum of Natural History; Mr. George Kanakoff and Miss Joan Troesch, Los Angeles County Museum; Mr. Fernando Dayrit, National Museum, Manila; Mr. and Mrs. John Q. Burch; Mr. and Mrs. F. K. Hadley; Mr. Anthony d'Attilio; Mr. James Bailey; Mrs. Mary Saul; Mrs. Z. W. Craine; Dr. Howard R. Hill; Mr. Ditlev Thaanum, and Mr. E. W. Ulrich.

With the likelihood established that a new species was involved, further correspondence was indicated in order to obtain as much ecological information as possible. Mr. Fernando Dayrit of Manila, who sent the original shipment of shells containing the specimen in question, has kindly furnished from his personal experiences and observations much additional information pertaining to the Balabac region.



The island of Balabac (see map), just north of Borneo, is very sparsely populated by a tribe known as Melebuganon Moros, numbering altogether not over 2,000 individuals. These people differ from the less isolated and better-known Moros of the Sulu Archipelago in several ways: they live in shacks at the edge of the forest instead of in stilt-houses built high above the water; they confine themselves to the relatively small area of Balabac, seldom venturing away from the island, whereas the Moros of the Sulu Sea islands are more inclined to be seafarers. The Melebuganons prefer dry land under all circumstances to any contact with water; therefore they do no diving of any sort and the shells they collect for food or for barter are always taken at low tide in water no more than knee-deep.

The favorite and most profitable collecting locality for shells at Balabac is a small beach to the northwest of the lighthouse at Cape Melville; the shell of the new species was collected here on the reef, on the patches of sand between coral heads. Fringing coral reefs border the shoreline at this point, and at low tide a wide area is exposed, giving easy access to the reef-dwelling mollusks. Offshore, in the Balabac Strait which separates the island from British North Borneo, there is a swift current, particularly during the change of tides, making navigation especially hazardous in view of the submerged coral reefs. It is quite possible that this condition is responsible for the natives' reluctance to venture further afield, especially when one realizes the nearest land was until recently inhabited by the head-hunting savages of North Borneo. On the other hand, a personal letter from Mrs. Mary Saul of Kudat, North Borneo (January 1961) states that the more adventureous natives of her country frequently cross the Balabac Strait (a distance of only a few miles) and collect shells — quite possibly on this same beach at Cape Melville. For about six months Mrs. Saul has been watching for additional specimens of the new species among the material brought in by her collectors for barter at Kudat, but to date she has not seen a shell similar to the one discussed here.

The shallow coral reefs and warm tropical water at Cape Melville furnish a suitable environment for many molluscan species. Among these Mr. Dayrit mentions the following: Conus nobilis Linnaeus, 1758 ("seems to be found only in this area"), C. stramineus Lamarck, 1811, C. pica Adams & Reeve, 1848, C. nocturnus Solander, 1786, C. omaria Bruguière, 1792; Polinices fluctuatus (Sowerby, 1825); Rhinoclavus fasciatus (Bruguière, 1792); assorted Terebras and many others. Mitra species also found living on this reef include M. tigrina A. Adams, 1851, M. dactylus Lamarck, 1811, M. stigmataria Lamarck, 1811, M. episcopalis (Linnaeus) Gmelin, 1790, M. papalis (Linnaeus) Petiver, 1767, M. pontificalis Lamarck, 1811, M. puncticulata Lamarck, 1811, M. filaris (Linnaeus, 1771), Vexillum plicarium (Linnaeus, 1758), V. corrugatum (Lamarck, 1811), and V. vulpecula (Linnaeus, 1758). Vexillum regina (Sowerby, 1825), V. vittatum (Swainson, 1821), and V. taeniatum (Lamarck, 1811) are also mentioned by Mr. Dayrit as coming from Cape Melville, but as there is presently so much confusion regarding their identification, and since they are included in the complex group under consideration in the separate study mentioned above, I believe it unwise to include them in the present faunal list.

Superfamily

VOLUTACEA

Family

MITRIDAE

Subfamily

VEXILLINAE

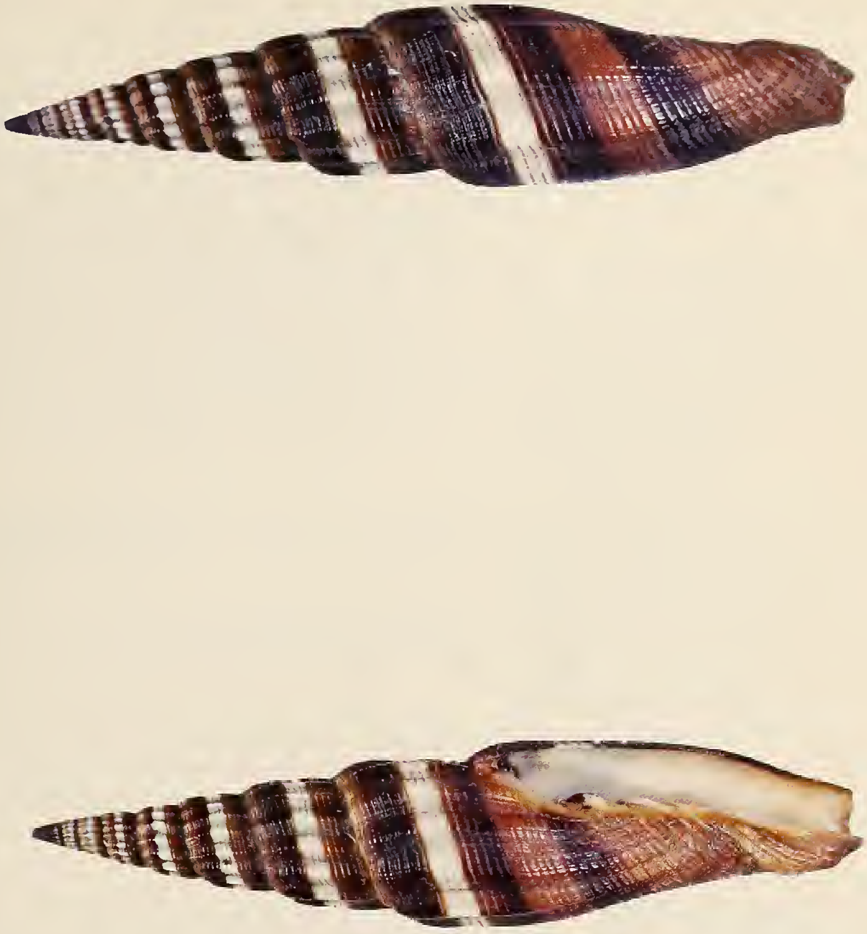
Genus

Vexillum RÖDING, 1798

Vexillum coloscopulus J. CATE, spec. nov.

(Plate 1, Figures 1, 2)

Shell long, straight, slender, fusiform, somewhat turriculate; spire longer than the last whorl. Protoconch lacking; teleoconch consisting of 11 slightly convex abutting whorls; sutures impressed, shoulders rounded. Axial sculpture of low, fairly sharp collabral costae (about 13 on penultimate whorl) which tend to become obsolete near outer lip; costae not regularly aligned between sutures. Spiral ornament of low cords, rounded, crenulated and narrow below the sutures, flattened into slightly wider bands at the periphery, again becoming rounded, narrower and faintly granulose at lower part of neck; all spiral cords separated by smooth, shallow, impressed striae. Aperture straight, siphonal canal slightly recurved; labrum thin, simple, about 12 faint lirae within. Parietal ridge present; columella straight, inductura restricted adaperturally; three strong oblique adapical columellar folds and one faint anterior columellar fold. Peristome discontinuous. Siphonal fasciole weakly produced, helicocone nonumbilicate.



Vexillum coloscopulus J. Cate, spec. nov.

Dorsal and Ventral Aspects of Holotype

Color of holotype dark brick-red (Maerz & Paul Dictionary of Color, 1950 Rev. Edit., Plate 8, L-9, Domingo Brown) with one narrow dirty-white band centrally placed on adapical whorls, bordered on each side by a blackish zone that occupies most of the remainder of each whorl. White band composed of three flat spiral cords separated by narrow, smooth, shallowly incised striae; its bordering black zones, approximately twice as wide, composed of five cords. Color at sutures orange-brown where successive whorls overlap just below the black zone; with two wide brick-red zones, interrupted by an additional black zone, on the neck of the shell; the brick-red of adapical band (M & P, pl. 8, L-9) lightening adaxially to orange-red (M & P, pl. 6, B-12, Gypsy). Final abapical band slightly paler (M & P, pl. 7, L-12, Caldera), also lightening to Gypsy Brown at columella. Color of aperture ivory, darkening slightly toward labrum. Columella and folds yellowish-orange. Animal of the species unknown.

Measurements of holotype: Height, 71.4 mm.; maximum diameter, 15.8 mm.; length of aperture, 34.6 mm.

The type locality of Vexillum coloscopulus is here designated as Cape Melville, Balabac, Philippine Islands (7°30' North Latitude, 117° 00' East Longitude).

The holotype will be deposited in the Geology Department Type Collection, California Academy of Sciences, San Francisco, California, where it will bear the catalog number 12'363.

The specific name is derived from the combination of two Latin words most closely approximating a description of the mollusk's habitat. According to Cassell's Latin Dictionary, 1959 Revised Edition, the Latin word scopulus means "dangerous rocks in the water", or reef; colare means "to dwell"; therefore the combination coloscopulus signifies a reef-dweller. As the word coloscopulus is a masculine noun in apposition, no change in ending can be made.

Comparison of Holotype with Hypotypes: The two similar specimens, kindly loaned for this study, are designated as hypotypes rather than paratypes since they are not from the type locality.

Hypotype 1. (Plate 2, fig. 2) Collection of Mr. and Mrs. John Q. Burch, Los Angeles, California. Locality: Sulu Archipelago.

Hypotype 2. (Plate 2, fig. 3) Collection of Mr. Anthony d'Attilio, Valley Stream, New York. Locality: Zamboanga, Philippine Islands.

Table 1: Measurements of Holotype and Hypotypes (in millimeters)

	Height	Maximum Diameter	Length of Aperture
Holotype	71.4	15.8	34.6
Hypotype 1	68.1	17.6	35.5
Hypotype 2	55.3	15.5	28.9

All three specimens agree very closely in general shape and proportions, the holotype, however, being the most slender. Morphologically they are all very similar, even to being decollate, as are all available specimens of the other species in the complex which includes Vexillum regina.

Hypotype 2 matches the holotype exactly in the distribution of its color pattern, the narrow white band being placed in the center of each whorl and the proportions of each color-zone matching those of the holotype as well. Hypotype 1 has a somewhat more coarse, blurred appearance than either of the other two specimens and is possibly a shell from an older animal; its black zones are better defined as black bands, narrower than in the other two specimens and revealing more of the brick-red color between. In Hypotype 1 the narrow white band is not so centrally placed on the apical whorls; in fact, in the first five whorls this white band abuts the lower suture and no black zone is apparent there. It does approach the central position more closely, however, on the penultimate and antepenultimate whorls, whereas in other species of this complex the white zone is always seen adjoining the sutures abapically. The color of all three specimens differs very little; the holotype is the darkest in color, but it is possible that a certain amount of periostracum remains; it was deemed better not to attempt a further cleaning in order to ascertain whether an epidermis was present. It is likely that further cleaning might render the white band a purer white but would not otherwise change the specimen's appearance materially. Hypotype 2, the smallest of the three shells, is the lightest in color, its reddish bands more nearly approaching a creamy-yellow shade. Both hypotypes possess a heavier labral edge than the holotype, which is generally more delicate in appearance than the others.

Comparison of Vexillum coloscopulus with V. regina (Sowerby, 1825): The following six specimens of Vexillum regina were used in this comparative study, all approximately the same size as the holotype of the new species:

1. Collection of Anthony d'Attilio, New York; locality, Zanzibar
2. Collection of E. W. Ulrich, Long Beach, California; locality, Andaman Islands
3. Collection of James Bailey, Los Angeles, California; locality, China
4. Collection of Los Angeles County Museum, No. A2'777, Los Angeles, California; locality, Moluccas

5 and 6. Collection of Stanford University Paleontology Department, lot No. 1'660; locality, Moluccas

Vexillum coloscopulus and V. regina resemble one another only superficially, upon close inspection. Both species possess spires longer than the last whorl, although this characteristic is somewhat more pronounced in V. regina. Both species possess four columellar folds, arranged in a similar fashion. Otherwise, except for the faintly similar coloration and arrangement of color pattern, the features they possess in common are generic characters and could apply equally to many of the other species of Vexillum; i. e., axial costae, produced spire, spiral ornament, and so on.

Vexillum coloscopulus differs from V. regina (Sowerby, 1825), its most closely related described species, in the following ways, tabulated for easier comparison:

Table 2: Comparison of Characters

Characters compared	*Vexillum regina* (Sowerby)	*Vexillum coloscopulus* spec. nov.
Sutural ramp	angular, gradate	rounded
Axial costae	extremely coarse, elevated	smooth, somewhat flattened
Spiral ornament	coarse, rough	smooth
Spire	turriculate	fusiform
Aperture	constricted	straight
Parietal lip	well defined	lacking
Neck of shell	roughly granulate	nearly smooth
Pseudumbilicus	faintly produced	lacking
Canal	sharply recurved	slightly recurved
Labral lirae	about 3 raised lirae	about 12 faint lirae
Color	bright orange, or blackish	brick-red
White band on last whorl	one wide, one narrow	one narrow band only
White band placement	contiguous to sutures	central on adapical whorls
White band bordered by	narrow black lines	wide black zones
White band ornamentation	central yellow thread	lacking
Aperture color	white	cream to dark ivory

Acknowledgment

I should like to express my sincere appreciation to all those who aided me in so many ways in the preparation of this paper: first, Mr. Fernando Dayrit of Manila, who sent the holotype specimen and provided background information on the ecology of the new species; Dr. Myra Keen, Mr. George Kanakoff, Mr. Tony d'Attilio, Mrs. John Q. Burch, and Mr. E. W. Ulrich for generously allowing me the use of comparative material; Dr. Rudolf Stohler for his unfailing kindness and helpful suggestions, and particularly Crawford Cate for his patience and helpfulness in countless ways.

The map of the type locality was furnished by Mr. Fernando Dayrit and adapted for use as a textfigure by Mrs. Emily Reid of the Veliger staff.

The terminology employed in the description of the new species was derived from the 1960 Treatise on Invertebrate Paleontology, Part I, Mollusca 1, pp. 106-135.

The photographs of Vexillum regina were furnished through the courtesy of Stanford University. All other photographs are by Pierson, Oswald and Pierson. The color reproduction for Plate 1 was done by the California Academy of Sciences from Kodachrome slides.

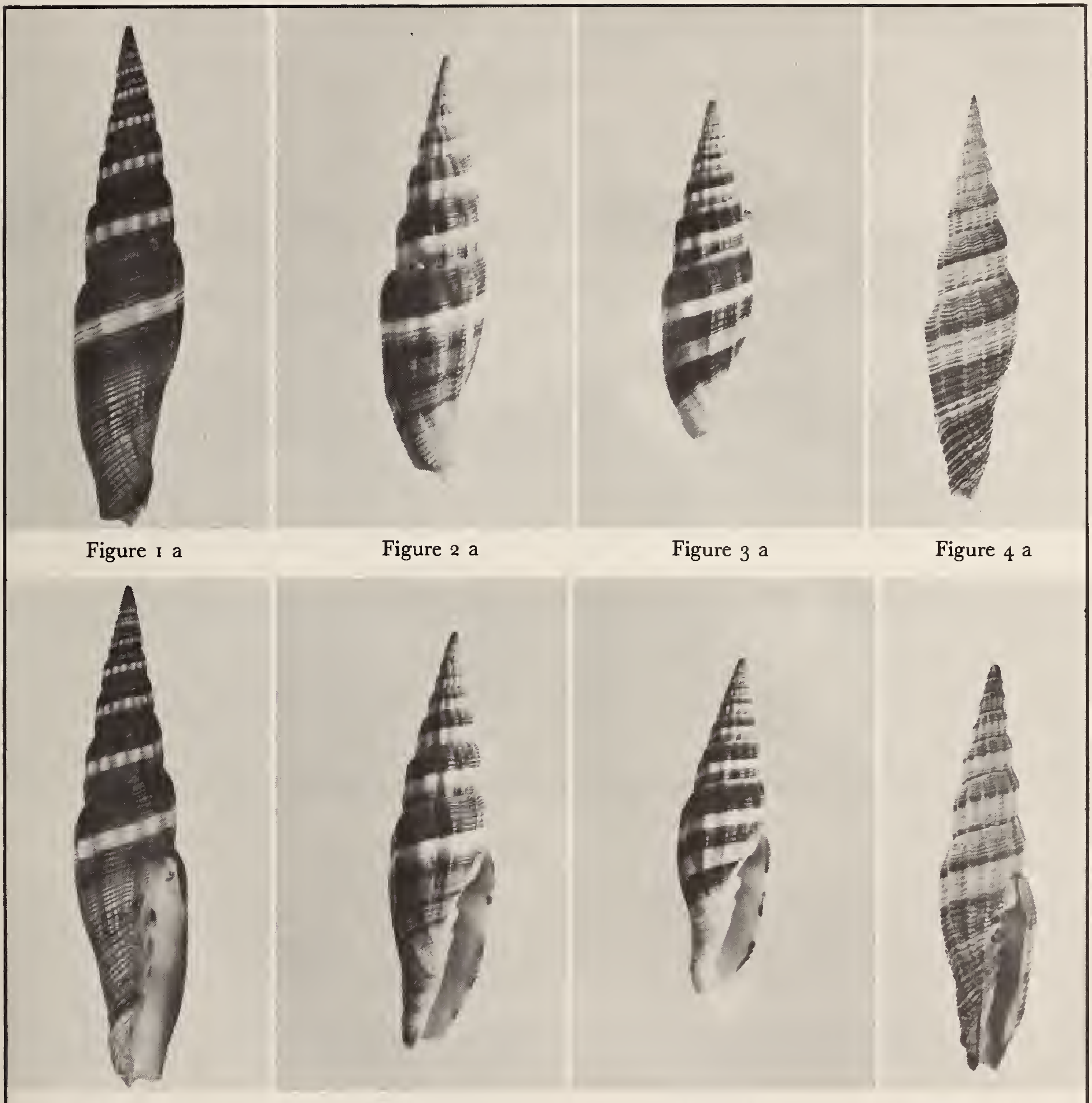


Figure 1 a Figure 2 a Figure 3 a Figure 4 a

Figure 1 b Figure 2 b Figure 3 b Figure 4 b

Figures 1, 2, 3: *Vexillum coloscopulus* J. CATE, spec. nov.
Figure 1: Holotype. Figure 2: Hypotype No. 1. Figure 3: Hypotype No. 2.
Figure 4: *Vexillum regina* (SOWERBY, 1825)
(a: dorsal aspects; b: ventral aspects)

What is *Anatina anatina*?

by

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(Five Textfigures)

The generic name Anatina (literally, pertaining to a duck) has been applied in molluscan literature to two unrelated bivalve groups that look alike because they have a posterior gape surrounded by an extension of the shell shaped a little like a duck's beak. Lamarck used the French equivalent, "Anatine", as early as 1809, but he did not Latinize it until 1818 (Hist. Anim. sans Vertèbres, vol. 5, p. 462). Tautonymy would fix the type species — Solen anatinus Linnaeus, 1758, a nacreous-shelled form related to Periploma. In 1817 Schumacher had proposed the name Anatina for Mactra anatina Spengler, 1802, a mactrid clam with a thin, porcelaneous shell. As tautonymy was frowned upon in those days, Schumacher renamed the species Anatina pellucida and provided an illustration. Some attempt has been made to rescue Lamarck's usage by dating it from 1816, when Bosc cited Anatina Lamarck in proper Latin fashion (Nouvelle Dictionnaire d'Histoire Naturelle, vol. 1, p. 492), but this falls short of validation because the only species mentioned, "le solen canard", is a nomen nudum and also in the vernacular. Even if one could salvage Lamarck's Anatina in this way, one still would find obstacles preventing its use. Röding in 1798 had proposed the name Laternula, which has for type Solen anatinus Linnaeus (by subsequent designation of Gray, 1847). Also, Auriscalpium Megerle von Mühlfeldt, 1811, is based on the same species. Thus, if the name Anatina is to survive at all, it must be as of Schumacher's usage, for a genus in Mactridae. The substitute name Labiosa Müller, 1832 (ex Schmidt MS), has been favored by some authors, a name proposed when Anatina Schumacher was considered homonymous. Letting both uses of Anatina lapse and accepting Labiosa still would not solve the problem of interpreting the type species, for the type of Labiosa necessarily is Mactra anatina Spengler. Let us, therefore, examine this form.

Mactra anatina was briefly described by Spengler thus: "Testa diaphana, transverse striata, vulva hiante, ano planato." There was a longer description in Danish but no figure. The length was stated to be $3\frac{1}{2}$ T, breadth $2\frac{1}{2}$ T. The shell was said to be a rare form, from South America. Fifteen years later, Schumacher, who lived in Denmark, mentioned in the introduction to his Essai (pp. 16-17) that, writing at his residence in the country, he had to rely on his own private collection but that he had opportunity to compare his material with that of Spengler in Copenhagen, especially for such groups as Mactra, on which Spengler had published. The implication is, then, that Schumacher's figure of Anatina pellucida (see fig. 1a-b) illustrates either Spengler's holotype or a shell very much like it. An inquiry addressed to Dr. Henning Lemche brought the reply that Spengler's material still is in Copenhagen, now at the Universitetets Zoologiske Museum. Dr. Lemche (letter dated April 13, 1961) resolves the problem of identifying the holotype by a tracing of the outline of the shell (see fig. 2) and by quoting the label, which he says is in Mörch's handwriting: "M. anatina Spengler/ Anatina pellucida Sch.: 125. VIII, f. 1. Original." The traced outline compares almost exactly in size and shape to the figure given by Schumacher (length, 41 mm.). It is in the pro-

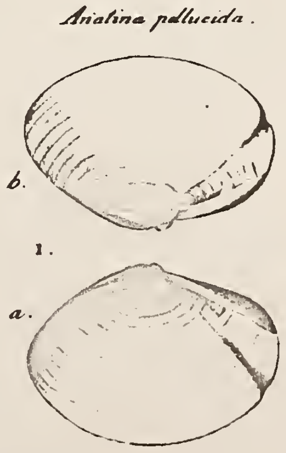


Figure 1: Reproduction of Spengler's original figure of *Anatina pellucida*.

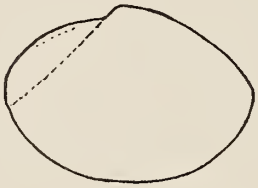


Figure 2: Tracing of outline (courtesy of Dr. H. Lemche) of the holotype of *Anatina anatina* (Spengler). Length, 41 mm.

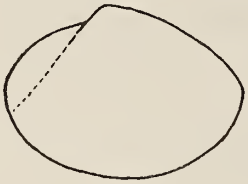


Figure 3: Outline of a shell from Florida of comparable size (Stanford University collection).

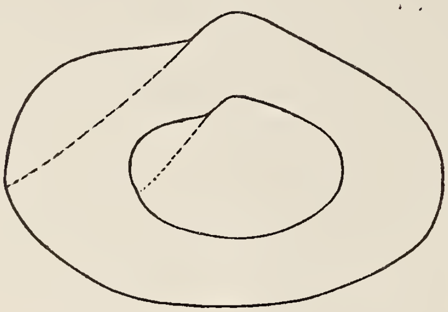


Figure 4 (Inner figure): Outline of right valve, specimen from off Guaymas, Mexico (Stanford University collection). Length, 35 mm.

Figure 5 (Outer figure): Tracing of outline of *Mactra cyprinus*, holotype, as figured by Wilkins, 1957. Length, 70 mm.

portion of $3\frac{1}{2}$ to $2\frac{1}{2}$, and one can thus infer that Spengler's "T" was a measure of length approximately one-half inch long. Spengler's *Mactra anatina* and Schumacher's new name for it seem in the main to have been ignored by other nineteenth century workers. Dall, however, in 1894 (p. 41), without giving evidence for his statement, cited the species as occurring in West Mexico. He listed as synonyms "*Lutraria papyracea* (Lam.) Sowerby, 1824" and *Mactra cyprinus* Wood, 1828. Accepting Dall's identification, I utilized the name *Anatina anatina*, taking as illustration Reeve's excellent figure of Wood's *Mactra cyprinus* (Keen, 1958, p. 159, fig. 363). When first described this latter shell was thought to have come from Peru, but Reeve felt uncertain as to the locality and merely said, "Hab. ---?". It is fortunate that I overlooked a discussion of the Cracherode collection by Wilkins (1957, p. 164), where the holotype of this form was refigured, with the conclusion that it is conspecific with *Labiosa lineata* (Say) and was actually from the Caribbean. The specimen is in the collection of the British Museum (Natural History) (see fig. 5). It had been purchased in 1797 by the Rev. Cracherode (for whom the abalone *Haliotis cracherodii* was named), having formerly come from the Calonne collection. Wilkins concurred in the judgment of previous British Museum curators, such as E. A. Smith, that the differences in outline between this specimen and a normal *L. lineata* were a matter of relative maturity and also the result of an injury that had given this shell an unusually wide gape — in other words, that the degree of difference could be within the range of variation of the species. Wilkins, of course, had no reason to explore synonymic history prior to 1822, the date of Say's name *lineata*.

So long as no authentically-located West American specimens were available, one had no basis for questioning the conclusions of workers like E. A. Smith, Dall, or Wilkins, even though these conclusions were not in complete agreement. The existence of a problem came to light in the summer of 1960 when three fragmentary specimens of an *Anatina* (two unmatched opposite valves and the upper halves of two matched valves) were dredged by the Ariel Cruise at two stations in the Gulf of California — off Cabo Haro, near Guaymas, depth 15-25 fathoms, and off Carmen Island, 15-20 fathoms. These specimens corresponded almost exactly in size and outline with the illustration of *Anatina anatina* in my book, that figure having been reproduced at approximately one-half the size of Reeve's original. We therefore identified the find on the spot as *Anatina anatina*. Later, when I had returned to Stanford and had compared the specimen with Schumacher's figure, I became increasingly perplexed and now feel obliged to raise the question of whether authors have not been in error as to the synonymies for both the Caribbean and the West Coast species of *Anatina*.

Literature aside, a comparison of 14 available East Coast specimens (for a sample outline, see fig. 3), from Florida and Brazil, with the newly-found West American material reveals the following consistent differences:

WEST COAST	EAST COAST
No radial sculpture, except for the rib bounding the siphonal area	Fine radial striae and wrinkles, especially in front of rib
Concentric sculpture weak, fine	Concentric sculpture apparent, coarse
Umbones broad, not pointed	Umbones narrow, pointed
Anterior dorsal margin smooth, even	Anterior dorsal margin flared, set off by a radial depression
Posterior end longer, 53 percent of total length	Posterior end shorter, 47 percent of length
Posterior dorsal margin angular	Posterior dorsal margin curved
Posterior gape wide	Posterior gape moderate
Ventral margin nearly straight	Ventral margin evenly curved
Proportion of height to length, 68 percent	Proportion of height to length, 72 percent

These differences are sufficient to distinguish the two species even if there were no demonstrable geographic separation, being consistent, with little variation among the available specimens. Re-examining the type illustrations one sees that all of the characteristics listed above for the West Coast form are evident in the photograph of the holotype of Mactra cyprinus Wood published by Wilkins. The only real difference between this specimen and the Gulf of California material (see fig. 4, inner outline) is in size, for Wood's specimen is about twice as long as the others which possibly may be juveniles. To my mind, this is good evidence that Wood's specimen came from the West Coast. Whether it was actually from Peru remains to be seen, but surely it must have been from the Panamic province. Support for this argument came while the present paper was in preparation: Olsson (1961) figures a single somewhat broken valve he had collected at Santa Elena, Ecuador. It is 42 mm. long, thus slightly larger than the specimens from the Gulf of California. It exhibits all of the "West Coast" characteristics listed above.

Schumacher's illustration does not show the exterior sculpture, but otherwise all the characteristics cited under "East Coast" above apply to this shell. I would therefore suggest that the following revised synonymy be considered. It represents, of course, a radical departure from established convention. It is offered with a query, in the hope of stimulating further investigations.

Anatina anatina (Spengler, 1802)

Mactra anatina Spengler. Skrifter af Naturh.-Selsk., Bd. 5, Heft 2, p. 126. "South America"; Mörch, 1870. Malak. Bl., vol. 17, p. 124.

Anatina pellucida Schumacher, 1817. Ess. vers test., p. 125, pl. 8, fig. 1.

Lutraria lineata Say, 1822. Jour. Acad. Nat. Sci. Philadelphia, vol. 2, pt. 2, p. 310. Southeastern United States.

Lutraria sp. Sowerby, 1824. Genera of shells, pt. 24, pl. 7. Loc. --? (Compared to but not identified with L. papyracea Lamarck, a composite species).

Mactra recurva Wood, 1828. Index Test., Suppl., p. 4, pl. 1, Mactra, fig. 2. South Carolina.

"Mactra nuttallii Conrad" of Reeve, 1854. Conch. Icon., vol. 8, Mactra, fig. 125 (not of Conrad, which is a Schizothaerus).

Geographic distribution: East Coast of the United States, from New Jersey southward; Gulf of Mexico; northern South America to Brazil.

Anatina cyprinus (Wood, 1828)

Mactra cyprinus Wood. Index Test., Suppl., p. 4, pl. 1, Mactra, fig. 1. "Peru".

——— Reeve, 1854. Conch. Icon., vol. 8, Mactra, sp. 37.

"Labiosa anatina (Spengler)" of Dall, 1894. Nautilus, vol. 8, no. 4, p. 41. "West Coast of Mexico".

——— of Lamy, 1918 (in part). Jour. Conchyl., vol. 63, no. 4, p. 349. (With extensive synonymy and citation of two specimens in the Paris Museum, presumably from the West Coast but without exact locality.)

"Labiosa lineata (Say)" of Wilkins, 1957. Bull. British Mus. (Nat. Hist.), Historical Series, vol. 1, no. 4, p. 164, pl. 24, fig. 9. (Refigured holotype of Mactra cyprinus.)

"Anatina anatina (Spengler)" of Keen, 1958. Sea Shells of Tropical West America, p. 158, fig. 363. (Reproduction of Reeve's figure.)

"Labiosa anatina (Spengler)" of Olsson, 1961. Mollusca of the Tropical Eastern Pacific, p. 333, pl. 57, figs. 3, 3a. Santa Elena, Ecuador.

Geographic distribution: Gulf of California, from off Guaymas and Carmen Island, to Santa Elena, Ecuador, possibly to Peru.

In a review of Spengler's collection, Mörch (1870) gives evidence that further strengthens the case for Spengler's holotype having been an East American shell as he says that Spengler's principal sources for material were the Danish colonies in the East and West Indies and elsewhere. There were no Danish colonies on the West Coast of the Americas. Of course, Spengler could have purchased imported shells, as did other wealthy collectors. Even if we accept the premise that his holotype was from the East Coast, the puzzle remains as to what collector, prior to 1800, could have found so rare a shell as Anatina cyprinus (and especially so large an individual as the holotype) in Peru or anywhere else along the West Coast. The Calonne collection was worldwide in scope and did contain other rare items from western South America. We must assume, therefore, that some enterprising early sailor conveyed it back to Europe, where it has graced three collections and survived two World Wars.

Acknowledgment

I wish to thank Dr. Henning Lemche of the University at Copenhagen for his prompt and effective reply to my inquiry about Spengler's type specimens, Dr. Leo G. Hertlein of the California Academy of Sciences for consulting a reference unavailable to me, and my colleagues who have encouraged me to write down these observations instead of merely talking about them. Also, I should not forget to thank the members of the Ariel Cruise, who made the discovery of these specimens in the Gulf of California possible.

Literature Cited

Dall, William Healey
1894. Synopsis of the Mactridae of North America. Nautilus 8 (4): 25-28; (5): 39-43.

Keen, A. Myra
1958. Sea shells of tropical West America. xi + 624 pp., illus. Stanford Univ. Press, Stanford, Calif.

Lamy, E.
1917-1918. Révision des Mactridae vivants du Muséum d'Histoire Naturelle de Paris. Jour. Conchyl., 63 (3): 173-275; (4): 291-411; 2 pls.

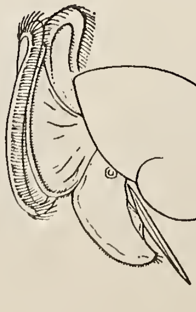
Mörch, O. A. L.
1870. Übersicht der von Lorentz Spengler beschriebenen Conchylien. Malakozool. Blätter 17: 99-124.

Olsson, A. A.
1961. Mollusks of the tropical eastern Pacific. Pt. I. Ithaca, N. Y. 572 pp., 86 pls.

Schumacher, H. C. F.
1817. Essay d'un nouveau système des habitations de vers testacés. Copenhagen. iv + 287 pp., 22 pls.

Spengler, Lorenz
1802. Beskrivelse over det toskallede Conchylie-slaegt Mactra. Skr. Nat. Selsk., Copenhagen, 5(2): 92-128.

Wilkins, G. L.
1957. The Cracherode shell collection. Bull. British Mus. (Nat. Hist.), Historical Ser., 1 (4): 121-184, pls. 20-25.



A New Whale Barnacle from Late Pleistocene Deposits at San Quintín Bay, Baja California

by

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(Plate 3)

Two isolated compartmental plates of a new species of the whale barnacle Cryptolepas Dall, 1872, were collected from late Pleistocene deposits at San Quintín Bay, on the Pacific Coast of Baja California. This new species represents the only known fossil record of the genus Cryptolepas, which until now has included only the living North Pacific species, C. rhachianecti Dall, 1872. The new species closely resembles C. rhachianecti, but the lamellar ribs of the shell of the former terminate distally in T-shaped flanges which form an outer wall (pl. 2, figs. 3, 4). In this respect, the new species resembles the genus Coronula Lamarck, 1802.

The whale barnacles including the genera Coronula, Cryptolepas, Tubicinella Lamarck, 1802, and Xenobalanus Steenstrup, 1851, form a morphologically allied group within the subfamily Coronulinae Leach. All of the species of these genera live partially or wholly embedded in the skin of cetaceans, as opposed to the platylepadid group of coronulines which have a diversity of hosts, but have never been found on cetaceans. The whale barnacles can be distinguished morphologically from other coronulines by the presence of an oral hood covering the cirri, and by the absence of the internal midribs, median parietal sulci, and parietal furrows which characterize the platylepadid-group.

Within their own group, the whale barnacles have attained a great deal of morphological diversity, apparently as a result of their individual habitats. The fossil record of the coronulines, hitherto restricted to species of the genus Coronula, is sparse, but the world-wide distribution of these fossils in deposits no older than late Miocene indicates that the whale barnacles have achieved their present diversification in a relatively short period of time.

Apparently Cryptolepas, Tubicinella, and Xenobalanus developed from Coronula, but until now, no intermediate forms have been found to substantiate this hypothesis. The lack of fossil specimens of these genera is evidently a result of the fragile nature of their shells. The shell of Coronula, which is only partially embedded in the skin of the whale and therefore exposed to the surrounding environment, is tough and stout, and difficult to disarticulate or break. However, the shells of Cryptolepas, Tubicinella, and Xenobalanus, which are totally buried in the whale's skin and are not exposed to the surrounding environment are friable and easily disarticulated or broken and would probably be reduced to fragments before being preserved. This theory is demonstrated by the new fossil species whose shell, although closely resembling that of Cryptolepas rhachianecti in most features, is structurally more similar to the shell of Coronula.

Pilsbry (1916, p. 279) must have envisioned such an intermediate form as represented by the San Quintín specimens in his statement concerning the origin of Cryptolepas rhachianecti:

> "With the exception of the grooves of the sheath, nearly all of the differences from Coronula are degenerative changes apparently correlated with the protected station of the animal embedded in the skin of the host. An outer wall is no longer needed. The branches of the ribs, which in Coronula serve as buttresses, have become short and extremely variable."

Pilsbry also noted that among the species of Coronula, Cryptolepas rhachianecti most closely resembles Coronula (Cetopirus) complanata (Mörch, 1852) in its depressed exterior outline and cylindric body chamber, and he concluded that Cryptolepas had been derived from such an ancestor. The discovery of compartmental plates of Coronula complanata in late Pliocene deposits at Cape Blanco, Oregon, supports Pilsbry's conclusion, although there are no authenticated Recent records of this species in the North Pacific.

The new fossil species of Cryptolepas, therefore, appears to be an intermediate, having all the characteristics of Cryptolepas, but retaining the outer wall of its Coronulid ancestor.

Family BALANIDAE Gray, emended

Subfamily CORONULINAE Leach, emended

Genus *Cryptolepas* Dall

Cryptolepas Dall, 1872, Proc. Calif. Acad. Sci., vol. 4, p. 300; Pilsbry, 1916, U. S. Nat. Mus. Bull. 93, p. 278; Kruger, 1940, in Bronn's Klass. u. Ordn. des Tierreichs, Bd. 5, Abt. 1, Buch 3, Teil 3, p. 453.

Type species: Cryptolepas rhachianecti Dall (by monotypy). Living on the California gray whale, Rhachianectis glaucus Cope. Subsequent authors (e. g., Pilsbry, 1916, p. 279; Cornwall, 1955, p. 44) have not retained the first "h" in the spelling of the specific name.

Range: Late Pleistocene, Baja California; Recent, North Pacific.

Cryptolepas murata Zullo, spec. nov.

Dimensions:	Holotype	Paratype
	UCMP no. 34676	UCMP no. 34677
Height:	10.3 mm.	12.1 mm.
Width of ribs:	8.4 mm.	10.1 mm.
Width of base of ribs:	11.1 mm.	12.5 mm.

Description: Two worn lateral compartmental plates; six parietal ribs per compartmental plate formed by four complete radial lamellar folds and two sutural half-folds; ribs unbranched or with one or two short, free-ending branches and terminating in T-shaped flanges forming a more or less complete outer wall; ribs composed of outer and inner lamellae; inner lamellae separated by closely-spaced, longitudinal septa, forming longitudinal tubes; ornamentation of ribs consisting of fine, closely-spaced, vertical striae crossed by distantly-spaced growth wrinkles; growth wrinkles prominent in apical half and fading in basal half; sheath transversely grooved, three-fourths height of shell; basal edge of sheath not projected, but nearly flush with lamellar folds below; sutural edges of radii intricately crenulated; opercular plates unknown.

The specific name is derived from the Latin "muratus" signifying "walled".

Holotype: University of California, Museum of Paleontology, no. 34'676 (pl. 3, figs. 1, 2, 3); paratype: UCMP no. 34'677 (pl. 3, figs. 4, 5).

Occurrence: UCMP locality no. A-8677. Late Pleistocene, San Quintín Bay, Baja California. One mile south of San Quintín pier at base of cliffs. This locality is identical to that described by Jordan (1924, p. 243). Jordan listed 225 species of invertebrates from this locality, including 13 not known to be living and several whose northern limits are presently south of this locality. It was concluded that this fauna could be correlated with the late Pleistocene warm water San Pedro fauna of Southern California.

Discussion: Cryptolepas murata differs from the living C. rhachianecti in the presence of an outer wall formed by T-shaped flanges at the ends of the ribs, and in the less complex branching of the ribs. Pilsbry (1916, p. 280) noted that a few individuals of C. rhachianecti he examined had one or more compartments with only three or four loops of the inner wall, and with rib branches parallel with and close to the upper sides of the ribs, forming a secondary, incomplete "outer wall". The terminal flanges of C. murata, however, are homologous with the terminal flanges forming the outer wall in the genus Coronula.

Darwin (1854, p. 413) observed that the shell of Coronula complanata is more completely buried in the skin of the whale than are the shells of other species of Coronula. Probably Cryptolepas murata was also deeply buried, approaching the habit of C. rhachianecti. The body chamber was probably cylindric with its base equal in size to its orifice. The exterior outline of the shell would therefore be approximately that of C. rhachianecti (pl. 3, figs. 6, 7).

Literature Cited

Cornwall, I. E.
1955. The barnacles of British Columbia. Brit. Columbia Prov. Mus., Dept. Educ., Handbook no. 7, pp. 1-69, figs. 1-9.

Darwin, C.
1854. A monograph on the sub-class Cirripedia, Balanidae, Verrucidae. Ray Soc. London, 684 p., 11 figs., 30 pls.

Jordan, E. K.
1924. Expedition to Guadalupe Island, Mexico, in 1922. No. 4. Molluscan fauna of the Pleistocene of San Quintín Bay, Lower California. Proc. Calif. Acad. Sci., fourth ser., 15 (7): 241-255, textfig. 1, pl. 25.

Pilsbry, H. A.
1916. The sessile barnacles (Cirripedia) contained in the collections of the U. S. National Museum; including a monograph of the American species. U. S. Nat. Mus. Bull. 93, xi, 366 p., figs. 1-99, pls. 1-76.

Figure 1

Figure 2

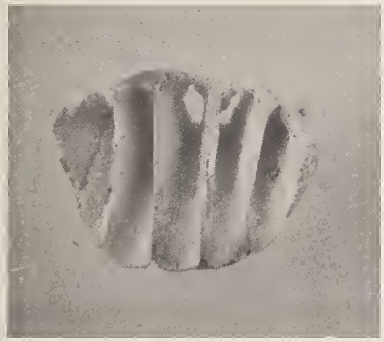

Figure 3

Figure 4

Figure 5

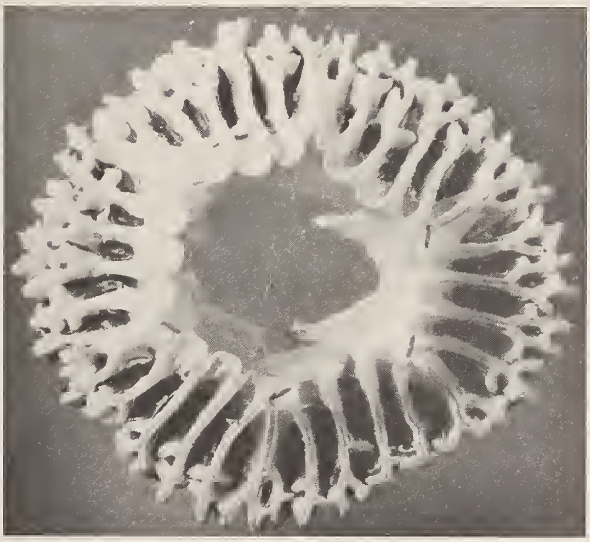

Figure 6

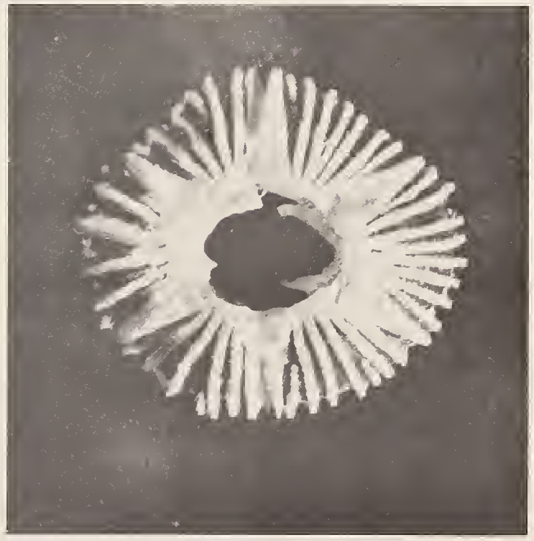

Figure 7

Figures 1 to 5: *Cryptolepas murata* Zullo, spec. nov., x 3

Figure 1: interior view of holotype UCMP no. 34676; Figure 2: outer wall of the same; Figure 3: basal view of the same, showing terminal T - shaped flanges; Figure 4: basal view of paratype UCMP no. 34677, showing branching lamellar ribs; Figure 5: sutural edge of radius of holotype UCMP no. 34676. Figures 6 and 7: *Cryptolepas rhachianecti* Dall, hypotpye UCMP no. 34678. Figure 6: basal view, x 1.4. Figure 7: oral view, x 0.9.

A Statistical Study in Cowries:
The Size of *Mauritia arabica* (Linnaeus)

by

F. A. Schilder

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(2 Textfigures)

Mauritia arabica (Linnaeus) ranges from the Red Sea and Natal to Japan and the Samoan Islands, if we include the well separable East African race immanis Schilder & Schilder, as well as the distinct species M. grayana Schilder which replaces M. arabica in the Red Sea and in the Persian Gulf. The other allied species, however, as M. eglantina (Duclos), histrio, (Gmelin), maculifera Schilder, depressa (Gray), etc., will not be discussed in the present paper as they belong to other superspecies (Schilder, 1947).

For forty years we have accumulated accurate notes on more than one hundred thousand cowry shells examined by us personally; they include almost 3,000 Mauritia arabica coming from about 350 localities.

We have stated the exact length of each shell in tenths of a millimeter (using a vernier); in this paper, however, the mean length of the shells coming from each locality or geographical area has been expressed in millimeters. As the standard deviation in these series of shells generally is about 4 to 7 mm., the mean error of their average length mostly is about ±1 mm., never exceeding ±2 mm.

The following list contains 55 habitats from which we have examined a significant number of Mauritia arabica personally; there are a few specific localities from which we received plenty of shells, and numerous extended areas containing several adjacent localities from which the number of specimens was too small to be treated separately. The geographical names are preceded by the average length of shells in millimeters, and they are followed by three figures: the first figure indicates the number of examined specimens divided by ten, so that, e. g., 3 is equal to about 25 to 35 shells; while the second figure indicates the number of different localities included in the area (independent collectors said to have collected at the same "locality" have been treated as different localities also). The average length of specimens living in each area can be estimated more accurately by a few shells coming from several localities than by numerous shells coming from one locality only in which the size of the shells may be influenced by an unusual environment. The third figure (in parentheses) indicates the average temperature (in degrees Centigrade) of the surface of the sea in the coldest month (February or August).

Mauritia grayana:

52 Aqaba — Ras Benas 2/10 (21°)
44 Jidda — Assab 2/6 (25°)
42 "Red Sea" (no locality) 5/8 (25°)
40 Perim — Berbera — Obbia 3/11 (25°)
49 Aden 2/9 (23°)
59 Muscat — Persia 2/4 (21°)
63 Karachi 3/5 (21°)
43 Seychelles — Mauritius (The occurrence needs confirmation, see Schilder & Schilder, 1939; Allan, 1956.) 2/5 (23°)

Mauritia arabica immanis:

74 Mogadishu — Delagoa Bay 3/11 (24°)
78 Natal 1/5 (21°)
68 Madagascar 2/12 (23°)
66 Réunion -- Rodriguez 2/9 (22°)
72 Seychelles 1/3 (25°)

Mauritia arabica arabica:

59 Bombay — Malpé 1/2 (25°)
47 C. Comorin — Pamban — Galle 2/6 (26°)
58 "Ceylon" (no locality) 5/5 (27°)
56 Trincomali 5/4 (27°)
58 Madras -- Waltair 1/5 (26°)
55 Mergui Archipelago 1/2 (27°)
47 Penang (Griffiths, 1956) 5/9 (28°)
52 Andaman Islands 6/8 (27°)
45 Atjeh — Nias — Oosthaven 7/16 (28°)
44 Labuan — Wijnkoopsbay 1/4 (27°)

42 Tjilaut Eureun (Schilder and Schilder, 1934) 54/1 (27°)
40 Tjilatjap — Sumbawa 2/7 (27°)
46 Tiger Islands — Macassar — Kutei 2/6 (27°)
47 Northcoast of Java 6/9 (27°)
50 Belitong — Singapore 1/6 (27°)
50 Siam Gulf — Pakhoi 1/7 (23°)
54 Hong Kong → Amoy 2/6 (14°)
58 Tokyo — Shikoku 1/3 (13°)
53 Ryukyu Islands — Taiwan 2/8 (20°)
45 Philippine Islands 4/12 (27°)
44 Sangi Islands — Mapia Island 1/2 (27°)
36 Ternate 7/1 (27°)
39 Menado 1/2 (27°)
44 Busak (N. W. Minahassa) 2/1 (27°)
43 Obi — Buru — Banda 9/12 (27°)
45 Kaimana — Kei — Aru 3/4 (26°)
61 Port Essington — Broome 1/2 (25°)
55 Sydney — Torres Straits 1/7 (20°)
42 Geelvink Bay — Huon Gulf 2/7 (28°)
41 Purdy Islands, Admiralty Islands 2/2 (28°)
45 New Britain (Schilder and Schilder, 1937): Bitokara 3/2 (28°)
44 id.: Ulamona 4/2 (28°)
38 id.: Mope — Iltishuk 46/6 (28°)
40 id.: Karlei 1/1 (28°)
43 Solomon Islands — Santa Cruz Islands 4/8 (28°)
53 New Caledonia 4/16 (23°)
56 Fiji Islands -- Tonga Islands 2/5 (24°)
55 Samoan Islands?? (Schilder, 1958) 3/1 (27°)
49 Samoan Islands 2/7 (27°)
48 Wallis Island — Marshall Islands 2/7 (28°)
49 Palau Islands — Yap Island 2/6 (27°)
49 Guam, Marianas Islands 1/4 (26°)

According to this list, the average length of Mauritia arabica varies in various areas from 36 mm. (Ternate) to 78 mm. (Natal). We can afford a general view of these figures, if we reduce them into classes differing from each other by 5 mm. (e. g., class 40 embraces 38 to 42 mm., class 45 embraces 43 to 47 mm., etc.). Then we express these classes by visually impressible signs so that darker signs and triangles indicate larger shells than plain and round signs; we enter them on a map (fig. 1) from which we can learn the following interesting facts:

1. The smallest Mauritia arabica (classes 40 and 45 mm.) inhabit all areas between the Solomon Islands, the Philippine Islands, and Western Sumatra; this central zone can be indistinctly traced as far as to the Southern Red Sea.
2. On the Northern and Southern border of this equatorial zone the average size becomes larger (Bergmann's rule, Schilder, 1956); the gradual increasing of size in Mauritia arabica towards the polar confines of its distribution can be followed most distinctly from Singapore to Japan and from Berbera in both directions towards Aqaba and Karachi.

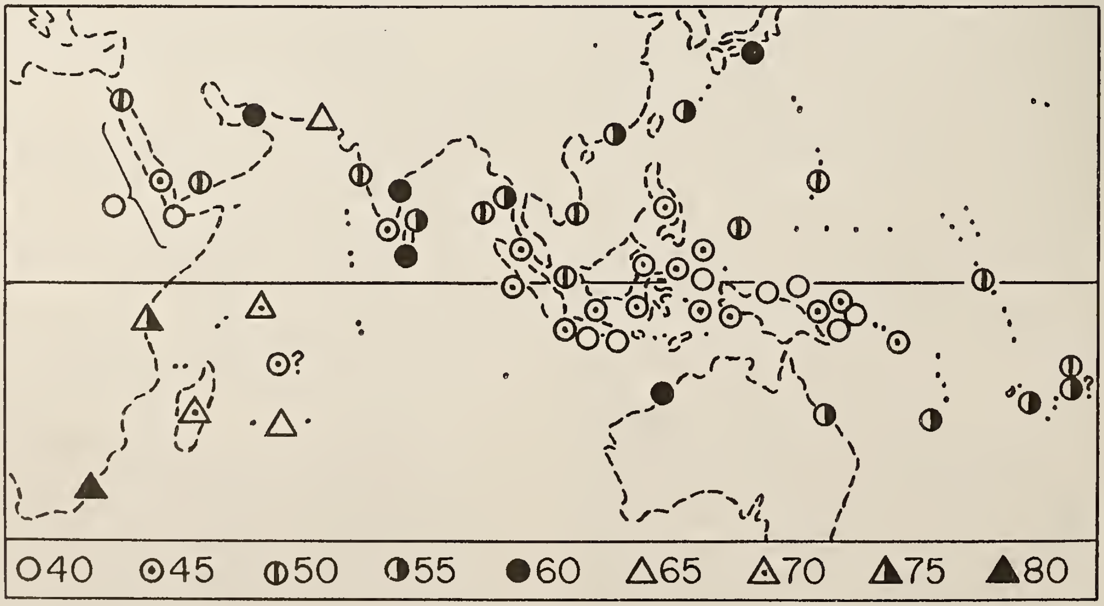

Figure 1

3. In addition, there is also a distinct increasing of size from the Malayan and Melanesian region towards the Eastern and Western borders of the habitat of Mauritia arabica arabica, i. e., towards Polynesia and India, so that the central zone around the Moluccas with small M. arabica becomes totally encircled by a zone with larger ones.

4. The North Western Mauritia grayana generally agrees in size with the Eastern M. arabica arabica, but the South Eastern race of the latter, M. arabica immanis, is extremely large; its size gradually increases from the Mascarene Islands to the African coast, and attains its maximum on the South Western border (Natal).

5. The North West Australian Mauritia arabica also seem to be much larger than one would expect, but the material available is too scanty for a definite statement; most Mauritia coming from this region belong to M. eglantina (perconfusa) and M. histrio (westralis).

These facts can also be shown by plotting the size against the winter temperature of the areas (fig. 2). The general ecological influence increasing the size in colder waters is modified by the probably genetical enlargement of shells in the central Pacific (nameless) and in the Indian race (dilacerata Schilder and Schilder) which becomes far surpassed in the East African Mauritia arabica immanis. Even in M. grayana there seems to be a racial difference between the Western and the Eastern populations {see Schilder and Schilder, 1939; the mean size of M. grayana from the Red Sea (Aqaba to Berbera) and from the Persian Gulf (to Karachi) is 43.8 ± 0.74 mm. and 61.8 ± 1.32 mm., respectively; the difference is significant ($P < 0.001$)}.

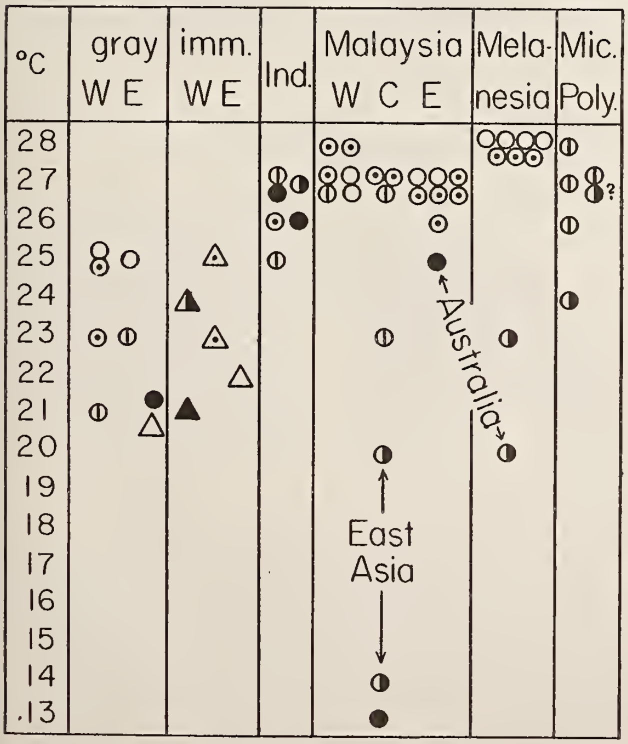

Figure 2

Annex. The correlation between the length of the shells and their relative breadth (i. e., the maximum breadth expressed in percent of the length) may be shown by the following table concerning 154 adult Mauritia arabica from Tjilaut Eureun:

	Length							
Relative Breadth	30	35	40	45	50	55	60	65
73	—	1	5	—	—	1	—	—
70	1	9	8	5	12	3	—	—
67	1	8	16	11	6	4	1	—
64	2	7	9	6	3	2	2	1
61	2	4	5	3	4	1	—	1
58	—	5	2	1	—	—	—	—
55	—	1	—	1	—	—	—	—

The correlation coefficient between these classes has been computed at $r = +0.104 \pm 0.080$ so that no correlation can be proved: broad shells generally occur among small specimens about as frequently as among large ones.

Literature Cited

Allan, Joyce
1956. Cowry shells of the world seas. Melbourne. x + 170 pp., 15 plts.
Griffiths, R. J.
1956. Cypraea in north-west Malaya. Journ. Conch., London, 24 (3): 85-90; pl. 3; 2 textfigs.
Schilder, Franz Alfred
1947. Die Cypraeacea im Lichte der Formenkreislehre. Arch. Molluskenkunde, 76 (4-6): 169-189.
——, ——
1956. Die Bergmannsche Regel bei Porzellanschnecken. Zool. Anz. Suppl. vol. 20: 410-414.
——, ——
1958. Eine fast unbekannte Porzellanschnecke der Hawaii - Inseln.
Veröff. Überseemus. Bremen (A) 3: 32-38.
Schilder, F. A., & M. Schilder
1934. Thirteen thousand Cypraeidae from South Java. Proc. Malac. Soc., 21 (3): 199-213.
——, ——
1939. Prodrome of a monograph on living Cypraeidae. Proc. Malac. Soc. 23 (4): 181-231.
Schilder, M., & F. A. Schilder
1937. Die Cypraeidae des Bismarck-Archipels. Zool. Anzeiger 119: 177-194.

New Deep Water Mollusks from the Gulf of California

by

Donald R. Shasky

Conchological Club of Southern California, Los Angeles 7, California

(Plate 4, Figures 1 to 10)

The Ariel Expedition in the Gulf of California during late August and early September 1960 provided collectors of the Conchological Club of Southern California an opportunity to secure first hand deep water shells seldom seen in private collections.

Although all of the material is not yet worked up, it can be safely estimated that 12 to 15 new species were obtained. Several papers dealing with new species are now in preparation by other members of the expedition.

It was discovered during the preparation of this paper that some of the museum collections on our west coast already had specimens of some of the species described below, either unnamed or confused with similar species. Dr. Leo Hertlein generously provided me with material from the California Academy of Sciences collection which greatly assisted in describing some of these species.

In addition to Dr. Hertlein, I wish to thank Dr. A. Myra Keen for her suggestions in the preparation of this manuscript, Dr. G. Bruce Campbell, Joe and Helen DuShane, Dr. Homer King, and Captain Xavier Mendoza for the loan of specimens, John Q. and Rose Burch for their encouragement and the privilege of spending many hours in their fine library, and last but not least my wife, Ruth. The photography is by Elwyn Spaulding.

Emarginula velascoensis Shasky, spec. nov.

(Plate 4, Figures 1 to 3)

Shell small, oval, white; anterior slope strongly convex; posterior slope concave below apex; apex small, of one and one-half whorls, placed about two-thirds of the way down the shell; radial sculpture of approximately 24 primary ribs and numerous secondary ribs which intersect with concentric cords to form square pits; concentric cords become increasingly stronger toward the periphery so that they are of nearly equal strength with the primary axial ribs at the margin; fissure narrow, about one-sixth the length of the anterior slope; anal fasciole laminated, with lamellae about equal in number to the concentric cords; fasciole marked internally by a tiny ridge; interior of shell probably glossy in living specimens; measurements of holotype: length 3.9 mm., width 2.8 mm., height 2.1 mm.; measurements of paratype: length 5.3 mm., width 3.7 mm., height 2.7 mm.

Holotype: Stanford University Paleontological Type Collection No. 8'619

Paratype: Shasky Collection

Type locality: in 40-80 fathoms, off the southwest end of Isla Montserrate, Gulf of California, Lat. 25°39'N.; Long. 111°05'W., September 1, 1960. Ariel Expedition

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Explanation of Plate 4

Figure 1: *Emarginula velascoensis* Shasky, spec. nov. Dorsal view of holotype; x 4.5. Figure 2: Same specimen, ventral view; x 4.5. Figure 3: Sideview of paratype; x 2.5. Figure 4: *Cancellaria strongi* Shasky, spec. nov. Holotype, x 2. Figure 5: *Trigonostoma campbelli* Shasky, spec. nov. Holotype, x 2. Figure 6: *Trigonostoma funiculatum* (Hinds). Guaymas, Sonora, Mexico; x 1.5 Figures 7 and 8: *Arielia mitriformis* Shasky, spec. nov. Holotype, x 2. Figure 9: Paratype, x 2. Figure 10: *Clathrodrillia bicarinata* Shasky, spec. nov. Holotype, slightly enlarged. Figure 11: *Diodora pusilla* Berry. Montserrate Island, Baja California, Mexico. x 2.5. Figure 12: *Thyca callista* Berry. Pt. Diablo, Baja California, Mexico. x 2. Figures 13 and 14: *Sinum grayi* (Deshayes). Gulf of Fonseca, El Salvador. x 1. Figure 15: *Turitella sanguinea* Reeve. Guaymas, Sonora, Mexico. x 2.5. Figure 16: *Cantharus biliratus* (Reeve). Montserrate Island, Baja California, Mexico. x 2.


Figure 1

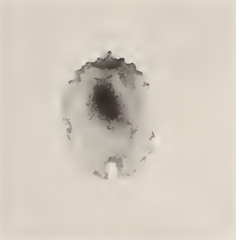
Figure 2

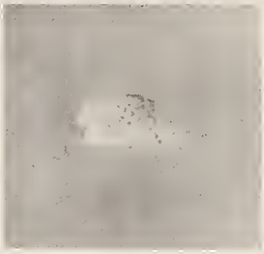
Figure 3

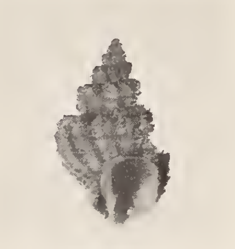
Figure 4


Figure 5


Figure 6


Figure 7


Figure 8


Figure 9


Figure 10


Figure 11


Figure 12


Figure 13


Figure 14


Figure 15


Figure 16

Comparison and Discussion: This species is closest to Emarginula phrixodes Dall, 1927, from the tropical Western Atlantic. E. velascoensis differs in having a longer, narrower fissure, fewer radial ribs, and proportionally fewer lamellae of the anal fasciole. It should be noted, however, that Dall apparently recorded the number of primary axial ribs of a single sagittal diameter, while the number of primary ribs described for E. velascoensis is the total at the circumference.

I take pleasure in naming the first tropical Eastern Pacific representative of the genus for Señor Miguel Velasco Pechir of the Mexican Fish Commission. When the permits for the Ariel Expedition seemed impossible to obtain, his intervention and help turned a very dark hour into a most rewarding week.

Cancellaria strongi Shasky, spec. nov.

(Plate 4, Figure 4)

Shell small, olive brown, with a slightly darker, thin, somewhat scaly periostracum, which is tufted at the shoulder where the axial and spiral sculpture intersect; whorls, including nucleus, eight; nucleus smooth, blunt, polished, of one and one-half whorls; subsequent whorls strongly shouldered and tabulate; axial ribs stronger than the spiral cords; axial ribs 12 to 13 forming prominent nodes at the intersections with the spiral cords; shoulder nodes spinose; spiral cords between the shoulder and the suture much weaker than those on the whorl; aperture subtrigonal; white in the adult, brown in immature specimens; outer lip thickened, with about 14 lirations in fully mature individuals; inner lip thinly calloused and somewhat reflected back over a small umbilicus; columella bent toward outer lip; columellar plaits three, the inferior the strongest; canal short; length of holotype 17.7 mm.; maximum diameter 10.7 mm.

Holotype: California Academy of Sciences Paleontology Type Collection, No. 12'348

Hypotypes: Stanford University Paleontological Type Collection, Conchological Collection of the San Diego Natural History Museum, Campbell collection, DuShane collection, King collection, Schowalter collection, Mendoza collection, and Shasky collection

Type locality: in 33-55 fathoms, off Point Arena, Baja California. Crocker-Beebe Expedition, 1936.

Hypotype stations:

1. in 20-55 fathoms, off Cabo Haro, Guaymas, Sonora, Mexico, Lat. 27°50' N., Long. 110° 55' W., December 27 and 31, 1959. Collectors — B. Campbell, X. Mendoza, T. Schowalter, D. Shasky, and I. Thompson
2. in 20-40 fathoms, off Montserrate Island, Gulf of California, Lat. 25°35' N.; Long. 111°05' W., September 1, 1960. Ariel Expedition
3. in 50-90 fathoms, off Partida and Espíritu Santo Islands, Gulf of California, Lat. 24° 32' N.; Long. 110°26' W., August 30 and 31, 1960. Ariel Expedition

Comparison and discussion: Of the known West American species this is closest to Cancellaria (Admete?) californica Dall, 1908, from which it differs in having fewer axial ribs, stronger shoulders, a narrower umbilicus, a pronounced tufting of the periostracum, and a definite canal.

Since a comparison of Cancellaria strongi with the figure of C. elata Hinds, 1843, might lead to some confusion, mention should also be made of this species. Cancellaria elata was described from a single dead specimen dredged in Panama Bay and has not been reported subsequently. Cancellaria strongi would seem to differ in being chunkier, lacking the fine spiral sculpture, having fainter columellar plaits and a straight canal. Hinds failed to mention a periostracum and it is assumed that if one were present in living individuals, it was eroded away in his specimen.

It would appear that Cancellaria californica and C. strongi belong to a subgenus, not yet described, that is intermediate between Admete and Trigonostoma. As Dall pointed out in the discussion of C. californica, "It has the aspect of an Admete, in spite of the presence of an umbilicus, but is perhaps only a delicate form of Trigonostoma."

That these two species do not belong in the genus Admete seems certain. Their relationship to Trigonostoma remains to be evaluated.

This species is named in honor of the late A. M. Strong, who recognized it as a new species but failed to provide a name and complete description. The holotype was mentioned in his notes on Cancellariidae, published after his death, as Cancellaria (Cancellaria) sp.

Trigonostoma campbelli Shasky, spec. nov.

(Plate 4, Figure 5)

Shell small, acutely turreted, dark brown; whorls six, including one and one-half smooth, glossy nuclear whorls; whorls pinched at base so that succeeding whorls override the previous whorl and immerse the suture; axial ribs six, rounded at the shoulder, crossed by fine primary and secondary spiral threads; aperture trigonal, brown within; outer lip finely lirate; columella two-plaited with the superior plait stronger; columella angled toward outer lip; inner lip calloused and reflected back to form a deep umbilicus; canal short, open; length of holotype 16.0 mm.; maximum diameter 9.3 mm.

Holotype: Stanford University Paleontological Type Collection No. 8'620.

Paratypes: Campbell collection, Mendoza collection, and Shasky collection

Hypotypes: Conchological Collection of the San Diego Natural History Museum and Shasky collection

Type locality: in 30-50 fathoms, off Cabo Haro, Guaymas, Sonora, Mexico, Lat. 27°50' N.; Long. 110°55' W., December 14, 1958, and December 27 and 31, 1959. Collectors — B. Campbell, X. Mendoza, T. Schowalter, and D. Shasky

Hypotype stations:

1. in 10 fathoms, Puerto Peñasco, Sonora, Mexico. February 1934. Collector — H. N. Lowe
2. in 20 fathoms, off Punta Final, San Luis Gonzaga Bay, Baja California, Mexico, Lat. 29°47' N., Long. 114°18' W. January 1, 1961. Collectors — B. Campbell, G. Sphon, and D. Shasky

Comparison and discussion: Trigonostoma campbelli is close to T. funiculatum (Hinds, 1843) (see Plate 4, figure 6) but differs from it in its dark brown color, being more acutely turreted, the sutures more deeply impressed and immersed, the aperture more trigonal, and the two-plaited columella bent more toward the outer lip.

Despite these differences the two are easily confused, and it was not until I collected both species from off Cabo Haro, Guaymas, Sonora, that their differences were recognized.

Lowe (1935) reported collecting Trigonostoma funiculatum at Puerto Peñasco and Guaymas, Sonora, and Manzanillo, Colima. Examination of his material, however, reveals that the specimen from Puerto Peñasco is T. campbelli.

I also reported Trigonostoma funiculatum (Shasky, 1960), but the material reported is the type material for T. campbelli.

This fine species is named in honor of my close friend and colleague, Dr. G. Bruce Campbell, whose enthusiasm for diving and dredging for shells has and will continue to be a stimulant to all West Coast conchologists.

Arielia Shasky, gen. nov.

Shell small, fusiform, reticulately sculptured; nucleus smooth, planorboid, of one and one-half whorls; aperture long, narrow, about one-half length of shell; anal notch abrupt, shallow, with no subsutural callous pad; columella two-plaited; outer lip lirate within; type species Arielia mitriformis.

As much as one dislikes adding another genus to the already overcrowded turrid nomenclature, the type species did not seem to fit into any of the recognized genera.

Arielia mitriformis Shasky, spec. nov.

(Plate 4, Figures 7 to 9)

Shell small, fusiform, with one and one-half smooth, white, planorboid nuclear whorls followed by seven sharply reticulate whorls; suture inconspicuous with a strong subsutural bicarinate band; axial sculpture of fine ribs which form small nodes with the spiral cords, leaving shallow rectangular depressions; axial ribs 18 to 19 on the body whorl; spiral sculpture, in addition to the subsutural band, of three cords which arise weakly but become increasingly stronger until they reach the antepenultimate whorl where they are of equal strength with the axial ribs; spiral cords increase to 18 or 19 on the body whorl; aperture long, narrow, about one-half the length of the shell; anal notch open, shallow, and lacking a subsutural callous pad; outer lip thin, lirate within; columella two-plaited, the superior plait much stronger; inner lip not calloused; canal short, open; color presumably tawny white banded with brown; length of holotype 12.5 mm., width 4.5 mm.

Holotype: Stanford University Paleontological Type Collection No. 8'621

Paratypes: California Academy of Sciences Paleontology Type Collection, Campbell collection, DuShane collection, Shasky collection, and Sphon collection

Type locality: in 40-90 fathoms, off Islas Partida and Espíritu Santo, Gulf of California, Lat. 24°32' N.; Long. 110°26' W. August 30 and 31, 1960. Ariel Expedition

Comparison and discussion: Arielia mitriformis has the general outline of a Daphnella, but the columellar plaits preclude its inclusion with that group.

It has been suggested that it might fall into the genus Zetekia, but Dall proposed this for a much smaller shell with a short and proportionally more open aperture, and four or five lirations on the columella.

Because of the columellar plaits, Arielia mitriformis also has the appearance of a small Mitra, and during the hasty initial sorting aboard ship it was included with specimens of Mitridae.

Clathrodrillia (Carinodrillia) bicarinata Shasky, spec. nov.

(Plate 4, Figure 10)

Shell medium size, turreted, with 15 whorls, three of which form a smooth convex nucleus; color mocca brown with dark reddish brown spiral bands between the spiral cords; spiral cords two, increasing to three or four, on later whorls; the two primary spiral cords form a double undulating keel as they intersect with the axial ribs; later whorls with one or two lesser spiral cords except the body whorl which has 12 to 15 spiral cords separated by fine spiral threads; axial sculpture of seven to nine sharp ribs; aperture long, narrow, bluish white within; anal sulcus rounded, with a moderately heavy subsutural callus; outer lip thin, crenulate, and gently curved, smooth within; pillar relatively straight; canal open; length of holotype 48 mm.; length of aperture 19 mm.; maximum diameter 15 mm.

Holotype: Stanford University Paleontological Type Collection No. 8'622

Paratypes: Burch collection, Campbell collection, DuShane collection, King collection, Rogers collection, Schowalter collection, Shasky collection, and Sphon collection

Type locality: in 45-90 fathoms, off Islas Partida and Espíritu Santo, Gulf of California, Lat. 24°32' N.; Long. 110°26' W. August 30 and 31, 1960. Ariel Expedition

Hypotype stations:

1. in 20-120 fathoms, off Cabo Haro, Guaymas, Sonora, Mexico, Lat. 27°50' N.; Long. 110°55' W. September 2, 1960. Ariel Expedition
2. in 12-25 fathoms, off Loreto, Baja California, Lat. 26°01' N.; Long. 111°18' W. August 29, 1960. Ariel Expedition

Comparison and discussion: This is the largest of the Carinodrillias so far described. That it should escape description until this late date is difficult to understand since it seems to be distributed widely in the southern half of the Gulf of California.

Of the previously described species, from the Panamic region, it is closest to Clathrodrillia (Carinodrillia) alcestis (Dall, 1919), from which it differs in its larger size, the double keeled sculpture, the curved outer lip, and the spiral color banding.

Literature Cited

Dall, William Healey
1908. Reports on the dredging operations off the west coast of central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California. XIV. The Mollusca and Brachiopoda. Bull. Mus. Comp. Zool., Harvard, 43 (6): 205-487, pls. 1-22.

——, ——
1919. Descriptions of new species of mollusks of the family Turritidae from the west coast of America and adjacent regions. Proc. U. S. Nat. Mus., 56: 1-86, pls. 1-24.

——, ——
1927. Diagnosis of undescribed new species of mollusks in the collection of the United States National Museum. Proc. U. S. Nat Mus., 70 (no. 2668): 1-11.

Hinds, Richard Brinsley
1844. The zoology of the voyage of H. M. S. Sulphur, under the command of Capt. Sir Edward Belcher. London. Mollusca, vol. 2: 1-72, pls. 1-21.

Keen, A, Myra
1958. Sea shells of tropical West America. xi, 624 pp., illus. Stanford Univ. Press, Stanford, Calif.

Lowe, H. N.
1935. New marine mollusca from west Mexico, together with a list of shells collected at Punta Penasco, Sonora, Mexico. Trans. San Diego Soc. Nat. Hist. 8 (6): 15-34, pls. 1-4.

Perez Farfante, I.
1947. The genera Zeidora, Nesta, Emarginula, Rimula, and Puncturella in the western Atlantic. Johnsonia, 2 (24): 93-148, pls. 41-64.

Pilsbry, H. A., & H. N. Lowe
1932. West Mexican and central American mollusks collected by H. N. Lowe, 1929-1931. Proc. Acad. Nat. Sci. Phila., 84: 33-144, pls. 1-17, 7 text figs.

Shasky, Donald R.
1960. Deep water collecting off Guaymas, Mexico. The Veliger, 3 (1): 22-23.

Strong, A. M.
1954. A review of the eastern Pacific species in the molluscan family Cancellariidae. Minutes Conch. Club Southern Calif., no. 135: 7 to no. 136: 23.

Notes on Rare and Little Known Panamic Mollusks

by

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(Plate 4, Figures 11 to 16)

During the last five years I have engaged in extensive collecting in the Gulf of California, especially along the coast of northern Baja California. Almost every trip has brought to light one or more species previously reported only from the type locality, frequently 1,000 – 3,000 miles south of the stations to be discussed here.

These trips are usually in company with other collectors who will be mentioned in the text as various species and records are considered.

I have also had the opportunity to examine several lots of shells from the Gulf of Fonseca, El Salvador, and from the Chiapas and Oaxaca coasts of Mexico. These were sent to me through the courtesy of Captain Xavier Mendoza currently of Salina Cruz, Mexico. In the Salvador material were several examples of a species previously considered to range from Peru to Chile.

Mention is also made of a common California bivalve recently discovered in the Gulf of California.

Lioberus salvadoricus (Hertlein & Strong, 1946)

This small mytilid was originally described from Costa Rica but has more recently been reported from along the Sonora coast of Mexico.

Station: in 6-8 fathoms, five miles north of Punta San Felipe, Baja California. Lat. 31° 7' N.; Long. 114°46' W. March 1959. B. Campbell and D. Shasky.

The bottom in which we took this species is a thick mud that quickly clogs the dredge. It seems to be one of the few species living in this area, although valves of Aequipecten palmeri (Dall, 1897) were quite common.

Tivela stultorum Mawe, 1823

It is well known that in the northern Gulf of California there exists a cold water fauna that compares in many ways with that of the Pacific Coast of California and northern Baja California. To list here species that are common to both areas is not within the scope of this paper. It is mentioned merely to add another species common to both regions. Tivela stultorum is reported by Fitch to range only as far south as Magdalena Bay, but Oldroyd lists Socorro Island as its southern limit.

Station: intertidally at southwest end of Willard Island, San Luis Gonzaga Bay, Baja California. Lat. 29°49' N.; Long. 114°24' W. January 1, 1961. G. Sphon and D. Shasky.

Approximately 20 specimens were uncovered in a very small area. These ranged in size from 4½ to 6 inches. Although it has been suggested that these might have been introduced here, it is difficult to reason why this rather isolated location in an already semi-isolated area would be chosen.

Diodora pusilla Berry, 1959 (Plate 4, fig. 11)

This small off-shore form has only recently been described from off Acapulco, Mexico. It is figured here for the first time.

Stations:

1. in 40-80 fathoms, off the southwest end of Isla Montserrate, Gulf of California. Lat. 25°39' N.; Long. 111°05' W. September 1, 1960. Ariel Expedition, D. Shasky.
2. in 20 fathoms, off Punta Final, San Luis Gonzaga Bay, Baja California. Lat. 29°47' N.; Long. 114°18' W. January 1961. B. Campbell, G. Sphon, and D. Shasky.

Thyca callista Berry, 1959 (Plate 4, fig. 12)

This very interesting form, parasitic on the starfish Phataria unifascialis Gray, was first taken by Leonard Bessom in 1954 while diving at San Carlos Bay, Guaymas, Sonora, Mexico. I collected a single specimen in an adjacent area in 1958.

Stations:

1. Mazatlán, Sinaloa, Mexico. December 1959. James McLean.
2. in 2½ fathoms, off Punta Diablo, Baja California. Lat. 24°18' N.; Long. 110°19' W. August 31, 1960. D. Shasky.

All specimens of this species taken to date have been off-shore in depths of 6-20 feet, although the starfish host is frequently seen at extreme low tides.

Mr. Bessom and I estimate that Thyca callista occurs once on every 1,000-1,500 starfish examined.

Sinum grayi (Deshayes, 1843) (Plate 4, figs. 13, 14)

This magnificent deep water species has been reported only once north of Peru, and then it was supposed to have been taken living at San Pedro, California. I have grave doubts concerning the accuracy of the San Pedro record.

Stations:

1. in 20-40 fathoms, Gulf of Fonseca, El Salvador. Lat. 13°15' N.; Long. 87° 45' W. October 1960. X. Mendoza.
2. specimens brought in by the Guaymas shrimp fleet have recently been acquired by C. Zimmerman, R. Burch, and Dr. M. Keen. It is assumed these were all taken within the territorial waters of Mexico.

Lamellaria inflata (C. B. Adams, 1852)

Range: Panama

Stations:

1. in 1-1½ fathoms, in siftings, Puertecitos, Baja California. Lat. 30°25' N.; Long. 114° 39' W. June 1960. D. Shasky.
2. in 10 fathoms, La Paz Bay, Baja California. Lat. 24°12' N.; Long. 110°22' W. Ariel Expedition. G. Sphon.

Mr. Sphon's specimen was living when collected. He reports that the animal is light yellow marked with brown.

Turritella sanguinea Reeve, 1849 (Plate 4, fig. 15)

This species does not seem to have been recognized since Reeve's original description. The type locality was cited as California.

Station: in 20-40 fathoms, off Cabo Haro, Guaymas, Sonora, Mexico. Lat. 27°50' N.; Long. 110°55' W. December 28 and 31, 1959. B. Campbell and D. Shasky.

Our specimens match Reeve's description and figure except that he described the color as blood red while our six shells tend to be brownish red.

We had this mixed in the same lot with Turritella leucostoma Valenciennes, 1832, until we noted the more inflated early whorls. With this in mind, separation was relatively simple.

Typhis lowei Pilsbry, 1931

Previously reported only as far north as the coast of Oaxaca, Mexico.

Stations:

1. crab specimen, under a rock, about five feet below the surface. Puerto Ballandra, Isla Carmen, Gulf of California. Lat. 26° 01' N.; Long. 111°11' W. August 29, 1960. D. Shasky.
2. in 20-40 fathoms, off Loreto, Baja California. Lat. 26°01' N.; Long. 111°18' W. August 29, 1960. Ariel Expedition. G. Sphon.

Cantharus bilirata (Reeve, 1846) (Plate 4, fig. 16)

Previous range: Galapagos and Viti (Fiji) Islands.

Stations:

1. in 40-80 fathoms, off Isla Montserrate, Gulf of California. Lat. 25°39' N.; Long. 111°05' W. September 1,1960. Ariel Expedition. B. Campbell.
2. in 20 fathoms, off Punta Final, San Luis Gonzaga Bay, Baja California. Lat. 29°47' N.; Long. 114° 18' W. January 1, 1961. B. Campbell, D. Shasky, and G. Sphon. (Specimens taken here were fragments only.)

Nassarius howardae Chace, 1958

Recently described from San Felipe, Baja California.

Station: in 10-15 fathoms, off Cabo Haro, Guaymas, Sonora, Mexico. Lat. 27°53' N.; Long. 110°50' W. December 14, 1958. D. Shasky.

Although not mentioned in the description, this species is closely related to Nassarius catallus (Dall, 1908). Most apparent differences in these two species are the more acute apex, solid buff-white color and flaring outer lip in N. howardae.

Cancellaria obesa Sowerby, 1832

Although this is not an uncommon off-shore form, it is included here to record it as having been collected alive intertidally.

Station: intertidally, bumping in sand at night, one cove south of Puertecitos, Baja California. Lat. 30°25' N.; Long. 114°39'W. November 1959 (G. Sphon); January 1961 (D. Shasky); and February 1961 (W. Barber).

Daphnella allemani (Bartsch, 1918)

Previous record: Taboga Island, Panama.

Stations:

1. in 20-40 fathoms, off Loreto, Baja California. Lat. 26°01'N.; Long. 111°18'W. August 29, 1960. Ariel Expedition. D. Shasky.
2. in 20 fathoms, off Punta Final, San Luis Gonzaga Bay, Baja California. Lat. 29°47' N.; Long. 114°18'W. January 1, 1961. B. Campbell, G. Sphon, and D. Shasky.

Daphnella mazatlanica Pilsbry and Lowe, 1932

This species is taken occasionally at Guaymas, but this seems to be the first record in the northern Gulf of California.

Station: intertidally, under a rock, Willard Island, San Luis Gonzaga Bay, Baja California. Lat. 29°49'N.; Long. 114°24' W. January 1, 1961. Ruth Shasky.

Clavus melea (Dall, 1919)

This seems to have been recorded only from Panama.

Stations:

1. in 20-40 fathoms, off Loreto, Baja California. Lat. 26°01'N.; Long. 111°18'W. August 29, 1960. Ariel Expedition. D. Shasky.
2. in 20 fathoms, off Punta Final, San Luis Gonzaga Bay, Baja California. Lat. 29°47' N.; Long. 114°18'W. January 1, 1961. B. Campbell, D. Shasky, and G. Sphon.

Mangelia finitima (Pilsbry and Lowe, 1932)

Unreported since taken by Lowe in Nicaragua.

Stations:

1. crab specimen, under a rock, 6-10 feet below the surface, Saladita Bay, Guaymas, Sonora, Mexico. June 1958. D. Shasky.
2. crab specimen, under a rock, intertidally, Puertecitos, Baja California. April 25, 1959. D. Shasky.

Tenaturris burchi (Hertlein and Strong, 1951)

Type locality: 45 fathoms off Arena Bank, Gulf of California.

Stations:

1. in 20-40 fathoms, off Cabo Haro, Guaymas, Sonora, Mexico. Lat. 27°50'N.; Long. 110° 55'W. December 27 and 31, 1959. D. Shasky.
2. crab specimen, under a rock, 4-5 feet below surface, Puerto Ballandra, Isla Carmen, Gulf of California. Lat. 26°01'N.; Long. 111°11'W. August 29, 1960. D. Shasky.

Tenaturris carissima (Pilsbry and Lowe, 1932)

Originally described from Manzanillo, Colima, Mexico, it has recently been dredged off Isla Carmen, Gulf of California.

Station: crab specimens under rocks, intertidally, San Luis Gonzaga Bay, Baja California. December 30 and 31, 1960. B. Campbell and D. Shasky.

Tenaturris nereis (Pilsbry and Lowe, 1932)

Type locality: San Juan del Sur, Nicaragua.

This species is quite common in the Gulf of California as crab specimens, intertidally, under rocks. I have taken this species at the following areas: Puertecitos and San Luis Gonzaga Bay, Baja California, and Puerto Peñasco and Guaymas, Sonora, Mexico. It has been taken by H. DuShane at San Felipe, Baja California.

Literature Cited

Berry, S. S.
1959. Notices on new eastern Pacific Mollusca - III. Leaflets in Malacol. 1 (18).
Chace, E. P.
1958. A new mollusk from San Felipe, Baja California. Trans. San Diego Soc. Nat. Hist., 12(20): 333-334, one fig.
Dall, William Healey
1919. Descriptions of new species of mollusks of the family Turritidae from the west coast of America and adjacent regions. Proc. U. S. Nat. Mus., 56: 1-86, pls. 1-24.
Emerson, William K., & Elton L. Puffer
1957. Recent mollusks of the 1940 "E. W. Scripps" cruise to the Gulf of California. Am. Mus. Novit. no. 1825: 1-57, 2 figs., 1 table.
Fitch, John E.
1953. Common marine bivalves of California. Calif. Dept. Fish & Game, Fish Bull. No. 90; 106 pp., 63 figs.
Keen, A. Myra
1958. Sea shells of tropical West America. xi, 624 pp., illus. Stanford Univ. Press, Stanford, Calif.
Oldroyd, Ida Shepard
1924. The marine shells of the west coast of North America. Stanford Univ. Publ. Geol. Sci., vol. 1, 247 pp, 57 pls.
Pilsbry, H. A., & H. N. Lowe
1932. West Mexican and central American mollusks collected by H. N. Lowe, 1929-31. Proc. Acad. Nat. Sci. Phila. 84: 33-144, 6 figs., pls. 1-17.
Reeve, L.
1846. Conchologia Iconica. Buccinum. London.
———, ———
1849. Ibid. Turritella. London.
Tryon, G. W., Jr.
1886. Manual of conchology, vol. 8. Philadelphia.
Turner, R. D.
1956. The eastern Pacific marine mollusks described by C. B. Adams. Occ. Pap. Mollusks, Mus. Comp. Zool., Harvard, 2 (20): 21-135.

Four New Panamic Gastropods

by

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(Plate 5)

As areas of the Gulf of California and Panamic region become more accessible and as dredging operations become more frequent, mollusks new to science are certain to appear. There will be extensions of ranges, and doubtful species of early authors may be rediscovered. The four new species described in this paper were collected in this region during the past three years, obtained by shore collecting at low tide, from the trawling of the Ariel Expedition, from the nets of the shrimp fleets, and by dredging from my small outboard boat.

Genus *Trivia* Broderip, 1837

Subgenus *Pusula* Jousseaume, 1884

Trivia (Pusula) myrae Campbell, spec. nov.

(Plate 5, Figures 1 to 3)

DESCRIPTION:

The shell is minute, ovately globular, and dark brownish purple with the right side and extremities thickened and margined but not quite as rounded as the columellar portion. The shell is moderately produced at the extremities, and a fine, shallow, dorsal sulcus is crossed by eight ribs without interruption. There are 22 ribs on each side, nine of which are interrupted or intercalary and correspond to 15 sharp labial teeth, with 14 similar teeth extending over the columella and internal lobe. As the ribs enter the dorsal sulcus, the color is lighter, giving the impression of very slight beading. The ribs are narrow and sharp, equaling about one-half the width of the interspaces, which are filled with minute granulations that extend up on the sides but not to the crests of the ribs. The spire is completely obscured. Holotype: length 4.8 mm.; width 3.6 mm.; height 2.8 mm. Paratype I: length 4.5 mm.; width 3.4 mm.; height 2.9 mm. Paratype II: length 3.9 mm.; width 3 mm.; height 2.7 mm. Holotype: Stanford University Paleontological Type Collection No. 8'529; Paratype I: private collection of Dr. Donald Shasky. Paratype II: in my private collection.

TYPE LOCALITY:

The holotype and the two paratypes were trawled off Loreto in the channel between Loreto, Baja California, and Carmen Island, Gulf of California, on the Ariel Expedition at an approximate depth of 25 fathoms on August 29, 1960. Lat. 26°01' N.; Long. 111°18' W.

HYPOTYPES:

Seven additional specimens were trawled off Monserrate Island, Gulf of California, on the Ariel Expedition at a depth of 40-80 fathoms on September 1, 1960. Two specimens were dredged off Punta Final, 10 miles south of San Luis Gonzaga Bay, Baja California, in approximately 30 fathoms by Dr. Donald Shasky, Mr. Gale Sphon, and myself.

Discussion

So far this species appears to be limited to the eastern shore of Baja California at moderate depths, 25-80 fathoms. Extensive dredging at Puerto Peñasco, Guaymas, Mazatlán, Salina Cruz and El Salvador, all on the mainland, has failed to produce this small Trivia. Considerable time has been spent reviewing the 23 or more species of Trivia that have been reported from the Eastern Pacific, and with the help of Dr. Keen, it was determined that there is no valid name to which this small species can be assigned. Of the recognized species of Panamic Trivia, T. myrae resembles T. atomaria Dall, 1902, which was dredged in Panama Bay at a depth of 18 fathoms. Trivia atomaria belongs to the subgenus Cleotrivia, which differs from Pusula in that the rib ends are not beaded on either side of the dorsal sulcus. Trivia myrae is further separated from T. atomaria by having produced extremities, slightly beaded ribs, and more numerous ribs. In comparison with T. sanguinea (Sowerby, 1832), T. myrae is much smaller, has fewer ribs, is much more globular, and has more produced extremities.

This new species of Trivia is named in honor of Dr. Myra Keen for her participation in the Ariel Expedition during which time this species was discovered, and for the many hours that she has devoted in helping me with problems regarding mollusks.

Genus *Nassarina* Dall, 1889

Subgenus *Zanassarina* Pilsbry & Lowe, 1932

Nassarina (Zanassarina) anitae

Campbell, spec. nov.

(Plate 5, Figure 4)

DESCRIPTION:

The shell is fusiform, basically brown with a peripheral orange-brown band that colors the interspaces as well as alternately coloring the fourth node on one axial rib and the third and fifth nodes on the next; the remaining nodes are white. The protoconch consists of three conical, convex whorls, followed by six subsequent whorls with two weak, subsutural spiral cords and three remaining strong spiral cords that intersect the 12 straight axial ribs which are narrower than the interspaces, forming more prominent nodes. The ribs of the convex whorls are obtusely angled by the third spiral cord. There are 13 additional spiral cords on the base of the body whorl, the last 12 being generally brown, which continue under the columellar callus corresponding to 10 weak plications on the columella. The siphonal canal is not differentiated, slightly recurved and deep. The anal sinus is shallow and the siphonal fasciole is not discernible. There are five denticles within the outer lip, the first more prominent than the remaining four. Length 10 mm.; width 4.5 mm.

Holotype: Stanford University Paleontological Type Collection No. 8'530.

Paratypes: To be deposited in the U. S. National Museum, California Academy of Sciences, Academy of Natural Sciences of Philadelphia, and the private collections of Dr. Donald Shasky, Mr. Mark Rogers, Mr. Gale Sphon, Mr. Todd Schowalter, and myself.

TYPE LOCALITY:

The holotype and seven paratypes were trawled off Cabo Haro, Guaymas, Mexico, by the shrimp boat, "General Yañez", in 30 fathoms by Captain Xavier Mendoza, Dr. Donald Shasky, Mr. Todd Schowalter, Mr. Ivan Thompson, and myself in December of 1959. Lat. 27°50' N.; Long. 110°55' W.

Sixteen additional paratypes were trawled off Cabo Haro, Guaymas, Mexico, during the Ariel Expedition in 10-25 fathoms on August 28, 1960. Eight hypotypes were collected by Dr. Shasky under rocks at low tide on the north shore of Bacochibampo Bay, Guaymas, Mexico, in December of 1958.

Discussion

This species seems related to Nassarina xeno Pilsbry and Lowe, 1932, and N. poecila Pilsbry and Lowe, 1932. The somewhat flattened subsutural region, slightly obtuse-angled ribs, usually 12 per whorl, five spiral cords, and absent siphonal fasciole distinguish it from N. xeno, which has 10 to 12 convex ribs, small scattered black spots, broad, rounded anal sinus, six spiral cords and weakly developed siphonal fasciole, and from N. poecila, which has blackish brown blotches above the periphery on part of the ribs, seven spiral cords of which the subsutural cord is larger, and only 10 ribs.

It differs from Nassarina atella Pilsbry and Lowe, 1932, which has seven spiral cords, the five peripheral ones being stronger, and anal sinus separated by a callus from the suture.

Nassarina pammicra Pilsbry and Lowe, 1932, is a slender black shell with more numerous small diminishing ribs which, on the last whorl, scarcely reach the suture.

This new species is named in honor of my wife, Anita Campbell, who participated in the trip aboard the "General Yañez".

Genus *Terebra* Bruguière, 1789

Subgenus *Strioterebrum* Sacco, 1891

Terebra (Strioterebrum) berryi

Campbell, spec. nov.

(Plate 5, Figures 5, 6)

DESCRIPTION:

The shell is medium sized, slender, of light cream with brown spots between the subsutural nodes and brownish mottling of the whorls with exception of the protoconch and very early whorls, which are practically black. The four dark, glassy whorls of the protoconch are followed by 15 subsequent whorls. The early whorls have very narrow, slightly curved axial ribs, 14 in number, with scarcely any indication of a subsutural band. On later whorls the axial ribs are prominent, quite curved, and about equal to the interspaces and number about 16. There are three to four spiral grooves in the interspaces, usually not crossing the ribs, totaling 18 to 20 down over the base of the body whorl. The general surface is microscopically striolate, and the slightly convex axial ribs are mildly depressed or on an equal level with the subsutural band to form straight sides. The aperture is elongate and passes below into a short, open, slightly recurved canal with the siphonal fasciole convex, bounded by a weak cord, and the columella straight with one weak plication. Length 32 mm.; width 7 mm.

Holotype: California Academy of Sciences, Department of Geology, Type Collection No. 12'352.

Paratype I: Private collection of Mrs. Helen DuShane. Length 23 mm.; width 5.5 mm. This specimen displays a common variation in Terebridae by having 21 axial ribs, but in all other respects it agrees with the holotype.

Paratype II: Private collection of Mr. Mark Rogers. Length 27 mm.; width 6 mm.

Paratype III: Private collection of Dr. S. Stillman Berry.

TYPE LOCALITY:

The holotype was collected at Puertecitos, Baja California, crawling in the sand at a very low tide by the DuShanes in April, 1958. Paratype I, collected by myself on March 3, 1958, Paratype II, collected by Mr. Rogers on April 11, 1960, and Paratype III in the Berry collection were taken at the same locality. Lat. 30° 25'N.; Long. 114°39'W.

Discussion

There is no little confusion in the genus Terebra with regards to the Panamic area. I have collected more than 80 names from the literature for the 37 species as listed in "Sea Shells of Tropical West America". Fortunately, a good share of these names can safely be placed in synonymy. It is this background that causes some hesitance in describing this and the following species. The Terebra collections of the San Diego Museum of Natural History, Los Angeles County Museum, Stanford University, and the California Academy of Sciences were studied, and through the generosity of the respective curators, I was able to make color slides of each species at Stanford University and at the California Academy of Sciences. These have proved invaluable.

The first specimen of Terebra berryi was collected by the author along with numerous T. variegata Gray, 1834, at Puertecitos, Baja California. It was easily separated from T. variegata, but was regarded as a "freak". In October of 1960 the Terebra was shown to Dr. Berry who promptly produced a single specimen from his unnamed material that had been collected at Puertecitos. Friends who had collected in this area were then asked if they knew of any similar shells, and Mrs. DuShane had the one chosen as the holotype, and Mr. Rogers had another, both collected at Puertecitos.

Terebra berryi can be compared to the most common species found at Puertecitos, T. variegata which has a prominent subsutural band set out like a collar, a well developed siphonal fasciole that is concave, and axial ribs that are flat and almost straight. Terebra armillata Hinds, 1844, is also found there, but its subsutural band is even more prominent and the shell is deep brown. Another species found at Puertecitos is T. glauca Hinds, 1844. It is dark gray-brown with its axial ribs distinctly beaded. Terebra berryi differs from these in that the subsutural band is slightly depressed, the axial ribs are convex and curved, and the siphonal fasciole is less developed and convex. Terebra berryi can be separated most easily by examination of the protoconch and early whorls which differ uniquely from the other species as is seen in figures 6, 9, 10. After comparison with descriptions, pictures, and specimens of other Panamic species, it was felt that T. berryi should be described as new.

This new species is named in honor of Dr. S. Stillman Berry for his great contributions to the knowledge of malacology and for his generosity of time as well as material.

Terebra (Strioterebrum) ninfae

CAMPBELL, spec. nov.

(Plate 5, Figures 7, 8)

DESCRIPTION:

The shell is minute, medium to dark red-brown with a tan peripheral band. The three and one-half glassy whorls of the protoconch are followed by six whorls of the teleoconch. The first two whorls following the protoconch are transparent white with brownish subsutural bands. There are 12 convex, narrow, arched, axial ribs with sharp, round, beaded nodes on the subsutural band. On the subsequent whorls the axial ribs develop into a row of whitish peripheral nodes axially lengthened, narrower than the interspaces, and there is a continuous series of fine incised spiral grooves, two in the interspaces of the band and eight on the rest of the whorl between subsutural bands, intersecting the ribs, continuing down over the body whorl to total 16. The general surface is covered with microscopic striulae with the aperture elongate, canal open and recurved, and the columella is bent to the left with a single plication weakly entering the aperture. Length 6.2 mm.; width 2 mm.

Holotype: California Academy of Sciences, Department of Geology, Type Collection No. 12'353.

Paratypes: To be deposited in the Academy of Natural Sciences of Philadelphia, and in the private collections of Captain Mendoza, Dr. Shasky, and myself.

TYPE LOCALITY:

The holotype and three paratypes were trawled by the shrimp boat, "Cameronera No. 20", in 15-20 fathoms while working in the area between Puerto Madero and 30 miles north of the Guatemala border, Chiapas, Mexico, in January, 1961. Seven additional paratypes were trawled from this area by the same boat in 14-20 fathoms during March, 1961. Specimens supplied by Captain Mendoza. Lat. 14°55' N.; Long. 92°15' W.

Discussion

Due to the small size of the first four shells that were received, I thought that they were the young of one of the larger nodulosed Terebra. Using microscopy, the protoconchs and early whorls were compared with T. tuberculosa Hinds, 1844 (Pl. 5, fig. 14), and T. cracilenta Li, 1930 (Pl. 5, fig. 12), but T. ninfae was found to be very different as seen in figures 8, 11-14. Several weeks later seven more specimens of T. ninfae were received from Captain Mendoza, and they too were uniformly of the same small size.

Terebra ninfae resembles T. roperi Pilsbry and Lowe, 1932 (Pl. 5, fig. 12), except that T. roperi is much larger, light brown with a dark base and protoconch, has traces of two impressed spiral lines in the concavity of the whorls, and a concave siphonal fasciole, while T. ninfae is dark red-brown with a clear glassy protoconch and early whorls, and a convex siphonal fasciole. Terebra ninfae differs from T. bridgesi Dall, 1908 (Pl. 5, fig. 11), by having a peripheral row of nodes that are in line with the nodes on the subsutural band while T. bridgesi is purple with a broad, white peripheral band and has the sutural band distinctly set off by a strongly constricted sulcus with the ribs on the band alternating with the ribs on the whorl.

This new species is named in honor of Sra. Ninfa Mendoza, wife of Captain Xavier Mendoza.

Acknowledgment

Appreciation is expressed to Mr. and Mrs. John Q. Burch for the kind use of their library; to Drs. Hanna and Hertlein and the California Academy of Sciences, Dr. S. Stillman Berry, Dr. Donald Shasky, Mr. Mark Rogers, and Captain Xavier Mendoza for making study material available; to Dr. Myra Keen who has helpfully provided suggestions regarding historical and taxonomic problems, and to the several other persons and institutions mentioned in the text.

Literature Cited

Dall, William Healey
1902. New species of Pacific coast shells. Nautilus 16 (4): 43-44.

——, ——
1908. Report on the dredging operations off the west coast of central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California. XIV. The Mollusca and Brachiopoda. Bull. Mus. Comp. Zool., Harvard, 43 (6): 205-487, pls. 1-22.

Gray, J. E.
1834. Enumeration of the species of the genus Terebra, with characters of many hitherto undescribed. Proc. Zool. Soc. London, 2: 57-63.

Hinds, Richard Brinsley
1844. Descriptions of new shells, collected during the voyage of the Sulphur, and in Mr. Cuming's late visit to the Philippines. Proc. Zool. Soc. London, 11: 149-168.

Keen, A. Myra
1958. Sea shells of tropical West America. xi + 624 pp., illus. Stanford Univ. Press, Stanford, Calif.

Pilsbry, H. A.
1931. The Miocene and Recent mollusca of Panama Bay. Proc. Acad. Nat. Sci. Phila., 83: 427-440, pl. 41, 5 textfigs.

Pilsbry, H. A., & H. N. Lowe
1932. West Mexican and central American mollusks collected by H. N. Lowe, 1929—31. Proc. Acad. Nat. Sci. Phila., 84: 33-144, pls. 1-17, 7 textfigs.

Explanation of Plate 5

Figure 1: *Trivia myrae* Campbell, spec. nov. Dorsal view of holotype. Figure 2: Same specimen, ventral view. Figure 3: Same specimen, side view. Figure 4: *Nassarina anitae* Campbell spec. nov. Holotype. Figure 5: *Terebra berryi* Campbell, spec. nov. Holotype. Figure 6: Drawing of protoconch of the holotype. Figure 7: *Terebra ninfae* Campbell, spec. nov. Holotype. Figure 8: Drawing of protoconch of the holotype. Figure 9: *Terebra armillata* Hinds, 1844. Drawing of protoconch. Figure 10: *Terebra variegata* Gray, 1834. Drawing of protoconch. Figure 11: *Terebra bridgesi* Dall, 1908. Drawing of protoconch. Figure 12: *Terebra cracilenta* Li, 1930. Drawing of protoconch. Figure 13: *Terebra roperi* Pilsbry & Lowe, 1932. Drawing of protoconch. Figure 14: *Terebra tuberculosa* Hinds 1844. Drawing of protoconch.

(See text for actual measurements)


Figure 1


Figure 2


Figure 3


Figure 4


Figure 5


Figure 6


Figure 7


Figure 8


Figure 9


Figure 10


Figure 11


Figure 12


Figure 13


Figure 14

Observations of the Effect of Diet on Shell Coloration in the Red Abalone, *Haliotis rufescens* SWAINSON

by

DAVID L. LEIGHTON

(Contribution from the Scripps Institution of Oceanography, New Series)
University of California, La Jolla, California

(Plate 6)

The color of the ostracal shell layer of the red abalone, Haliotis rufescens Swainson, 1822, is typically a "dull brick red" (Cox, 1960). In many specimens the continuity of the general red aspect may be interrupted by zones of pink, white or green coinciding in position with the growth lines. Variation of shell color may be extreme; the writer has collected many specimens with predominantly or purely white shells. The feature of variable shell color occurs, to a greater or lesser degree, in all California abalones and has been reported to occur also in Japanese forms (Ino, 1952). Study has been made of the effect of diet on shell coloration in the topshell, Turbo cornutus (Solander, 1788), by the same investigator (Ino, 1949, 1958).

Coloration of shells in mollusks has in several other instances been linked with diet. Perhaps most notable of these is the demonstration that a diet of Mytilus edulis Linnaeus, 1758, is accompanied by secretion of brown shell in Purpura lapillus Linnaeus, 1758, and that feeding upon barnacles (Balanus balanoides and Chthamalus stellatus) results in deposition of white shell material (Moore, 1936). Purpura is, however, a carnivorous mollusk while the abalones and topshells are herbivores.

The red abalone was selected for the present study because the range of colors displayed in shells is appreciable. Also minute, juvenile and young adult individuals were easily obtained in the required numbers.

Valuable advice given by Dr. Denis L. Fox, Mr. John E. Fitch, and Dr. Wheeler J. North is gratefully acknowledged.

Materials & Methods

Specimens of Haliotis rufescens were collected, using SCUBA {Self Contained Underwater Breathing Apparatus}, at depths ranging from 40 to 80 feet in waters near La Jolla, California. Greatest numbers of small specimens (1.1 to 25.0 mm. in length) were found within holdfasts of the giant kelp, Macrocystis pyrifera (Linnaeus) Agardh, 1771. Larger individuals were commonly taken from beneath rocks. Kelp plants torn from the bottom and washed ashore by storms often yielded minute abalones in large numbers. As many as 23 specimens were retrieved from a single beached holdfast. Interestingly, the abalones collected from holdfasts were largely of the species H. rufescens, though occasionally H. corrugata Gray, 1828, and H. assimilis Dall, 1878, were taken. Only among specimens less than 3 mm. long was there any confusion as to species. Identification of smaller individuals was made by comparison with a carefully graded series of juvenile shells of each locally occurring abalone species.

Sizes of experimental animals ranged from 4 to 120 mm. in shell length. The smallest were maintained in one-quart polyethylene containers perforated with numerous holes $\frac{1}{8}$ inch in diameter and submerged in a wooden frame rack in circulating aerated sea water. The largest animals were held in 100-gallon concrete tanks similarly supplied with sea water. Low light intensities were maintained in the laboratory at all times precluding adventitious growth of algae.

Food consisted primarily of a variety of species of marine algae representing the brown, red and green algal classes. On several occasions such foreign materials as boiled potato, carrot, and yam were given.

Feeding experiments were conducted throughout one year during which time over 50 abalone were held for varying periods of time on restricted diets.

Results

Shells of juvenile Haliotis rufescens collected from holdfasts of Macrocystis were purely white, pale green or, when found in holdfasts with epiphytically growing red algae, were partially red. Predominantly red-shelled specimens were collected about rocks which supported red algae.

In the laboratory a wide variety of red algal species (Rhodophyta) were provided as food with the consistent result that red pigmented shell was deposited. Pink color appeared in newly deposited shell after red algae had been given together with brown algae (Phaeophyta). When brown algae, green algae (Chlorophyta), or a number of foreign foods (e. g., potato or yam) had been given, the shell formed was either white, cream, or green, but never red. Results of all feeding experiments are given tabular summary below (see Table I).

Diets of brown algae, Macrocystis and Laminaria, were found to result in either white or green color in the newly formed shell. Other brown algae (e.g., Egregia and Eisenia), when ingested, influenced the formation of cream colored shell. Pelvetia fastigiata (Agardh) De Toni, 1895, gave origin to olive-green shell coloration.

Individuals fed alternately red and brown algae for one-month periods displayed similar growth rates on either diet. Shells of these abalones show alternate banding of red and white. It is also noteworthy that growth was substantial in abalone fed either potato or yam. Light green shell was produced on occasions when those diets were provided.

The multiple-colored specimen shown in the accompanying plate (Lower, right) is one of nu-

Table 1: Coloration of shell (ostracum) secreted by *Haliotis rufescens* on restricted diets

Diet	Color of Shell Produced	Number of Observations
Rhodophyta (Red Algae)		
Pterocladia pyramidale	red	12
Plocamium pacificum	red	20
Gelidium purpurascens	red	6
Gelidium nudifrons	red	5
Gigartina spinosa	red	25
Gigartina californica	red	7
Gigartina canaliculata	red	8
Phaeophyta (Brown Algae)		
Macrocystis pyrifera	white or pale green	44
Laminaria farlowii	green	18
Egregia laevigata	white or cream	8
Eisenia arborea	cream	6
Pelvetia fastigiata	olive green	5
Chlorophyta (Green Algae)		
Ulva sp.	pale green	8
Miscellaneous		
Potato, boiled	pale green	6
Yam, boiled	pale green	6
Carrot, boiled	cream	4
Agar	cream	4

Explanation of Plate 6

Figure 1: "Normally" pigmented juvenile *Haliotis rufescens* collected from a kelp bed with a mixed benthic flora. Figure 2: White phase abalone collected from a holdfast of the giant kelp *Macrocystis pyrifera*. Figure 3: Multiple-colored specimen with bands formed as a result of restricted feeding in the laboratory. For convenience, diets and their respective color bands are listed in reverse order of their deposition: *Eisenia* (shell margin), cream; *Pterocladia*, red; Potato, green; Miscellaneous red algae, red; Potato, pale green; *Gigartina*, red; *Macrocystis*, pale green. For additional explanation of this specimen, see text.

(The scale adjacent to the specimens represents ten millimeters)

Figure 1

Figure 2

Figure 3

merous abalone which were maintained in the laboratory for as long as six months. When collected from beneath a rock on June 4, 1960, in the Point Loma Kelp Bed, it was 18.5 mm. long and had a predominantly red shell. When the animal was removed from the shell on January 15, 1961, it was 37.5 mm. long and its shell displayed bands of several colors. Initially, Macrocystis and Egregia were provided for a period of three months. The two minor red bands at the center of the shell were formed during brief feedings of Plocamium. Subsequently, it was supplied the foods listed in the explanation of the plate.

Microscopic epiphytes were found to contain substances influencing the formation of red shell. These small filamentous plants were probably red algae. A future study designed to demonstrate the effects of ingestion of sessile diatoms and other microflora on shell pigmentation will provide an answer to the question. In all feeding experiments of the present study care was taken to select fronds of algae which were free of epiphytic growths.

Discussion

White shell is secreted by Turbo cornutus, when restricted to a diet of the brown alga Eisenia bicyclis (Kjellman) Setchell, 1887, a Japanese form similar to our local E. arborea Areschoug, 1876, (Ino, 1949). Shell of "normal" color was secreted when both E. bicyclis and a coralline alga (Rhodophyta) were given. A diet consisting of a species of Sargassum influenced the production of white shell, while a species of Gelidium yielded a mixture of green-black and brown color. Haliotis rufescens, similarly, has been found in the present study to secrete cream colored shell when fed Eisenia and red shell when fed Gelidium.

The red pigment of shells of Haliotis rufescens has been given the name rufescine (Dhéré and Baumeler, 1930). Chemically it is a bilin, or member of a biochemical category of pigments including bilirubin and biliverdin, pigments of bile. The relationship of rufescine to phycoerythrin (the red pigment of red algae and also a bilin) has yet to be demonstrated. The nature of the other pigments of abalone shells must also be ascertained through careful biochemical analyses. These studies will be undertaken by the writer in the near future.

Ecologically there may exist a considerable utility in the type of study described in this paper, for a dietary history may be obtained from examination of the pigments in a given shell. Food habits may be indicated by the presence and arrangement of pigments. In abalones, which do not, as a rule, move about extensively (Cox, 1960) and which normally live in excess of a decade, the sequence of color bands in a number of specimens may indicate trends in floral succession occurring over periods of several years in their home area. A series of eight Haliotis rufescens was collected from the Point Loma Kelp Bed which shows impressive similarity of shell color arrangement and extent. The known kelp history of the area agrees well with the observed pigment patterns. Additional support is given this hypothesis by the findings of almost purely white adult H. rufescens by commercial abalone divers in areas rich in brown algae (primarily the giant kelp, Macrocystis) slightly south of Point Conception, and of "blood red" specimens from the red alga beds north of Point Conception (B. Owens, personal communication).

Conclusions

Pigmentation of the ostracum of the red abalone reflects the diet in nature. Feeding experiments performed in this study indicate that the source of red pigments may be found in the red algal foods. Shells lacking the typical red coloration are formed by abalone living in areas or niches with brown or green algae, but which lack red algae. A minor quantity of red algae in the diet may be detected as a diluted red pigment in the shell. Since red algae will usually form at least a minor portion of the diet of Haliotis rufescens in nature, the most prevalent color of the ostracum of H. rufescens is red. Color sequences in shells of this species may be used as a key to botanical succession in the home area of the respective animals.

Summary

Common collection of Haliotis rufescens with little or no red shell pigmentation from areas devoid of red algae, but rich in brown algae, suggested that shell pigmentation was related to the foods available. These observations prompted an investigation of the effect of restricted diet on shell pigmentation. Through controlled feeding in the laboratory it was consistently demonstrated that a primary source of red shell pigment is red algae. Feedings of brown or green algae resulted in secretion of shell of white or green color, but never red.

The ecological and biochemical significance of these observations is discussed.

Literature Cited

Cox, K. W.
1960. Review of the abalone of California. Calif. Fish and Game, 46: 381-406, 9 figs.

Dhéré, C., & C. Baumeler
1930. Recherches sur la rufescine, pigment de la coquille de l'Haliotis rufescens. Arch. Int. Physiol. 32: 55.

Ino, Takashi
1940. The effect of food on growth and coloration of the topshell, (Turbo cornutus Solander). J. Mar. Res. 8: 1-5.

——, ——
1952. Biological studies on propagation of Japanese abalone (Genus Haliotis). Tokai Reg. Fisheries Res. Lab. Tokyo, Japan.

——, ——
1958. Ecological studies of the topshell, Turbo cornutus (Solander). Bull. Tokai Reg. Fisheries Res. Lab. Tokyo, Japan, 22: 33-36.

Moore, H. B.
1936. The biology of Purpura lapillus. 1. Shell variation in relation to environment. J. Mar. Biol. Ass. U. K. 21: 61-89.

Notes on the Mitridae of the Eastern Pacific

I - *Mitra fultoni* E. A. SMITH

by

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(Plate 7 and one Textfigure)

Introduction

This is the first of a series of papers to be presented on the family Mitridae as it occurs in the Eastern Pacific area. It is my plan to take the four subgenera occurring in the area, Mitromica, Scabricola, Strigatella, and Tiara, separately, beginning with the subgenus Strigatella, and discuss each of the species involved in a series of papers, one paper to each species.

History & Classification

The family Mitridae was segregated from the Linnaean Volutidae by Röding (1798). The genus Mitra is usually incorrectly attributed to Lamarck (1799), but as Röding's work precedes that of Lamarck by one year, he is the author for the family and the genus under the rules of priority.

Mitra is an extremely large genus that has over a thousand specific and subspecific names assigned to it. Some authors have elevated subgenera to generic rank; there may be merit in this in the case of those subgenera which are well defined. This makes it possible to demonstrate, by the use of nomenclature, the closer relationship among the species of a subgenus. In other words, it would allow for one more subdivision which might be desirable in some, but not all, cases. If this system of classification were followed to its logical conclusion, the end result would be a large number of monotypic genera and subgenera. It is my feeling that the whole group is closely enough knit to use the single generic name Mitra; this is the classification which will be followed in this series of papers.

Description

The present paper deals with one of the rarer species of the subgenus Strigatella Swainson, 1841. Mitra fultoni was described by E. A. Smith (Ann. Mag. Nat. Hist., S. 6, vol. 9, 1892) and as far as I can ascertain, this is one of those few species which have no known synonyms.

Smith gives a good diagnosis in Latin and then goes on to complete his description with the English equivalent. Only the English description is quoted here:

> "This species is well characterized by the punctate sulci, the punctures falling in regular longitudinal rows, through which pass well-marked impressed lines of growth. It has, I believe, been confounded with M. orientalis, Gray, by some conchologists; but from that species it may be sufficiently distinguished by the above-mentioned feature and the difference of form. The whorls are more convex, the epidermis blacker, and the fine spiral striae which adorn the surface of that species are scarcely indicated in the present form."

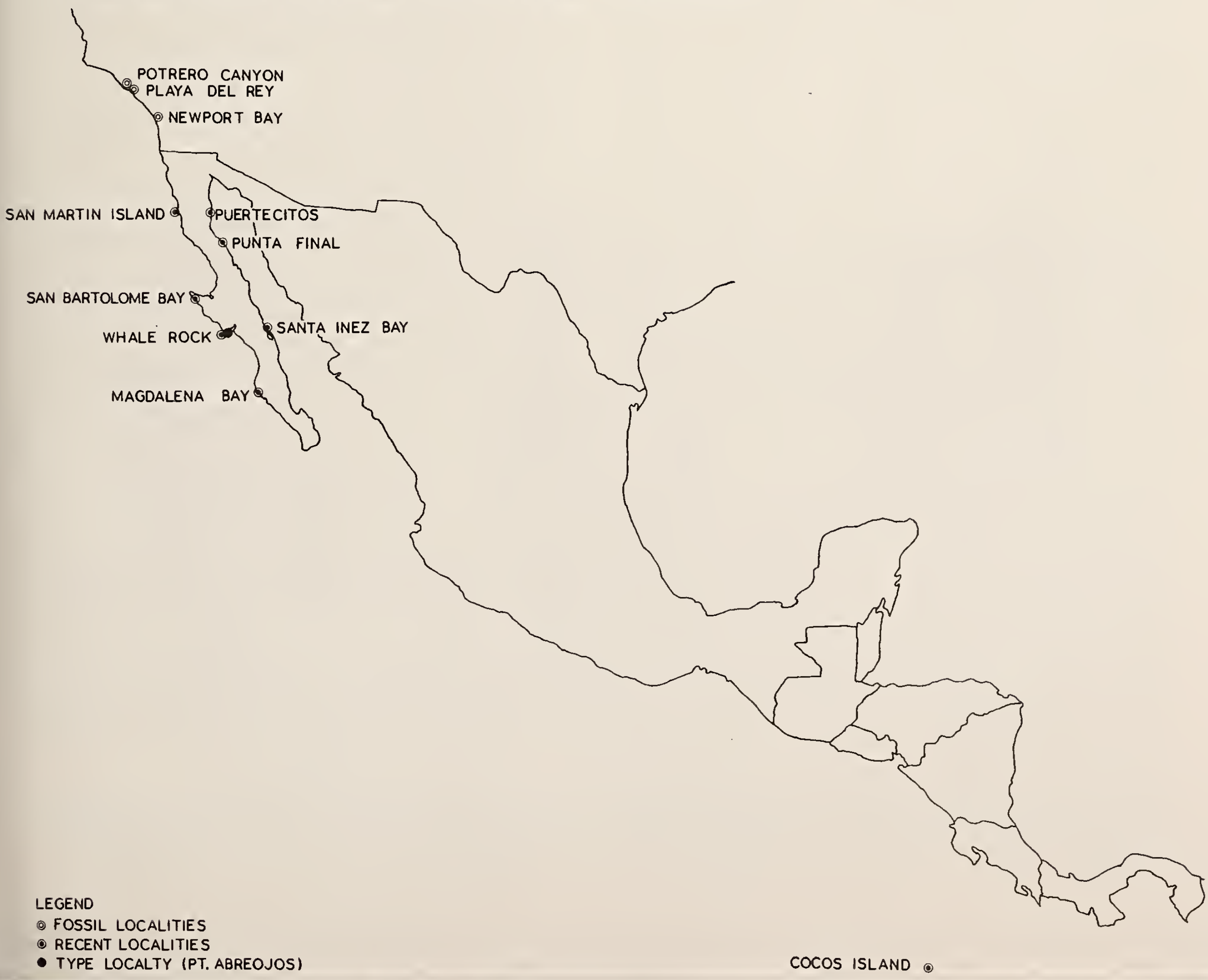
Mitra fultoni has a thin, smooth, shiny black periostracum which is often worn, revealing the brown shell underneath. The interior of the shell is white in the adult, while the younger specimens show brown through the white enamel. The soft parts of the animal are white. This holds true for all members of the genus examined by me so far.

Identification & Relationship

For identification of the species the main features are the punctate sulci mentioned by Smith in his description. These sulci appear not only spirally as he mentions, but also axially. The over-all appearance is similar to a checkerboard with the small pits in the corners of the squares. The pits occur even on the base of the nuclear whorls. Other Eastern Pacific species of Mitra which have this peculiar pitting are M. lens Wood, 1828; M. orientalis Gray, 1834; M. idae Melvill, 1893; and M. montereyi Berry, 1920.

Mitra fultoni can be distinguished from M. lens by the former's smooth appearance. The pitting in M. lens is limited to the area between the coarse, flattened axial ribs, the pits are twice the size of those occurring in M. fultoni, and are not nearly as numerous. In M. orientalis, M. idae, and M. montereyi the pitting occurs only on the spire and upper part of the body whorl whereas in M. fultoni the pitting covers not only the spire but the entire body whorl as well.

Mitra fultoni is one species of a complex (including M. idae, M. orientalis, and M. montereyi) within the subgenus Strigatella. The Peruvian species, M. orientalis, is the only other member of this complex whose range may possibly extend into the Panamic area. Both M. idae and M. montereyi are members of the Californian province, exclusively. The shape of M. montereyi and its slight pitting, which must be seen with a good hand lens or a microscope, suggest that M. fultoni and M. montereyi are closely related members of this particular group within the subgenus. Perhaps when further research on the radular structure, cytology and genetics has been done on the species involved, it will be possible to make more definite statements on the relationships within this complex.



Type Locality & Range

Smith gave the type locality for Mitra fultoni as Point Abreojos, Lower California, Mexico, Latitude 27° N., Longitude 113° W., on the Pacific side of the peninsula. Williamson (1906) quotes Dall as saying that he had seen no specimens from north of San Diego; in Burch (1945) S. Stillman Berry is reported as having taken specimens at San Diego.

One specimen in the California Academy of Sciences (no. 17'749 Cal. Acad.) extends the range to Santa Inez Bay in the Gulf of California. I have dredged one dead specimen (Sphon Collection, no. 504) and a fragment of another from Punta Final, near Bahía San Luis Gonzaga. I have also taken a living specimen at Puertecitos (Sphon Collection, no. 503), which extends the range still farther up the eastern side of Baja California. Another specimen (no. 23'077 Cal. Acad.) extends the range south to Cocos Island, approximately 300 miles off the coast of Central America. As far as it is possible to ascertain, there are no records, even vague ones, to place the species on the mainland of Mexico or Central America. It is on the basis of the specimens mentioned that the range extensions are recorded.

The majority of specimens I examined have come from the type locality. This is in the area where the greatest overlap between the Californian and Panamic faunas occurs; since there are far more records for the species occurring in the more northern Californian province, the species probably should be considered as a member of that province and merely a "straggler" in the Panamic area. At least it should be so considered until more specimens from the Panamic area come to light.

Fossil Record

The fossil records of Mitra fultoni are of no help in assigning it to a particular province. There are three localities in Southern California from which fossils of the species are known: Valentine (1956) reports it from Potrero Canyon in the Pacific Palisades area of Los Angeles County; Kanakoff and Emerson (1959) from the Newport Bay Mesa area in Orange County; and George Willett from the Lincoln Avenue deposit in the Playa del Rey area of Los Angeles County. These three records are from warm water, Upper Pleistocene deposits and are a mixture of what are now the Californian and Panamic faunas.

Type Specimen

In the original description of the species, Smith gives the dimensions of the holotype as: "Long. 39 mm., diam. 13; aperture $19\frac{1}{2}$ long; 5 lat." This would indicate that the type is an adult shell but not quite the maximum size as there are larger specimens in the Stanford University collection.

Smith figured the species with a line drawing and the only other illustration of the species which I can locate is in a paper by Mrs. Burton Williamson (1906). Smith did not say where the type was deposited; however, it is now in the British Museum (Natural History), B. M. (N. H.) Reg. No. 92.2.2.38.

Summary

Mitra fultoni E. A. Smith, 1892, is a rare species which belongs to the subgenus Strigatella and to the Mitra orientalis-idae complex within the subgenus. It is, however, quite distinct from all other members of that complex due to the distinct pitting which occurs in both axial and spiral lines on the spire as well as the entire body whorl.

The known Recent range of the species is along the Pacific Coast from San Diego, California, to the type locality into the Gulf of California to Santa Inez Bay, Punta Final, and Puertecitos on the eastern side of Baja California, and further south to Cocos Island. The species is not known to occur on the mainland of Mexico or in Central America. Probably it should be considered as a member of the Californian faunal province even though there are a few records of its occurrence in the Panamic province.

Specimens Examined

(Recent and Fossil)

1. 15 specimens from Potrero Canyon, Upper Pleistocene, Los Angeles County, California. UCLA Geology Collection (Sp. Cat. 10'078).
2. 12 specimens from Lincoln Avenue deposit, Upper Pleistocene, Playa del Rey, Los Angeles County, California. Los Angeles County Museum Collection (Loc. #59 S. 218, Willett Collection).
3. 4 specimens from Newport Bay Mesa, Upper Pleistocene, Orange County, California. Los Angeles County Museum (Loc. #66-2).

Explanation of Plate 7

Figures 1 to 3: *Mitra fultoni* E. A. Smith, 1892
(a: dorsal aspects - b: ventral aspects; all figures x 2.5)
Figure 1: Puertecitos, Baja California, Mexico (Sphon collection no. 503)
Figures 2 and 3: Whale Rock, near Point Abreojos, Baja California, Mexico
(Cate collection no. M - 46)

Figure 1

Figure 2

Figure 3

Figure 1 a

Figure 2 a

Figure 3 a

4. 1 specimen from San Martin Island, Baja California, Mexico. California Academy of Sciences (24'041 Cal. Acad.).
5. 3 specimens from San Bartolome Bay (Turtle Bay), Baja California, Mexico. Los Angeles County Museum (Willett Collection).
6. 2 specimens from Whale Rock area (near Point Abreojos), Baja California, Mexico. Cate Collection (46).
7. 1 specimen from Point Abreojos, Baja California, Mexico. Los Angeles County Museum (Willett Collection, A.375).
8. 4 specimens from Point Abreojos, Baja California, Mexico. California Academy of Sciences (367'002 Cal. Acad.).
9. 1 specimen from Point Abreojos, Baja California, Mexico. California Academy of Sciences (24'065 Cal. Acad.).
10. 10 specimens from Point Abreojos, Baja California, Mexico. Stanford University (4'543). (It is believed that these specimens may be part of the original collection of the species.)
11. 1 specimen from Magdalena Bay, Baja California, Mexico. California Academy of Sciences (24'063 Cal. Acad.).
12. 1 specimen dredged from 35 fathoms from Santa Inez Bay, Baja California, Mexico. California Academy of Sciences (17'749 Cal. Acad.).
13. 1 specimen and a fragment dredged from 50 fathoms off Punta Final (near San Luis Gonzaga Bay), Baja California, Mexico. Sphon Collection (504).
14. 1 specimen from Puertecitos, Baja California, Mexico. Sphon Collection (503). {Note: This number should also appear in the explanation of Plate 7. —— Ed.}
15. 1 specimen from Cocos Island, off Costa Rica. California Academy of Sciences (23'077 Cal. Acad.).

Additional Records

1. Three specimens from Point Abreojos, Baja California, Mexico. American Museum of Natural History, New York. (Arnold Constable Collection).
2. Two specimens from Point Abreojos, Baja California, Mexico. American Museum of Natural History, New York. (I. S. Oldroyd Collection).
3. One specimen from Point Abreojos, Baja California, Mexico. British Museum (Natural History). Holotype. B. M. (N.H.) Reg. No. 92.2.2.38.

Acknowledgment

I wish to extend my thanks to Miss Jane Turner of the Botany Department at the University of California at Los Angeles for her excellent chart. Mr. S. P. Dance of the British Museum (Natural History) was kind enough to confirm the location of the holotype. Mr. Todd Schowalter took the photographs.

My deepest thanks are extended to Mr. and Mrs. E. P. Chace of the San Diego Natural History Museum for making their own collection and that of the Museum available for me to use and for furnishing some much needed literature. I also wish to thank Dr. Myra Keen of Stanford University for her kind help and for making the Stanford University collection available for study. The staff at the California Academy of Sciences: Drs. G. Dallas Hanna and Leo G. Hertlein and Mr. Allyn G. Smith, were particularly kind in giving their time and help in making specimens available. Dr. William K. Emerson of the American Museum of Natural History, New York, furnished some locality records as did Mr. George Kanakoff of the Los Angeles County Museum.

Many private individuals have helped me by furnishing specimens, literature, references, and suggestions. Among these are Mr. and Mrs. Crawford N. Cate, Dr. Rudolf Stohler Mr. and Mrs. John Q. Burch, Mr. and Mrs. Joseph DuShane, and Mr. Mark Rogers. Lastly, I wish to give special thanks to one person in particular, Mrs. Faye Howard, without whose help, advice, and criticism this paper would not have been completed.

Literature Cited

Burch, John Q. (ed.)
1945. Minutes of the Conchological Club of Southern California, No. 49: 32.

Grant, U. S., IV, & H. R. Gale
1931. Catalogue of the marine Pliocene and Pleistocene mollusca of California and adjacent regions. Mem. San Diego Soc. Nat. Hist., vol. 1, 1036 pp., 15 text-figs., 32 plts.

Kanakoff, G. P., & W. K. Emerson
1959. Late Pleistocene invertebrates of the Newport Bay area, California. Los Angeles County Mus., Contr. in Sci. 31: 1-47, 5 figs., 3 tables.

Keen, A. Myra
1958. Sea shells of tropical West America. xi, 624 p., illus. Stanford Univ. Press, Stanford, Calif.

Linnaeus, C.
1758. Systema naturae per regna tria naturae. Editio decima, reformata.

Lamarck, J. B. P. A.
1799. Prodrome d'une nouvelle classification des coquilles. Mem. Soc. Hist. Nat. Paris, 1: 63-91.

Melvill, J. C.
1893. Description of a new species of Mitra. The Conchologist 2(6): 140.

Oldroyd, I. S.
1927. Marine shells of the west coast of North America. Stanford Univ. Press, vol. 2 (1): 297 pp., 29 plts.

Röding, P. F.
1798. Museum Boltenianum. Hamburg. viii + 199 pp.

Smith, E. A.
1892. Descriptions of new species of shells from Mauritius and California. Ann. Mag. Nat. Hist., ser. 6, 9: 255-256.

Swainson, W.
1840. A treatise on malacology. London, viii + 419 pp. 130 text figs.

Valentine, J. W.
1956. Upper Pleistocene mollusca from Potrero Canyon, Pacific Palisades, California. Trans. San Diego Soc. Nat. Hist. 12(10): 197.

Williamson, Martha Burton
1905. Some west American shells - including a new variety of Corbula luteola Cpr. and two new varieties of gastropods. Bull. Southern Calif. Acad. Sci. 4: 123 to 124.

——, ——
1906. West American Mitridae - north of Cape St. Luças, Lower California. Proc. Biol. Soc. Washington, 19: 193-197.

On *Cypraea tigris schilderiana* CATE

by

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(This paper is Contribution No. 156 from the Hawaii Marine Laboratory)

(Plate 8 and 2 Textfigures)

Cypraea tigris schilderiana from the Hawaiian Islands has recently been described by Cate (1961b). The purpose of this paper is to contribute further measurements and records of C. tigris both in the Hawaiian Islands and elsewhere in the Pacific, and to suggest three matters which merit further consideration: 1) the possible existence of C. tigris schilderiana outside the Hawaiian Islands; 2) the difference in habitat exhibited by C. tigris in the Hawaiian Islands and elsewhere in the Pacific; and 3) the variability in size of the subspecies within the Hawaiian chain of islands.

Shell measurements of Cypraea tigris were obtained from material in the Bernice P. Bishop Museum in Honolulu, and from numerous private collections in the State of Hawaii. A detailed geographical analysis of the specimens examined is summarized in Table 1. Measurements of length, breadth, and height were made to the nearest millimeter with vernier calipers, and the means and standard deviations for these measurements calculated. The shells were separated into three groups: 1) those from the Hawaiian Islands; 2) those from Johnston Island; and 3) those from other Pacific areas. The 75 percent rule for subspecies as set forth by Mayr, Linsley, and Usinger (1953) was applied by use of calculations of the coefficient of difference.

Figure 1 (see Plate 8), a length-frequency histogram, shows that whereas specimens of Cypraea tigris throughout the Pacific range in length between 51 and 147 mm., the majority of Hawaiian examples is longer than 100 mm., and the majority of those from other areas of the Pacific, with the exception of Johnston Island, is less than 100 mm. in length. Of the 403 individuals measured, only two specimens from the Hawaiian Islands were less than 95 mm. in length, and only nine from other Pacific areas excluding Johnston Island were greater than 95 mm. in length. The mean length of the Hawaiian specimens measured was 117 mm.; the mean length of those from other Pacific areas excluding Johnston Island was 77 mm.

The difference in size between specimens of Cypraea tigris from the Hawaiian Islands and Johnston Island, and those from elsewhere in the Pacific is further emphasized by comparisons of breadth and height (Table 1).

The figures for the coefficient of difference for the three linear dimensions of 1.9 for length, 1.9 for breadth, and 2.0 for height indicate that 95 percent of the Hawaiian population is different from the Pacific population (excluding Johnston Island) for these dimensions. Following Mayr, Linsley, and Usinger (1935), the Hawaiian population, considered only from the

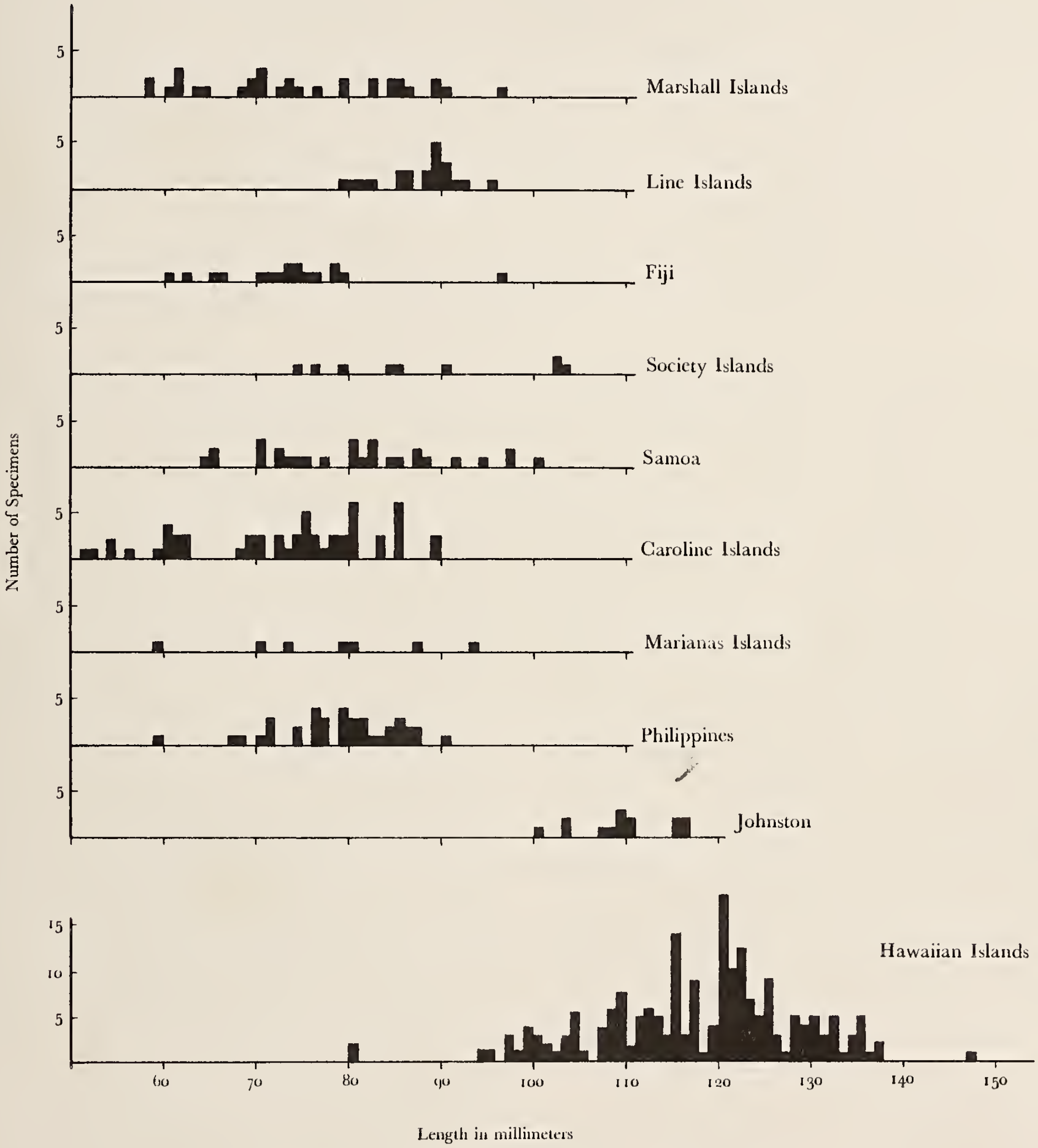


Figure 1: Length-frequency histogram showing the variations in size of *Cypraea tigris* in the Hawaiian Islands and other Pacific areas

Table 1: Geographical and Statistical Summary

Locality	No. of Specimens	Length			Breadth			Height		
		Range[1]	Mean[1]	S. D.[2]	Range[1]	Mean[1]	S. D.[2]	Range[1]	Mean[1]	S. D.[2]
Hawaiian Is.	198	80-147	117	10.1	56- 96	80	7.14	39- 81	64	6.3
Johnston Is.	14	100-116	100	—	72- 80	77	—	55- 65	59	—
Pacific	205	51-103	77	10.2	37- 77	54	6.1	28- 57	43	5.7
Marshall Is.	32	58- 96	76	—	42- 67	53	—	33- 57	43	—
Line Is.	21	79- 95	91	—	53- 65	54	—	41- 52	41	—
Samoa	29	64-100	77	—	43- 66	54	—	35- 54	44	—
Fiji	17	60- 96	73	—	42- 64	51	—	36- 47	41	—
Marianas Is.	7	59- 93	77	—	43- 63	54	—	35- 49	43	—
Caroline Is	52	51- 90	74	—	37- 65	49	—	28- 50	39	—
Society Is.	9	74-103	88	—	50- 77	60	—	40- 56	49	—
Philippines	38	59- 90	78	—	43- 59	54	—	35- 49	44	—

[1] Measurements in millimeters [2] Standard deviation

standpoint of linear dimensions, may be separated as a subspecies. No statistically significant differences were found for calculations of length/breadth and length/height ratios.

It is apparent from the data (Table 1 and fig. 1, Plate 8) that samples of Cypraea tigris from Johnston Island, which is 450 miles south of the Hawaiian Islands, fall within the size range of the Hawaiian specimens. The mean dimensions of the Johnston Island specimens are, however, slightly smaller than those of the Hawaiian sample. Because of the small sample of Johnston Island material, statistical tests for this group have not been included. However, it should be pointed out that the shells from Johnston Island resemble those from the Hawaiian Islands in color and lack a marginal callus, characters which Cate (1961 b) considers distinctive of the Hawaiian subspecies. An hypothesis accounting for the occurrence of a population of C. tigris at Johnston Island similar to the Hawaiian population has been put forward elsewhere (Kay, manuscript in press).

A survey of the literature and discussions with shell collectors in Hawaii disclose that the habitat of Cypraea tigris in the Hawaiian Islands is in contrast to its habitat elsewhere in the Pacific. In the Hawaiian Islands C. tigris is collected from depths of eight to ten feet and deeper (with one or two records of collection at depths of four to eight feet) where it is found beneath dead coral and on basalt boulders and spits. In other areas of the Pacific the species has been described as occurring exposed on the surface of large coral heads at Biak in the Marshall Islands (Bayr and Neurohr, 1946), in association with living coral heads on reefs between the tide marks in American Samoa (Ingram, 1939), and on various lagoon and seaward reefs in the Pacific (Demond, 1957).

Specimens of Cypraea tigris in the Hawaiian Islands vary in size with both depth and locale. Cate (1961a) has noted that "the smaller shells seem to come from the shallower localities in the southern end of the range, medium-sized ones from the intermediate depths of mid-range, and the largest known in the world from deep-water Oahu stations." Data confirming Cate's observations are presented in figs. 2 and 3. Although measurements for specimens from the Island of Hawaii are few and inconclusive due to the unavailability of records at the present time, the data from the islands of Kauai, Oahu, and Maui indicate a tendency for the larger specimens to be more abundant around the northern islands, with the exception of the extremely large specimens which were collected from deep waters off Oahu. It is also apparent that depth of collection varies with the islands; individuals from Kauai, the northernmost of the main islands in the Hawaiian chain, having been found at depths of 25 to 40 feet, while the islands to the south yielded collections from progressively shallower water.

Two specimens of Cypraea tigris have been examined from islands to the north of Kauai. It is noteworthy that both, one from Midway and the other from Kure, fall into the size range of material from the Pacific, being 63 mm. and 75 mm. in length, respectively. They also exhibit the callus and color pattern characteristic of the Pacific type. The dimensions of these specimens have not been included in the analysis of data, because of their apparent similarity to individuals from the other Pacific areas.

Another interesting feature concerning Cypraea tigris in the Hawaiian Islands is the shortage of collections of juveniles. There are only three known juveniles from Hawaii, all three collected by Dr. C. M. Burgess. Other

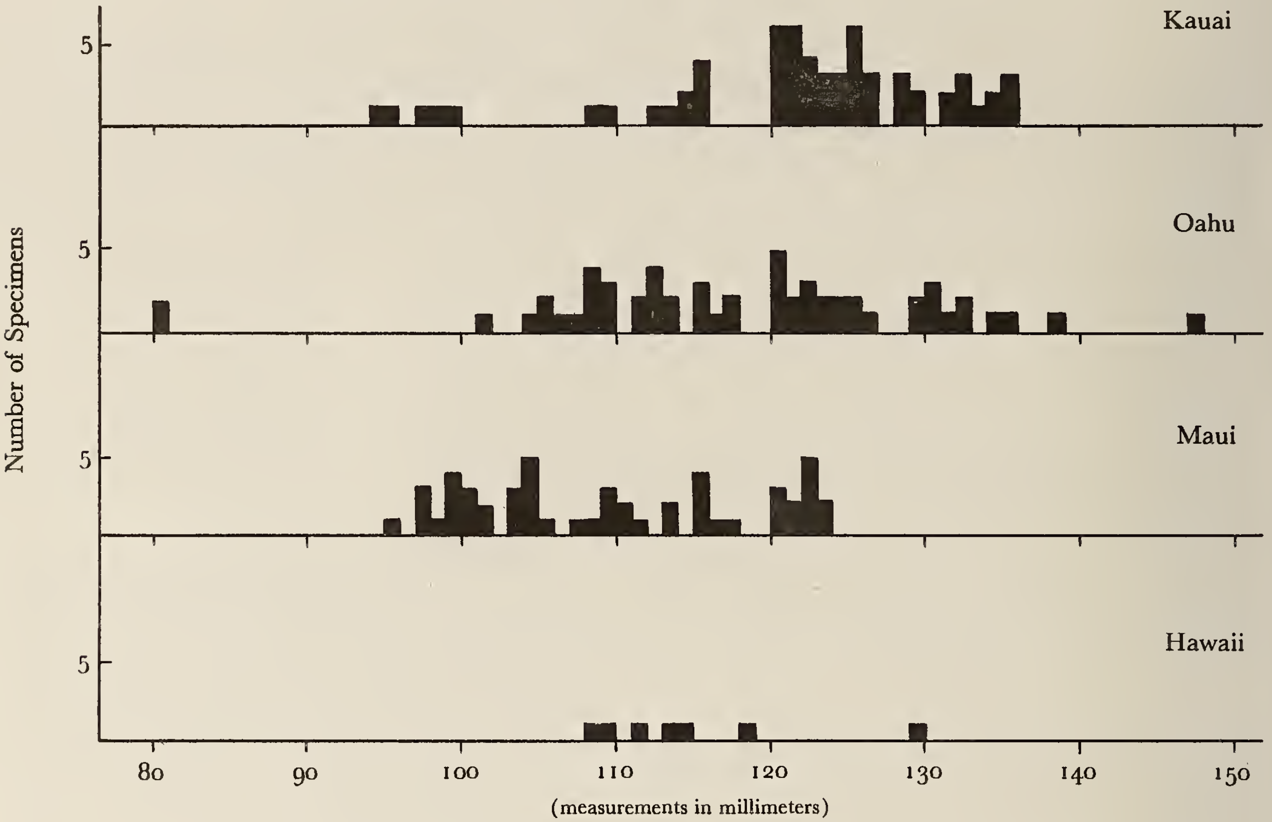


Figure 2: Length-frequency histogram showing the relationship between length and island for *Cypraea tigris* in the Hawaiian Islands

shell collectors with wide collecting experience have remarked that they have been unable to find juveniles of this species, although they are well known for other species of Cypraea.

The history of Cypraea tigris in the Hawaiian Islands is sparse. Cate (1961 a) has noted that Schilder (1933) considers early records of Garrett (1879), Baldwin (1898), and Hidalgo (1906) doubtful, and Cate regards the first authentic record to be that of a specimen collected in 1929 and recorded by Harris (1935). Cate's (1961 a) reference to a record cited by Martens and Langkavel (1871) is apparently an error; the reference quoted refers to Terebra tigrina from the Kingsmill Islands. Martens and Langkavel (1871) do not refer to C. tigris from the Hawaiian Islands.

Two early reports of Cypraea tigris in the Hawaiian Islands have recently come to the author's attention. The naturalist on the Portland and Dixon voyage to Hawaii mentions "... beautiful shells such as Cypraea tigrina..." from the Hawaiian Islands (Dixon, 1789). Another record is that of W. H. Pease, who described a specimen of "... Cypraea tigris from your island (Hawaii) five inches in length and over nine inches around the thickest part..." in a letter to Andrew Garrett dated March 5, 1857 (Manuscript Collection, B. P. Bishop Museum, Honolulu). As the dimensions mentioned by Pease fall well within the size range of the Hawaiian specimens, it would appear that C. tigris had been collected in the Hawaiian Islands prior to the 20th century, although Pease notes in the same letter, "... I never obtained but few."

While there are no records of Cypraea tigris in the Hawaiian archaeological collections of the B. P. Bishop Museum or among fossils from the late Pleistocene, there is one fossil example of C. tigris which has been tentatively dated as Recent. The shell was dredged from not more than four feet below the surface of a reef near Kaaawa, Oahu, in 1948 (R. Gage, personal communication). Ostergaard (personal communication) observes that the specimen cannot be assigned an age comparable to that of the fossiliferous limestone of Oahu (usually considered Late Pleistocene) because of its position below the surface of the reef.

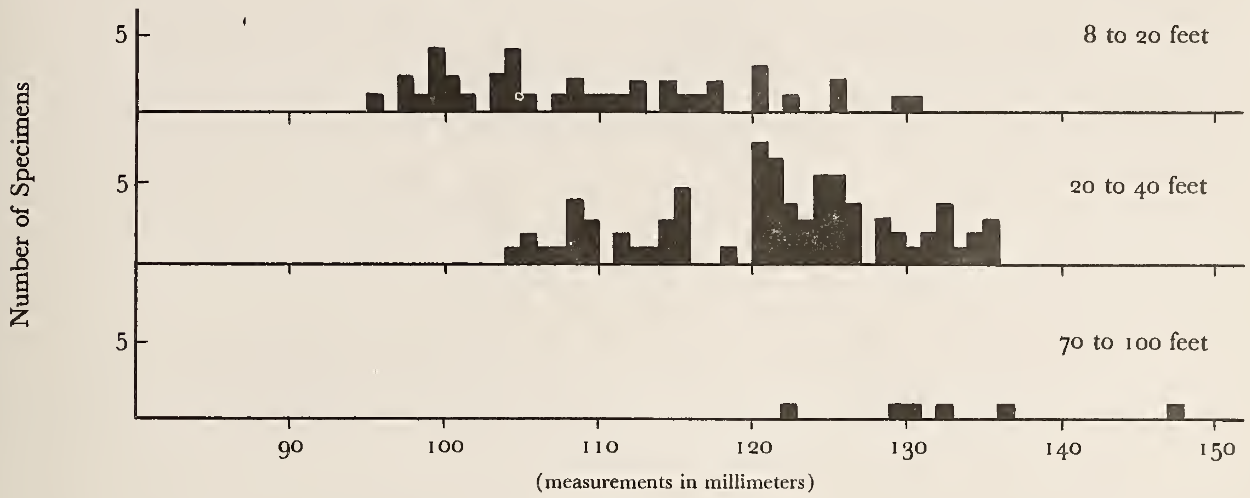


Figure 3: Length-frequency histogram showing the relationship between length and depth of occurrence of *Cypraea tigris* in the Hawaiian Islands

Conclusions

The data presented here, although somewhat scanty, are of interest not only with respect to studies of Cypraea, but as materials for speciation studies of marine invertebrates. It is well known that isolated areas and those near the periphery of a range are frequently inhabited by populations with distinctive biological characteristics. The existence of a distinctive population of C. tigris in the Hawaiian Islands, an area isolated from other Pacific islands by expanses of deep water and forming the eastern periphery of the range of C. tigris in the Indo-West Pacific is, therefore, not surprising. That the distinctive features of peripheral populations are correlated with ecological factors is also a generalization, but there is little information on the effects of ecological factors. We are particularly handicapped by the dearth of information and lack of experimental studies concerning early stages in life history. These data accumulated for adult C. tigris are, nevertheless, useful in that they focus on two major questions: 1) how are we to account for the large size of C. tigris in the Hawaiian Islands? and 2) is the size difference exhibited by the Hawaiian population genotypic or phenotypic?

Increased size in various animals has long been associated with low temperatures (Bergmann's Rule). Since surface temperatures of Hawaiian waters are at least 1.5°C. cooler than the lowest surface water temperature of other areas from which we have records of C. tigris (Sverdrup, et al., 1946), temperature must be considered as a possible factor affecting the size of individuals in the Hawaiian population of C. tigris. But the picture is complicated by the apparent presence of the Pacific type of C. tigris at Midway and Kure which have the lowest surface water temperatures in the Hawaiian chain, and of the Hawaiian type at Johnston Island which has a higher mean annual surface water temperature than that of the Hawaiian Islands (Sverdrup, et al., 1946). The occurrence of specimens in relatively deep water in the Hawaiian Islands compared with their existence in shallow water elsewhere in the Pacific, and variation in depth at which the species is found within the Hawaiian Islands is another complicating factor. Is there a relationship between water temperature and depth which would account for the observations? Or is there a factor associated with a different habitat? The Hawaiian Islands are high islands with reef formation and constitution considerably different from the atolls elsewhere in the Pacific. Are there differences in food and feeding habits? Is larval population density a factor affecting adult size?

The question as to whether the differences in size of Cypraea tigris are phenotypic or genotypic is equally provocative. It has been pointed out that slight geographical variation has been demonstrated in many marine invertebrates and the suggestion has been made that this sort of variation is a response to local environmental conditions (Mayr, 1954). The variation in size and depth of occurrence exhibited by C. tigris within the Hawaiian Islands is probably best considered an example of this type of variation. Is the presence of the Hawaiian type of C. tigris at Johnston Island, where there is a higher mean annual surface water temperature and an atoll-type environment, indicative of a genotypic difference when the pronounced difference in size of the individuals in the Hawaiian population is considered?

It is evident that there are no simple answers to the two questions posed above. That we are able to enumerate some of the factors and speculate on their possible effects is encouraging. With the further accumulation of ecological data and emphasis on experimental work we may in time contribute further information toward an elucidation of the factors affecting speciation in marine invertebrates.

Acknowledgment

I would like to acknowledge the patience and help of the many collectors in Hawaii who have contributed their collections of Cypraea tigris for measurement and their observations for analysis. I am particularly grateful to Dr. Yoshio Kondo of the B. P. Bishop Museum in Honolulu, to Dr. C. M. Burgess, Mr. and Mrs. Arch Harrison, Mr. Harold Jewell, and Mr. and Mrs. James Dennis of Honolulu, and to Mr. John Duarte of Kauai.

Literature Cited

Baldwin, D. D.
1898. Hawaiian Cypraeidae. Nautilus, 11: 123.

Bayer, F. M., & G. N. Neurohr
1946. Life on a tropical Pacific reef. Mollusca, 1: 107-112.

Cate, Crawford N.
1961a. Redescription of Cypraea tigris lyncichroa Melvill, 1888. The Veliger, 3 (3): 66-69, pl. 11.

——, ——
1961b. Description of a new Hawaiian subspecies of Cypraea tigris (Linnaeus, 1758). The Veliger 3(4): 107-108, pl. 19.

Demond, Joan
1957. Micronesian reef gastropods. Pacif. Sci. 11: 226-275.

Dixon, G.
1789. A voyage round the world . . . . . in the "King George" and "Queen Charlotte." London.

Garrett, A.
1879. Annotated catalogue of the species of Cypraeidae collected in the S. Sea Islands. Journ. Conch., 2: 105-128.

Harris, W.
1935. Cypraea tigris Linné in the Hawaiian Islands. Nautilus, 49: 39-41.

Hidalgo, J. G.
1906-1907. Monografía de las especies vivientes del genero Cypraea. Mem. Ac. Cienc. Madrid, 25: 1-588.

Ingram, W. M.
1939. Cypraeidae from American Samoa with notes on species from Palmyra Island. Nautilus, 52: 103 to 105.

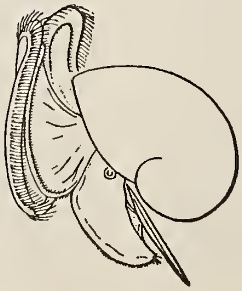
Martens, E. von, & B. Langkavel
1871. Südsee - Conchylien: Donum Bismarckianum. Berlin.

Mayr, E.
1954. Geographic speciation in tropical Echinoids. Evol., 8: 1 - 18.

Mayr, E., E. G. Linsley, & R. L. Usinger
1953. Methods and principles of systematic zoology. ix + 328 pp., 44 text figs. McGraw-Hill, New York.

Schilder, F. A.
1933. Cypraeacea from Hawaii. B. P. Bishop Mus. Occ. Pap., 10 (3): 3-22.

Sverdrup, H. U., M. W. Johnson, & R. H. Fleming
1946. The Oceans, their physics, chemistry, and general biology. x + 1087 pp. New York.



A Study of the Reproductive Cycle in the California Acmaeidae (Gastropoda)

Part III

by

HARRY K. FRITCHMAN II

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(Plates 9 to 14)

Subgenus COLLISELLA DALL, 1871

Acmaea pelta ESCHSCHOLTZ, 1833

Ecology: — This species was studied exclusively from the rocky point south of Rockaway Beach, San Mateo County, California (37°30'25" N.; 122°30' W.). The animals are common there, but are not as numerous as Acmaea scutum Eschscholtz, 1833. They seem to be about equally distributed between zone 2 and zone 3, and appear to require macroscopic algae upon which to browse. Acmaea pelta is somewhat more eurytopic than A. scutum and is often found high on the rocks among tufts of Endocladia and on rocks which are quite rough and have considerable barnacle growth on them. Acmaea scutum seems to prefer smoother surfaces and to avoid barnacles. There is also a behavioral difference in that A. scutum seeks moist, shady spots when the tide is out and may migrate onto the under surfaces. Acmaea pelta appears to be less sensitive to desiccation, perhaps due to its increased shell height and reduced aperture and may remain high on the boulder surface in the full heat of the sun.

Collections: — These were begun on September 25, 1949, and continued to April 16, 1952. At the outset and until mid-September, 1950, the sample consisted of about 25 animals. It became apparent that this rate of collecting would eventually deplete the population, and the number was reduced to 10 animals per collection beginning September 26, 1950, and continuing at this rate until the study was completed. A total of 934 animals was studied; 483 males, 422 females, 27 indeterminate, and 2 immature.

Results: — By comparing (Plate 9) the spawning record of Acmaea pelta with that of A. scutum (Fritchman, 1961), it will be seen that there is a striking similarity between the two. Both species were studied over the same period of time and from the same habitat. During this interval A. scutum definitely spawned 12 times and A. pelta 11 times. The spawnings of both were restricted, for the most part, to the fall, winter, and spring months. Despite this, however, there are only three times when the periods of spawning of the species coincide: January 22 to February 5, 1950, March 28 to April 11, 1950, and April 15 to April 28, 1951. In addition to these, there are three other times in which the spawning periods are adjacent in time to one another. Those of A. pelta are October 9 to October 22, 1949; March 12 to March 28, 1950; and September 26 to October 14, 1950. Thus, of the 11 spawnings of A. pelta, six either coincide with or else precede or follow by a maximum of only two weeks corresponding spawnings by the other common limpet in zone 2, A. scutum.

Analysis of Environmental Conditions Coincident with Spawning: —

As explained for Acmaea scutum, only nine spawning periods can be evaluated with reference to tidal and lunar phases, five being associated with full moons (January 22, 1950, March 28, 1950, June 18, 1950, March 18, 1951, and April 15, 1951) and four with new moons (October 9, 1949, February 5, 1950, March 12, 1950, and September 26, 1950). It is thus impossible to assess the role, if any, played by the moon in the spawning of this species. As previously noted with several other limpet populations, the summer months seem to inhibit the reproductive activity of this species, only the minor spawning of June 18 to July 2, 1950, occurring in this period of high temperature. Since A. pelta has been found to spawn at water temperatures ranging from 48.5°F. (January 22 to February 5, 1950) to 60.0°F. (September 26 to October 14, 1950), or over the entire yearly mean range of the surface water temperatures, it is doubtful that the spawnings are initiated by critical temperature levels. However, temperature levels may, as indicated before, play a role in rate of gonad redevelopment. During the fall and winter of 1949 we again see a retarded development of the gonads of A. pelta. The fall months of 1950 and 1951, both of which were warmer than 1949, each have two spawnings during that period, while 1949 has but one. It may be supposed that the spawning expected for November, 1949, was postponed until January, 1950. If this is assumed, then a general yearly cycle for A. pelta would appear to be as follows: one or two spawnings in the period of January through April, this depending on the mean temperatures of the winter months (if warm, as in 1950-1951 and 1951-1952 then possibly two, one in January and one or two close together in March and April); a reduced reproductive activity from May through August followed by a spawning in late September and October and another about two months later in November. Thus a total of three, or possibly four, spawnings occur throughout the year.

Acmaea limatula moerchii Dall, 1879

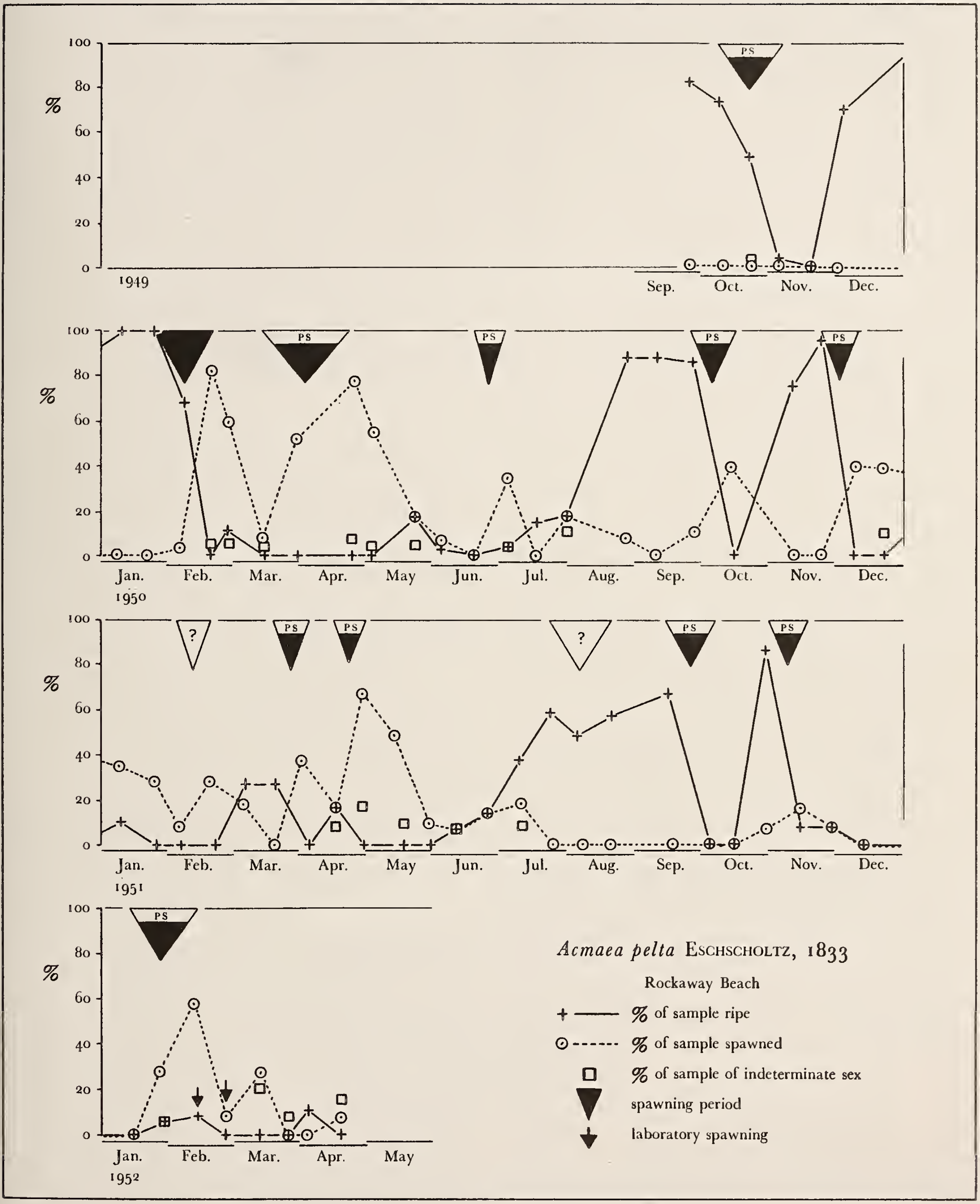
Ecology: — This species does not occur in numbers large enough to be studied north of Monterey, California, except for a restricted population found in Tomales Bay, Marin County, California, where it is the dominant limpet, and because of certain modifications of the shell and its markings, it has been given the rank of a subspecies, Acmaea limatula moerchii Dall. While the open coast A. limatula have a low shell which is predominantly yellow in color and lacking in brown markings, the subspecies moerchii has a high shell similar to that of A. digitalis Eschscholtz, 1833, and is strongly marked with brown. Both the animals from the open coast and bay have the dorsal surface of the foot pigmented with black but the degree of this pigmentation is reduced in the bay form and is rather grayish. In the bay this limpet is very eurytopic and can be found from the upper limit of the barnacle, Balanus, down to the lowest limit uncovered by the tide. The east side of the bay which receives the brunt of the wind and waves from the northwest does not have large growths of algae, probably because of the constant deposition of silt. The only alga present at the sites of collection was small amounts of Ulva, the collections being made at about the level of zone 2. The animals are scrapers of the bare rock surfaces and ingest large amounts of the mud which has settled on them.

Collections: — These were made from three points located at distances of 0.9, 1.5, and 1.9 miles south of the post office of the village of Marshalls (38°09'45" N.; 122°53'30" W.). Collections from the most southern of these areas were begun on October 10, 1950, from the central area on December 31, 1950, and from the northern area on March 25, 1951. Each sample consisted of 10 animals from an area and a total of 434 was examined; 156 males, 204 females, and 74 indeterminate. Collections were made at monthly intervals, the final sample being taken on April 29, 1952. The graph on Plate 10 has been constructed using the information gained from the study of limpets from all three areas, there being little, if any, variation in the reproductive cycles among residents of the three populations.

Results: — It seems apparent (Plate 10) that this species is following a yearly cycle which is different from any encountered thus far in the study. However, the gonad of this species does not develop the extreme turgor which characterizes the ripe condition of many of the other species and for this reason it is difficult to determine when the gonad has progressed beyond the partially ripe stage. These conditions were not included in the plot since the spawned and indeterminate conditions are readily noted and provide a much more dependable basis for establishing the reproductive cycle. The collection of this species began on October 10, 1950, at a time when the animals were just beginning to spawn, as is evidenced by the 40 percent of the first sample which were in the spawned condition. The next collection, made on November 5, showed that approximately 50 percent were indeterminate and it is seen that this condition prevailed until December 31. By late January, 1951, most of the animals were in the process of redevelopment of the gonad, and this condition prevailed until the next spawning season which began in September and reached its peak in October. Here again indeterminate animals appear following the completion of spawning. Acmaea limatula moerchii thus spawns during the time of year when mean sea and air temperatures are at their maxima, a fact that correlates with the southern distribution of the species. The attainment of these temperature levels undoubtedly determines the period of reproduction in this species. Possible stimuli to spawning cannot be speculated upon since collections were made only at monthly intervals.

Acmaea asmi (Middendorff, 1847)

Ecology: — This stenotopic limpet is restricted to the shell of the trochoid gastropod, Tegula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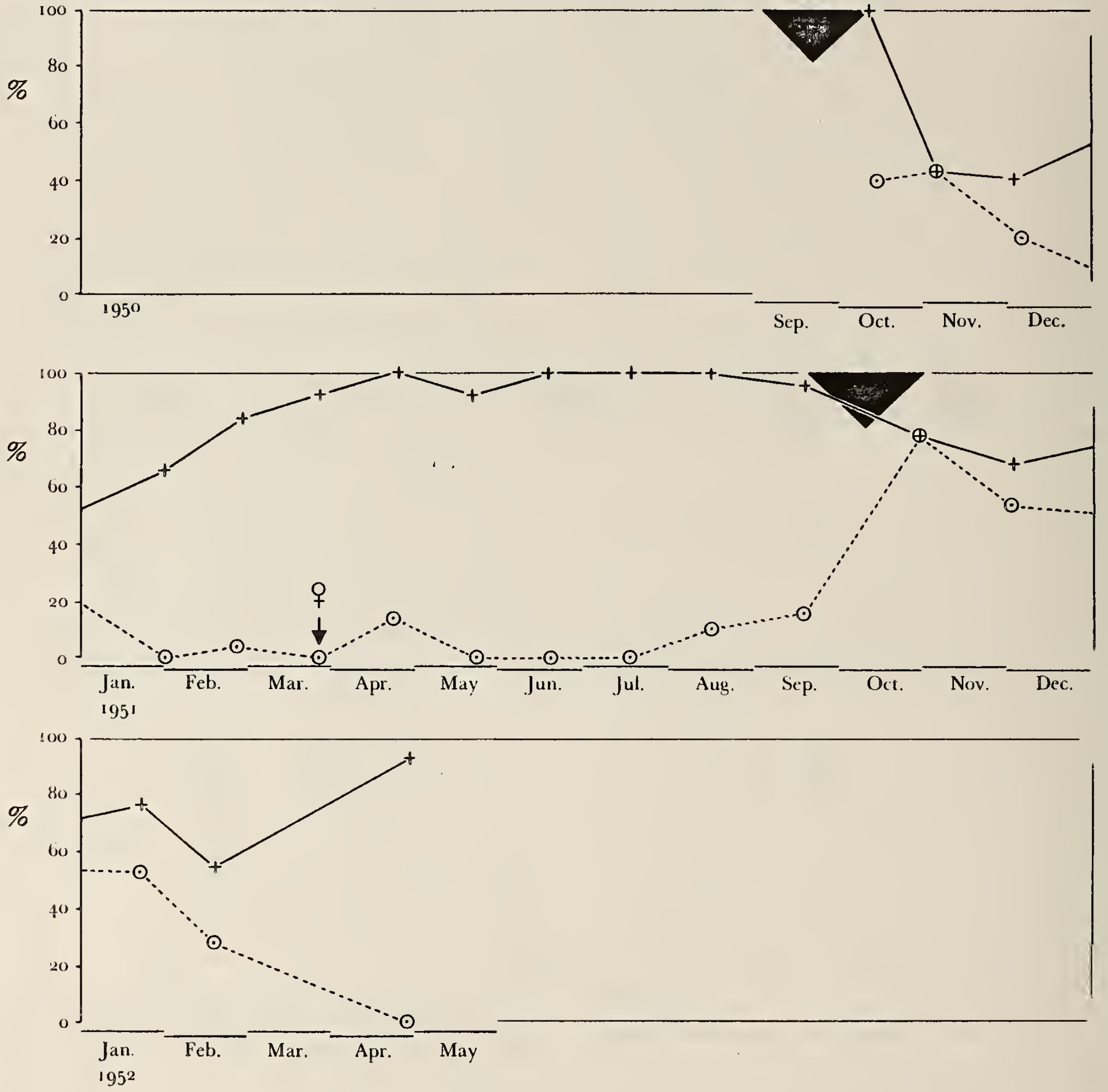
?
Jan.
1951
1952
Acmaea pelta ESCHSCHOLTZ, 1833
Rockaway Beach
+ —— % of sample ripe
⊙ - - - - % of sample spawned
☐ % of sample of indeterminate sex
▼ spawning period
⬇ laboratory spawning



Acmaea limatula moerchii Dall, 1879

Tomales Bay

+ —— % of sample sexually determinate

⊙ ----- % of sample spawned

▼ spawning period

↓ laboratory spawning

funebralis (C. B. Adams, 1854), a common zone 2 resident. This small limpet gathers its entire food supply from the diatoms and other microscopic plant life which are present on the Tegula shell. Casual observation of such shells shows that they are singularly barren of vegetable life and are all more or less eroded well into the prismatic layer. If the fecal pellets of the limpet are examined, it will be seen that they are purplish in color due to the large percentage of shell particles which have been rasped from the purple-black host. The poor source of food and the zone 2 location in the intertidal, which restricts feeding time and allows considerable periods of exposure to heating and drying, would appear to combine to render this unique habitat a rather unfavorable one for a limpet, but the species seems quite successful.

Collections: — Acmaea asmi has been collected from a rocky shelf which extends toward the sea and lies just to the north of the mouth of Sunshine Creek, a small stream found at Moss Beach, San Mateo County, California (37°31'30" N.; 122°31' W.). In this area Tegula funebralis is found in abundance, congregated in masses when the tide is out. The procedure was to collect all of the A. asmi present on the Tegula along this shelf at each collecting period. This usually provided between 20-25 animals and, of course, means that the area must be replenished with Acmaea-bearing Tegula every two weeks. Most of the immigrating Tegula probably came from the flat sandstone rocks to the north of the shelf, this area having moderate quantities of various algae growing upon it (Petrocelis, Endocladia, Gigartina, Iridophycus, and Cladophora). Since the creek runs not far to the south, replenishment from that area is unlikely.

Only the adult animals of this species have been examined, and because of the fixed size that the animals can attain, the thickness of the gonad can be used, in combination with that of degree of turgor, as an indication of ripeness. An adult animal which is ripe will have a gonad showing extreme turgor and which will be 1.5 to 2.0 mm. in thickness. Adult animals with gonads of 1.0 mm. or less are considered partially ripe or partially spawned, while spawned animals are readily identified by the thinness of the gonad and the small residual quantities of eggs and sperm. The study of this species was begun on November 5, 1949, and continued until April 16, 1952. However, during the first eight months, considerable difficulty was experienced in identifying the condition of the animals and for this reason these data have been discarded. Plate 11, then, has been prepared from the data of the collections of July 2, 1950, to April 16, 1952. A total of 851 animals was examined; 391 males, 446 females, 12 indeterminate, and 2 immature.

Results: — Acmaea asmi from this area of collection appears (Plate 11) to have a reproductive cycle which includes two spawnings per year, one in the spring in March or April, and another in the fall in September or October. Following the spring spawning, the gonads are redeveloped and remain in a ripe or partially ripe condition during the summer, much as was indicated for A. scutum. However, subsequent to the fall spawning period, this species passes into a rather strange condition, which extends until the following March or April. During this time the gonads are all much as they were at the conclusion of the fall spawning, practically none of them being ripe and a variable percentage spawned, but most of the animals possess gonads of 0.5 to 1.0 mm. in thickness and with moderate amounts of eggs and sperm. This latent period during the winter period is unusual since at that time all of the other species and populations studied are very active reproductively. This spawning pattern, like that found for A. limatula moerchii, reflects A. asmi's southern distribution and greater tolerance for and dependence upon high temperature.

Analysis of Environmental Conditions Coincident with Spawning: —

It is impossible to evaluate the effects, if any, which lunar and tidal periodicity have on this species because of the occurrence of periods of both new and full moons during the interval when spawnings are known to have taken place. As regards temperature, little can be said here since the temperatures at which reproductive activity begins in March and April, 52° to 53° F., is several degrees below that at which it ends, in the cases recorded, 57° to 60°F. It is thus difficult to designate any temperature as a critical one as has been done for several of the other species.

Acmaea digitalis Eschscholtz, 1833

Ecology: — (Rockaway Beach Population)

This species was studied from two localities and these will be considered separately. The first of these is a large concrete breakwater which stands at the tip of the rocky point which forms the southern boundary of the community of Rockaway Beach, California. This structure extends for about 100 feet in a north-south direction and stands about 12 to 15 feet high. It is anchored in the center to a huge boulder which divides it into north and south portions. It was from the lee side of this north section that extensive collections of Acmaea digitalis were made. The upper surface of the breakwater is never submerged although it is dashed by the surf at high tide. The leeward side furnishes a very uniform environment for the large numbers of A. digitalis which live upon it. The animals are completely protected from the direct beat of the surf and receive their water as it runs down the vertical face of the concrete. They receive uniform illumination from the east and south and are exposed twice daily to desiccation. The only source of food is that of microscopic plant life left by the surf and, during the winter, what algal film can proliferate. Throughout the summer months, the vertical faces appear to be burned bare of any living algae. The only other animals in this habitat consist of a few Littorina scutulata Gould, 1849, L. planaxis Philippi, 1847, and small barnacles, probably Balanus glandula Darwin, 1854. During the summer this habitat undergoes extreme heating and drying during the occasional long periods of low tide. Collections made at such times find the limpets in a state of extreme desiccation, the bodies of the animals being shrunken and brown within their shells, the foot being held to the substrate only by a thin film of dried mucus. This degree of desiccation is caused, to an extent, by the vertical surfaces of the breakwater which almost immediately drain and dry when the last wave of the descending tide has passed over the structure.

Collections: — These were begun from this habitat in February, 1949, and continued to April 16, 1952. A total of 9'902 animals was collected during this period at intervals of two weeks; 3'415 males, 3'365 females, 3'084 indeterminate, and 38 immature. The size of the samples varied. Initially, the sample consisted of approximately 250 animals. This practice was continued until February, 1950, at which time the number was reduced to about 100 per sample. A final reduction was made in October, 1951, to 50 animals per collection.

Results: — Two gonad conditions have been plotted (Plate 12): percent of the sample which was ripe and percent of the sample which was of a determinate sex. The two features which appear most evident from the plot of the reproductive cycle of this population are the single major spawning which occurs during the late winter or spring months and the indeterminate condition which is present during the summer months. The major spawning depletes the gonads completely except for a few residual eggs and sperm masses which remain for one to several months and permit the sex of the animal to be ascertained. Sooner or later these genital products are resorbed and the gonad becomes indeterminate. The major spawning may be preceded by a partial spawning in which all or only part of the animals participate. Such spawnings occurred in mid-January of 1951 and between late February and early March, 1951. After such spawnings, the gonad redevelops to a ripe condition prior to the major spawning. During the winter months when the gonads are developing, indeed, even before they have attained a fully ripe condition, spontaneous spawnings occur in the storage jars in the laboratory. Such occurred eight times during the winter of 1950-1951 and five times during the winter of 1951-1952. Accurate analysis of the condition of the population is seriously interfered with by this type of spawning and one of two alternatives may be used to express the data. One can assume that the population was either ripe or was approaching that condition and plot the sample as being ripe. This practice was followed for the 1950-1951 data. Or one can plot the actual condition of the sample when it was examined regardless of the degree of spawning which had taken place as was done in 1951-1952. The former method is preferred when the population is known to have reached a fully ripe condition prior to the first spontaneous spawning. There will usually be a few animals which will not have spawned and will, by the ripe condition of their gonads, give an indication of the status of the population at the time of collection. However, if the development of the gonad has been retarded as it was in the fall of 1951 and spontaneous spawning occurs prior to the fully ripe condition, then it is impossible to estimate what the natural condition of the population is at the time of collection. In such a case it is perhaps preferable to plot the data as it actually appears at the time of examination. This accounts for the low percentages of ripe animals which appear during the first two months of 1952.

Analysis of Environmental Conditions Coincident with Spawning: —

Of the five spawning periods which can be analyzed relative to the influences of lunar and tidal factors, namely April 24 to May 9, 1949, May 9 to May 23, 1949, March 18 to April 1, 1951, April 1 to April 15, 1951, and March 31 to April 16, 1952, three are associated with full moons and two with new moons. The maximal tidal ranges of these periods are 6.1, 8.0, 6.5, 5.8, and 6.5 feet. The only spawning period which was accurately reduced to an interval of seven days was that of February 5 to 12, 1950. This was a complete spawning so there could be no possibility of misinterpretation when the animals were examined. Here the tidal fluctuations were only moderate beginning with 5.8 on February 5 and continuing as follows: 5.0, 4.5, 5.0, 5.5, 6.0, 6.5, and 6.8 feet on February 12. Furthermore, this period does not fall under the influence of either a full or a new moon. Thus, there is no reason to suppose that the spawning periods of this population of high intertidal limpets are correlated with lunar periodicity and the attendant high tides. The surface water temperatures at which spawnings occurred are as follows: 1949, 55.0°F.; 1950, 49.5°F.; partial spawning 1951, 50.5°F.; complete spawning 1951, 52.0°F.; partial spawning 1952, 53.0°F.; and complete spawning 1952, 53.5°F.

Acmaea digitalis Eschscholtz, 1833

Ecology: — (Moss Beach Population) There are to be found at Moss Beach, San Mateo County, California, a series of large stone ledges located about 100 yards north of Sunshine Creek. These rocks are from eight to ten feet high and are very soft sandstone. They are seldom completely submerged but are wetted daily by the wash of the tide. The broad horizontal surfaces of the tops of these rocks have several small tide pools which support heavy growths of coralline algae. The top three or four feet of the vertical sides of the rocks support large colonies of limpets. Many occur in small depressions in the rock, either singly or in clusters of several per depression. Of these limpets, Acmaea digitalis is the most abundant, but A. scabra is also very common. The rock at this height supports a moderate growth of green algae, Ulva being the predominant type. In addition to the macroscopic algae, there is a film of microscopic plant life covering the rock. The porous rock allows these plants to thrive at a height which would be impossible, were the rock more dense, since the substrate is always damp. The limpets in feeding scrape up large amounts of sand and with it the attached plant life. Food is plentiful and, in addition, desiccation is reduced by the nature of the rock. All of the limpets were collected from the northern side of the northernmost of these rocks, thus assuring that they were taken from the most favorable area of this habitat which, because of its continued dampness, corresponds roughly to lower zone 2 or upper zone 3.

Collections: — These were begun in February, 1951, and extended to April, 1952. They were made every two weeks, each sample consisting of 15 animals. A total of 416 was examined; 247 males, 156 females, 5 indeterminate, and 8 parasitized.

Results: — The most striking difference (Plate 13) between the reproductive cycles of this population and that of the breakwater is the lack of an indeterminate period during the summer. Of the 416 examined, only five were indeterminate because of a complete spawning. Eight others were found to be indeterminate due to heavy infestations of trematode sporocysts and cercariae. The analysis of this population was more difficult because of its tendency to spawn during storage. This fact itself indicates the increased reproductive potential of this population as compared with that of the less favorable breakwater. These spontaneous spawnings took place throughout the year and resulted in normal trochophore larvae. The best indication of what was taking place in the population in its natural habitat was gained by recording the intensity of the laboratory spawnings and awaiting a sample which did not spawn and which, upon examination, showed itself to consist of recently spawned animals. Plate 13 indicates the condition of the sample when examined and also the extent of the laboratory spawning. By correlating these two pieces of information, the times of natural spawning may be approximated. An example of the method used is seen in relation to the collections of April 1 and April 15, 1951. The first of these spawned heavily as is indicated by the designation +3. This sample is believed to have been ripe when collected. The other sample showed only one ripe animal, the entire group being either completely or partially spawned. It is thus presumed that the population spawned between these dates. On the basis of this type of analysis, it is believed that the population spawned three times during 1951. This is considered, however, to be a conservative estimate. When the spawning reaction is as easily provoked as it is in this population, it is not at all improbable that minor, undetected spawnings may occur frequently and serve to augment the major spawnings.

The study of this population dramatically illustrates the effect which extrinsic environmental factors can have upon the reproductive capacity of these limpets. Both the Moss Beach and the Rockaway Breakwater populations are unquestionably Acmaea digitalis and in both habitats the limpets are abundant. The difference wrought in these animals by the environment is alteration of the reproductive potential

Analysis of Environmental Conditions Coincident with Spawning: —

Of the four spawnings recorded for this population of Acmaea digitalis, two coincide with spawnings of the breakwater group, these being in April, 1951 and 1952. The other two spawnings occurred in June to July and in December when the breakwater population was either indeterminate or in the process of gonad redevelopment. Two of the periods were in the presence of full moons (June 1951 and March to April 1952) and two in new moons (April 1951 and June to July 1951). The tidal ranges were 5.8, 6.5, 6.6, and 8.8 feet for the spawning periods. Sea temperatures ranged from 52.2°F. to 57.4°F., the latter temperature being 2.4°F. higher than the highest temperature at which the breakwater group spawned.

Acmaea scabra (Gould, 1846)

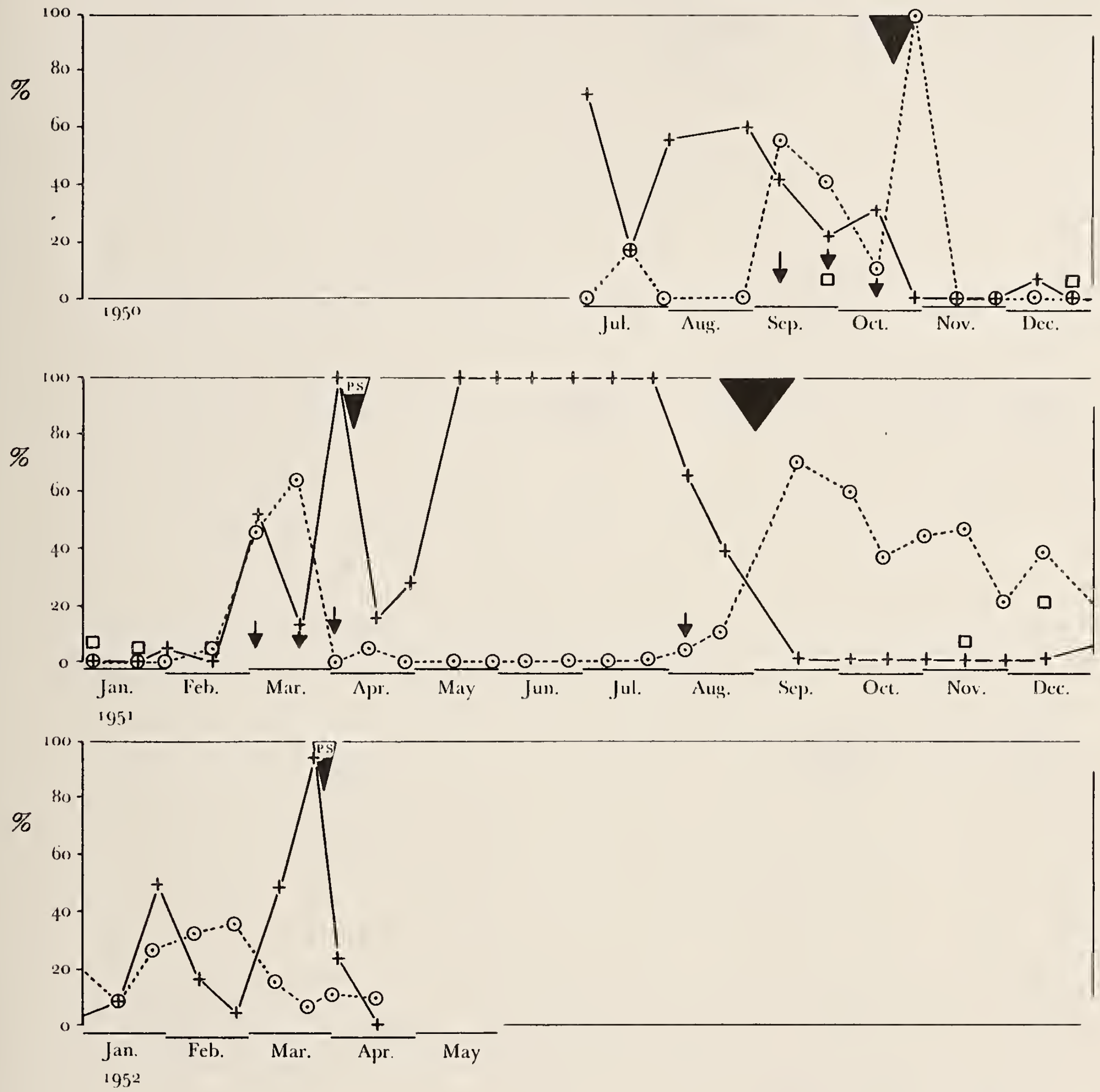
Ecology: — This species was studied from the horizontal surfaces of the Rockaway Breakwater. The top of this structure is about four feet wide and tends to retain water to a greater extent than that of the vertical surfaces from which Acmaea digitalis was collected. There is an increased concentration of barnacles, Balanus glandula, and moderate numbers of Mytilus californianus Conrad, 1837, along the seaward edge. Plant life is sparse, but some Endocladia is present. Although the radiation on this horizontal surface is probably more intense and of longer duration than on the vertical surfaces, the retention of water on the top reduces the degree of desiccation experienced. It appears that each A. scabra has a home scar on the rock from which it goes forth to feed and to which it returns when the tide recedes. Such a depression in the concrete allows the limpet to retain water in its shell and mantle cavities more effectively than A. digitalis which has no home scar and usually retreats to a shaded crevice when the tide is out.

Collections: — These were begun on September 25, 1949, and continued at approximately two week intervals until March 31, 1952. A total of 822 animals was examined: 414 females, 373 males, 33 indeterminate, and 2 immature. Although this is a sizeable number of specimens to be taken from a rather restricted area, and although the species managed to maintain its numbers despite the heavy collections, this habitat is not considered to be an optimal one for this animal. At no time, even at the time that collections were begun, was the species very numerous and some search was always necessary to obtain the desired number. In addition, the animals seldom attained the degree of gonad development which is associated with a condition of ripeness, or at least the degree found in animals from a lower position in the intertidal zone. This tendency for only moderate gonad development interfered, to an extent, with a clear-cut analysis of the reproductive cycle of this population. For this reason, the trend of gonad redevelopment was misinterpreted for the first year's study, and consequently no ripe animals are plotted for this period in Plate 14. Subsequent to this, only the categories of spawned and ripe have been plotted, with percentages of indeterminate whenever this condition occurred. During the period of April through August, 1950, collections were too infrequent and specimens too few to be considered reliable and thus this section of the graph is incomplete.

Results: — On the basis of data obtained from this study, it seems probable (Plate 14) that Acmaea scabra, in this habitat, spawns three times per year, in the late winter or early spring, in the early summer, and in late fall. There is no extensive period of indeterminacy in the summer as is seen for A. digitalis. This difference may be partially related to the somewhat more favorable habitat inhabited by A. scabra as described above, but, as will be discussed later, probably also is correlated with the greater tolerance of A. scabra to high temperatures. That A. scabra will become indeterminate in the summer months when it inhabits a very high intertidal position is shown by a brief examination of a population living on the high granite rocks near the Hopkins Marine Station, Pacific Grove, California. This study was made in July, 1949, and showed that the limpets were all indeterminate, while those taken from zone 2 amidst the Ulva were all reproductively active. Here, then, is another example of the effect of the environment on two ecologically different populations of a single eurytopic species.

Analysis of Environmental Conditions Coincident with Spawning: —

Of the six spawnings recorded for Acmaea scabra, two coincide exactly with spawnings of A. digitalis: January, 1951, and February, 1952. A third in mid-February, 1950, very nearly coincides with A. digitalis in the early part of the month. During the two periods of coincidental spawnings, it seems not unlikely that the two species were responding to a similar stimulus and, considering the fact, as will be shown later, that the two limpets evidently differ in



Acmaea asmi (MIDDENDORFF, 1847)

Moss Beach

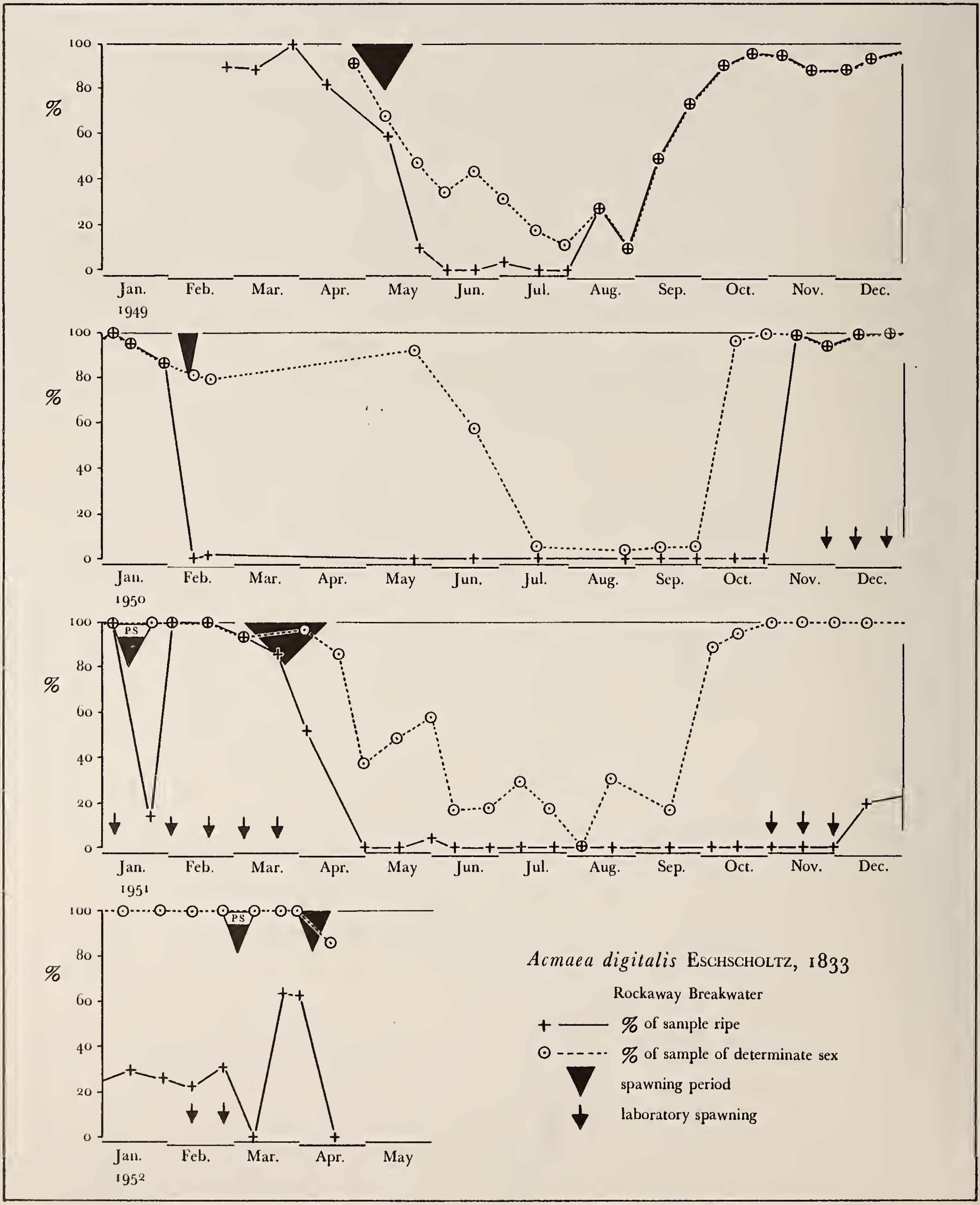
+ ——— % of sample ripe

⊙ - - - - - % of sample spawned

☐ % of sample of indeterminate sex

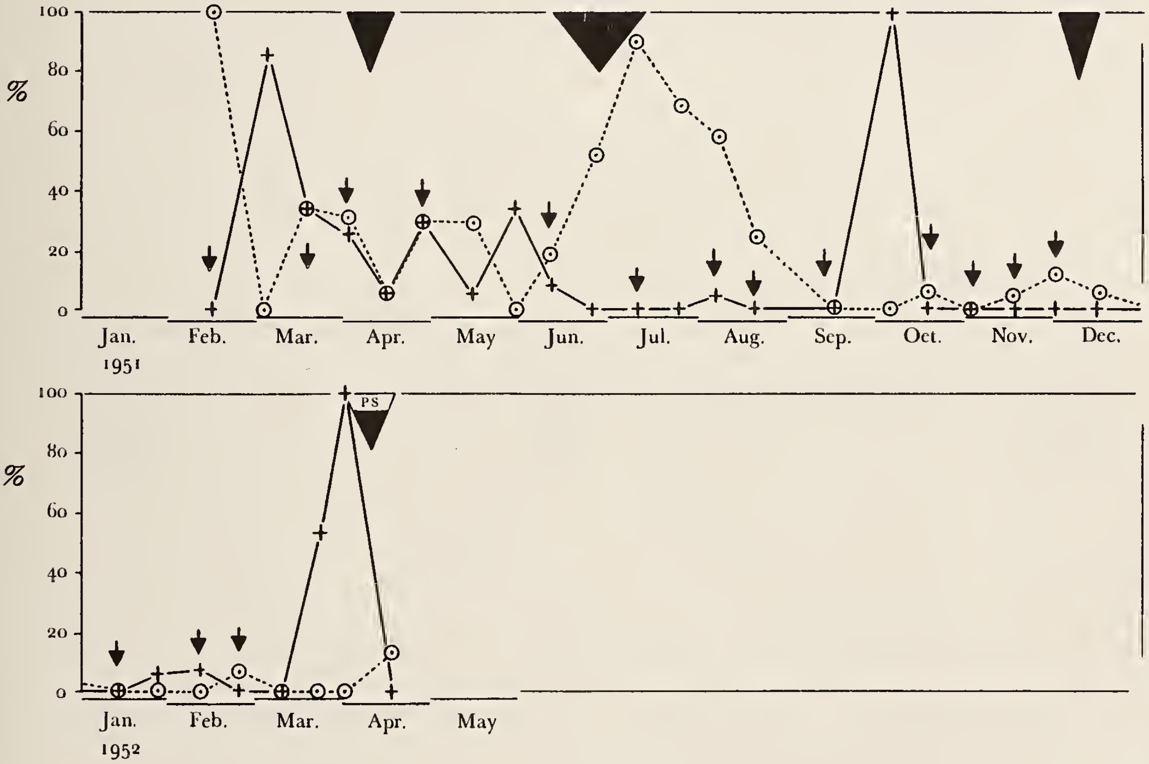
▼ spawning period

↓ laboratory spawning



Acmaea digitalis Eschscholtz, 1833

Rockaway Breakwater



Acmaea digitalis Eschscholtz, 1833

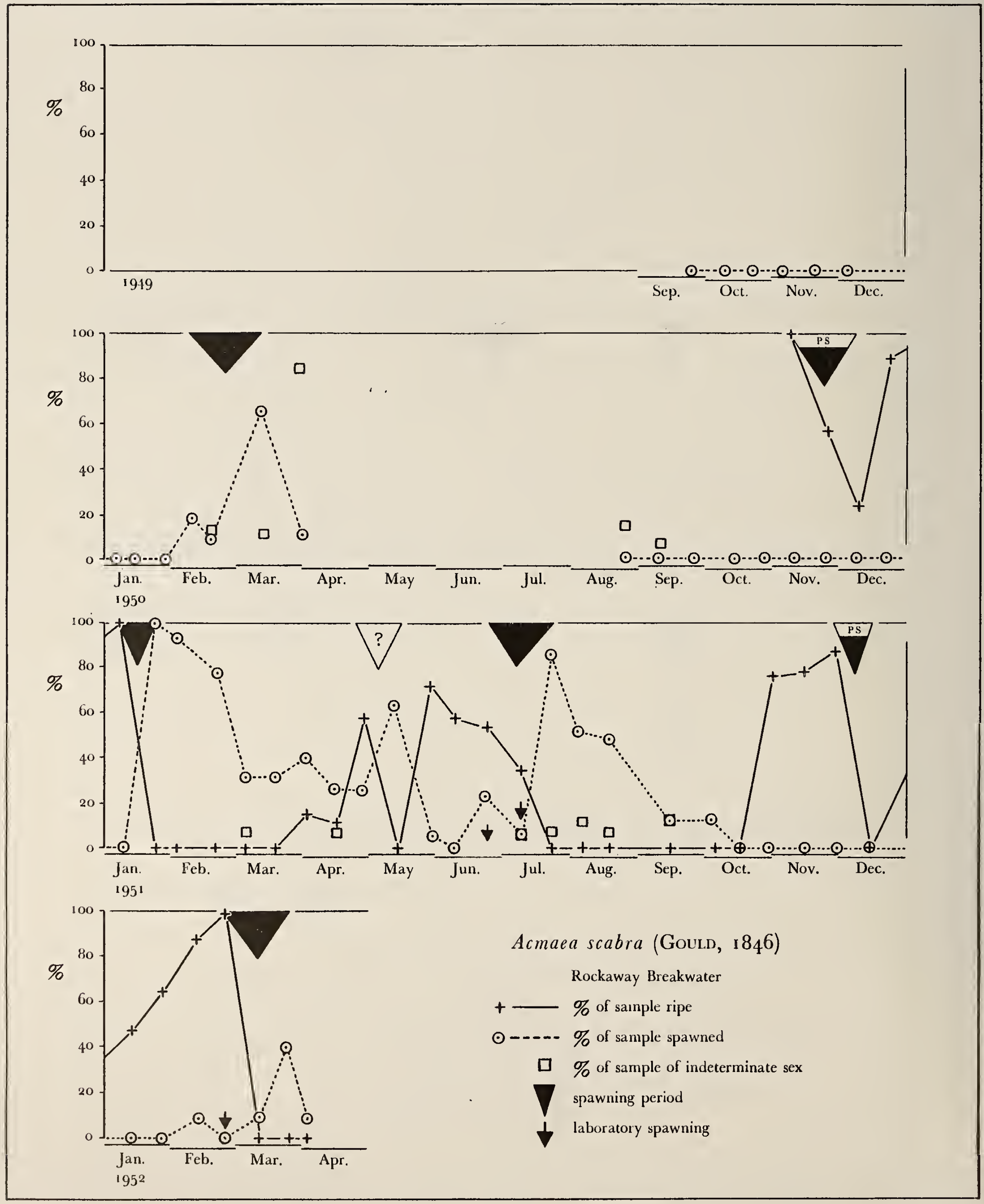
Moss Beach

+ ——— % of sample ripe

⊙ - - - - - - % of sample spawned

▼ spawning period

↓ laboratory spawning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Jul.
Aug.
?
1951
1952
Acmaea scabra (Gould, 1846)
Rockaway Breakwater
+ —— % of sample ripe
⊙ - - - - % of sample spawned
☐ % of sample of indeterminate sex
▼ spawning period
↓ laboratory spawning

their temperature requirements, this stimulus must probably be related to tidal action or lunar cycle. However, these influences cannot be accurately defined because of the appearance of both new and full moon phases during these periods. The maximum tidal ranges during which A. scabra spawned were 6.6 feet (June to July, 1951), 7.3 feet (February, 1950), and 8.7 feet (July, 1951). As with A. digitalis, these are quite inconclusive. The sea water temperatures at which spawnings occurred vary from a near minimum for this latitude (e.g., 50.0°F. in February, 1950) to 57.5°F. during June and July, 1951. This range is appreciably more than that found for the A. digitalis population on the breakwater.

Literature Cited

Fritchman, Harry K., II.
1961. A study of the reproductive cycle in California Acmaeidae (Gastropoda). Part II. Veliger 3 (4): 95 to 101, pls. 15-17.

Color Photography of Living Marine Mollusks

by

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FILMS

Any discussion of the color photography of scientific subjects must begin with some rather plain talk concerning the properties of the most readily available films. It should at the outset be realized that no color film made can reproduce exactly the complete range of tones of nature. The dyes which are presently available to the manufacturers are simply not that close to the theoretical needs. According to the statements of the makers, then, color films are designed to give an agreeable representation of what the eye sees. This is not to say that such films are necessarily poor in fidelity, but rather to point out that deviations from the ideal are to be expected and that they will differ from film to film. In fact, there will even be some deviations present between different batches of the same make and type of film.

My remarks on this subject will, of course, reflect my own experience to a considerable degree, but they will be supplemented to some extent both by certain statements by the manufacturers and by what I have read in the popular photographic press. Some basic knowledge of photography and its terminology will have to be assumed in order to limit the length of the discourse.

First of all, the films covered will be only the commonly available American products, because this is where my experience lies. Included will be Eastman Kodak's familiar Kodachrome and Ektachrome. Also mentioned will be Ansco's equally well known Anscochrome types. Negative materials will not be covered since the scientific uses normally require the transparency form. Only roll films are covered.

Probably the oldest and best known presently available color film is Kodachrome, which is respected everywhere for its very high resolution. In this respect it is easily the best film made. It also has the highest contrast of any color film made. Where sheer power to resolve fine detail is the main requirement, this film is the natural choice. Unfortunately, the high contrast brings difficulties in that lighting must be very soft and diffuse in order not to lose all shadow detail in a sink of blue-black nothingness. As to color fidelity, the common description of Kodachrome colors is "postcardy". That is, the colors are just too brilliant to be true. This is especially true in the blues and orange-reds. Lastly, the previously mentioned high contrast brings another trouble in that exposure latitude is thereby restricted, and small mistakes in exposure calculation show up all too readily.

But all is not lost. Eastman has just recently placed on the market the new Kodachrome II, which is said to correct many of the mentioned defects without loss of the great resolving power. In fact, they claim a slight gain. I have not yet completed my own first tests of this film, so can speak only from what I have read. The gist of this is that the contrast has been reduced, thus easing both the problem of lighting and that of correct exposure; the speed has been increased slightly, though not to the point where it will in itself cause any great revolution; and color fidelity is said to have been greatly improved, with special attention paid to reducing the tendency of reds to go orange, of blues to be too blue, and yellows to wash out. If this is all as reported the new Kodachrome II will be somewhat of a boon. Both types of Kodachrome are and will continue to be available to still photographers only in 35 mm. size. Kodachrome is out in daylight, flash, and tungsten emulsions. Kodachrome II is presently out in daylight, though a tungsten emulsion will follow shortly.

The next films to be considered will be Eastman's series of Ektachromes. Mainly there are three types, Ektachrome E-2, Ektachrome E-3, and High Speed Ektachrome. The first is their most readily available type and is a good all around film with excellent color fidelity throughout the spectrum except in certain delicate shadings between yellow and orange where ambiguity exists. Reds tend to be less orange than in Kodachrome, and violets and lavenders are produced particularly well. The E-3 type is similar to the E-2, but the fidelity in the yellows and oranges is better. Where available, this is a very fine film for scientific uses.

The High Speed Ektachrome is about like E-2 in color rendition, and has the highest normal film speed of any color film made. Where the need is for such high speed coupled with good colors, this is the film to use. Grain, however, is somewhat of a problem. By comparison to Kodachrome all other color films are grainy and not so good in resolution. In practice E-2 and E-3 Ektachrome, and the Anscochrome discussed later, are all quite satisfactory and can usually be used without disadvantage. High Speed Ektachrome is, on the other hand, grainy enough so that it may sometimes affect results. With all the Ektachromes contrast is sufficient to give good modeling, but not so great as to obscure normal rendition of shadow detail or to cause problems of exposure exactitude. Ektachrome E-2 is available in daylight and flash emulsions, E-3 and High Speed Ektachrome both in daylight and tungsten emulsions. E-3 is not, however, sold in 35 mm. size.

Lastly, we come to the Ansco products. The regular Anscochrome is comparable in nearly all respects to the two normal speed Ektachromes. Color rendition is without noticeable defects. It seems particularly good in reds, blues, and greens. Yellows seem not to suffer. Contrast and speed are moderate, and exposure latitude is good. Resolution and grain are satisfactory.

This manufacturer also makes Super-Anscochrome. For most scientific uses I personally do not care for this film. It has speed not far short of High Speed Ektachrome and is probably the most "pushable" color film made. That is, it can be forcibly developed to produce quite unusually high speed if one is willing to make sacrifices in grain and color fidelity. For most scientific uses, however, the color fidelity — even at normally rated speeds — is simply too poor. Reds go toward the brick-red. Violets and purples just come out as blues, and olive green comes out as a dirty grey. In normal use grain and resolution are similar to High Speed Ektachrome. In roll film sizes Anscochrome is available only in daylight emulsion. Super-Anscochrome can be had in daylight and tungsten emulsions.

In summary, one should choose a color film according to one's needs. For color copy or other use where brilliant color, high contrast, and high resolution are prime requisites, Kodachrome is the choice. For high speed with good color, use High Speed Ektachrome. For highest speeds — with forced development — without regard to color fidelity and grain, use Super-Anscochrome. For most other uses Kodachrome II, Ektachrome E-2 and E-3, and regular Anscochrome will all produce good results.

TECHNIQUES

Photography of live marine mollusks will usually be attempted in one of two locations. One may wish to do the job at tide-pool locations where the animals can be seen in their natural habitats, or it may be that the researcher's purposes will be better served by a studio situation where more attention can be paid to showing the form and color of the subject without concern for natural backgrounds. Since relatively little can be done in the former case, I here emphasize the studio methods.

The first requirement is an aquarium with one side made of clean plate glass of sufficient quality to minimize optical deviations when photographing through it. Cleanliness is essential, as any scum or other deposits on either side of the glass will have a very adverse effect on the sharpness of one's pictures. The water should also be as fresh and clean as possible for the same reason. In some cases, where one may wish to photograph directly downwards from above, a rather wide shallow container may serve. For most people, however, it will be more convenient to use an aquarium of normal proportions, placing one's camera in a horizontal position on a tripod.

Next comes the question of which type of camera is most suitable for this purpose. In my opinion, since the 35 mm. projection slide is the usual final objective, the most convenient instrument will be a 35 mm. single lens reflex. This type of camera allows direct viewing of the subject right up to the instant of exposure, a good feature where the subject is likely to be in motion across the field of view.

While good use can be made of the normal focal length lens of such cameras (usually about 50 mm.), it will often be found desirable to use a lens of longer than normal focal length. This is because such lenses will, at the same image magnification, allow a greater working distance between subject and lens. Of course, this may necessitate a longer bellows extension in order to get a desired image size. This is a matter for the photographer to decide according to his existing equipment and his means for getting more.

A setup which I have found useful is to arrange a sheet of glass within the tank in a vertical position and only an inch or so back from the side which will be the viewing port. The mollusks to be photographed can often be induced to adhere to this surface and will then be in position as though one were photographing directly down upon them. Some distance behind this glass is placed some piece of material of a color suitable for a pleasing background. For projection slides I have found that black seems to enhance the natural beauty of most colored specimens, especially as marine mollusks often have light or delicately shaded colors. If a light background is used, it may seem to sap the color of the specimen. This background is placed well back of the subject plane so that no sharp shadow will be thrown upon it and thereby cause edge lines to become ambiguous.

If it is desired to show the specimen in profile rather than from above, probably the best arrangement is to place a piece of material found in the habitat — perhaps stone or abalone shell — on the floor of the aquarium, and pose the specimen upon it. A background as described above can then be placed beyond to remove all unnecessary confusion from the background.

Lighting is probably best accomplished with either normal flash bulb attachments or with electronic flash, according to one's means. Flood lights usually do not allow sufficient speed in exposure. The simplest arrangement practical is to place one flash unit slightly above and to one side of the camera so that its light will strike the subject from an appropriate direction. Then, as close to the subject as can be arranged without entering the picture area, one places a white reflecting material directly opposite, that is, slightly below, on the side opposite the flash unit, though still on the camera side of the subject. This will cause enough light to bounce back to lighten the shadow areas.

A more comprehensive system of lighting would use three lights, all with a diffusing screen (white drafting tissue paper will do) placed in front to cut the harshness. One light is placed directly above the aquarium, pointing straight down on the subject. The other two would be placed one on each side of the camera. They would each be slightly above the camera level and would toe in so that their beams would converge on the subject. The object is to light the necessary area evenly, brightly, and softly with no obviously overlapping shadows. Some trial exposures should be made wherever possible in order to make sure that the lighting effects are harmonious.

Exposure will prove to be a matter for some conjecture. This is due in part to the light absorption of the glass of the tank and the water which fills it. Normally, flash exposures are determined by guide number, according to the instructions to be found upon the package of bulbs. The guide number is a function of three things: the type of bulb, the speed of the film, and the speed of the shutter. Knowing this guide number, one divides it by the distance in feet between the subject and the bulb. The resulting number is the diaphragm or f/stop to be used. In this use the guide number method of calculation is used as a starting point. Then several exposures should be made at slightly differing f stops. One should be on the calculated value, others should go above and below this in half-stop increments. Using any given standard set-up only, one series of tests like this should prove sufficient to guide one's actions in the future. It is always well, however, especially when the subject is rare or not easily replaceable, to cover things by making three different exposures for each desired shot: one on, one above, and one below. This assures the best results possible. The cost of the wasted film is much less than that of obtaining new specimens, when a single exposure has failed.

There now come several points for cautioning. One is that care should be taken to place the camera at right angles to the side of the aquarium to be shot through. Any slight angling-in will be likely to cause optical deviation through an offsetting of the image as it passes angularly through the glass. This results in an effect of slight stretching of the image in one direction and can ruin resolution of fine detail. The next thing to watch for is that improper placing of the lights will send reflections from the glass side of the tank into the camera lens, thus partially or completely obscuring the subject. And watch out also to see that no light sends its beams directly into the lens. At the very least, one will get a general weakening of the image and a lowering of contrast. So, shade the lens well.

No attempt has been made here to provide detailed drawings of any particular setup, or to give other overly detailed instructions. This is because every subject and every need will dictate changes and thereby nullify the value of the advice. In this area it is perhaps best to be general and allow the individual maximum room for decision according to his needs and equipment. About the only thing I can think of now is to observe how quickly the little devils can move across one's ground glass and out of the picture area. Be quick, but not abrupt.

Notes & News

Range Extension for *Trivia elsiae* Howard & Sphon

by

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Shortly after the description of *Trivia* (*Pusula*) *elsiae* Howard and Sphon, 1960, had gone to press — before it had actually appeared in the Veliger, vol. 3, no. 2, October 1, 1960 — a range extension was found.

The type locality was given as Punta Final, Baja California, Lat. 29°45'N.; Long. 114°25'W. One hypotype was cited from Bahia de Los Angeles, Baja California, about 75 miles south of the type locality. The shells described were all taken intertidally or from drift on shore.

In early September, 1960, the author had the opportunity to work over some of the small material from the dredge hauls of the Ariel Expedition taken near Isla del Carmen, Baja California. This material was taken August 29, 1960, at a depth of 25 fathoms. One apparently alive-taken, but slightly damaged, *Trivia elsiae* was found. It would be futile to attempt to mention associated species of shells because of the great numbers — about 85 species of pelecypods, well over 100 gastropods, at least three chitons, and fragments of one or more scaphopods. All these were taken from not more than a quart of unwashed dredgings.

This occurrence of *Trivia elsiae* near Isla del Carmen extends the geographic range southward about 250 miles and bathymetrically from intertidal to a depth of 25 fathoms.

Literature Cited

Howard, Faye B., & Gale G. Sphon, Jr.
1960. A new Panamic species of *Trivia*. The Veliger, 3 (2): 41-43, pl. 7.

Range Extension for *Tenaturris nereis* (Pilsbry & Lowe, 1932)

by

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This report concerns a living specimen of *Tenaturris nereis* (Pilsbry & Lowe, 1932) taken at San Felipe, Baja California, Mexico, June 10, 1960. The specific location for this shell is one mile north of the San Felipe lighthouse, at low tide, under a rock, near the edge of a sand beach.

The type locality for this shell according to Sea Shells of Tropical West America (Keen, 1958) is San Juan del Sur, Nicaragua. Although the Pilsbry and Lowe specimen was 7.6 mm. in length and 3 mm. in width, this single specimen exceeds these dimensions; it is 12 mm. in length and 6 mm. in width.

Literature Cited

Keen, A. Myra
1958. Sea shells of tropical West America. xi, 624 p. illus. Stanford Univ. Press, Stanford, Calif.

Name Change in *Mitra*

by

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The necessity for changes in several specific names has been apparent since Opinion 456 was published in 1957 by the International Commission for Zoological Nomenclature; this decision invalidated the four volumes of Thomas Martyn's Universal Conchologist because the author had not applied the principles of binominal nomenclature.

One of these invalid names, Mitra tessellata Martyn, 1784 thus becomes Mitra incompta (Solander in Humphrey, 1786), since this latter name was applied to the same species by George Humphrey in the Portland Catalogue just two years after publication of the Universal Conchologist, and therefore is the next available valid name. Humphrey's citation is as follows:

> "No. 2116. A large and a small specimen of Voluta incompta S. from the South Seas, extremely scarce. — Martyn, Vol. 1, fig. 19, 1."

This citation refers to the formerly accepted description and figure of Mitra tessellata Martyn.

Mitra terebralis Lamarck, 1811 is considered by some workers as a synonym of M. tessellata Martyn, and as such has generally been accepted as the name which would succeed tessellata; but Humphrey's reference to Martyn's figure antedates Lamarck's work by twenty-five years and should therefore take priority.

The name Mitra incompta Humphrey was correctly used by Jewell in the Hawaiian Shell News, December 1960, although he did not explain the reason for the change.

Literature Cited

Dall, William Healey
1921. Species named in the Portland Catalogue. Nautilus 34 (4): 131.
Humphrey, George
1786. Portland Catalogue, p. 96.
Jewell, Harold, Jr.
1960. Rare cowrie identified after two years. Hawaiian Shell News 9 (2): 4.
Lamarck, J. B. P.
1811. De la détermination des espèces de mollusques testacées: Mitra. Ann. Mus. d'Hist. Nat. 17: 201.
Martyn, Thomas
1784. Universal Conchologist, vol. 1, fig. 19, 1.

Eucrairia nom. nov. for *Drepaniella* Burn

by

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Geelong West, Victoria, Australia

Since the publication of Drepaniella Burn, 1961, The Veliger 3 (4): 102 - 104, it has been pointed out to me that this genus name is preoccupied by Drepaniella Del Guercio, Redia, 9: 188, 1913, a genus of Hemiptera. For the preoccupied name I wish to propose Eucrairia nom. nov., which is derived from the Greek word εὖ-Κραιρος--signifying "with fine horns."

A second species to be included in this genus is Ancula fuegiensis Odhner, Further Zool. Res. Swed. Antarctica Exp. 1901-1903, 2 (1): 45-46, pl. 1, figs. 20, 21. From this species the unknown radular formula for Eucrairia in my key to the Goniodoridid genera will be replaced by the formula 1.1.0.1.1.

Clementia solida Dall, 1902

Mr. E. C. Stiles has collected, during the past winter, what is probably the first complete specimen of Clementia solida Dall to be reported in Mexican waters. The species was described on the basis of a single incomplete valve. Better material has been cited recently and figured by Olsson from Panama and Ecuador. The new find was taken near Mazatlan, somewhat south of the type locality, Topolobampo. The specimen has been donated generously to the Stanford University Collection.

Ralph Arnold

(1875-1961)

Dr. Ralph Arnold, best known for his work on the Pleistocene of the San Pedro area, died April 20. In 1958 he was elected to Honorary membership in the American Malacological Union in recognition of his pioneer work on the California Pleistocene molluscan fauna. Dr. Arnold had just passed the 86th anniversary of his birth on April 14.

NEW CONCHOLOGISTS DIRECTORY IN PREPARATION

We have just learned that Mr. John Q. Burch is preparing the 1962 edition of the Directory of Conchologists. Mr. Burch expects to mail the first copies in January, 1962. However, he requests the cooperation of all interested persons to help him make this the most complete and up-to-date issue yet by sending in lists of members of conchological and malacological clubs (membership secretaries might be able to assist) or staff members of museums, universities, colleges, and other similar institutions. Special interests of the individuals should also be indicated, if possible.

Methods & Techniques

Narcotizing and Fixing Opisthobranchs

by

EDMUND H. SMITH

Pacific Marine Station, Dillon Beach, California

Over the years there have been cited a great number of methods for narcotizing and fixing mollusks in general and opisthobranchs in particular. I shall not attempt to review all of these methods but shall state some that I have found to work well on opisthobranchs.

Before discussing the actual methods of narcotizing and fixing opisthobranchs, one must stress the importance of complete field notes, which include careful color descriptions and pattern drawings. The color notes must be made before preservation as there seem to be no methods that will retain the delicate color of opisthobranchs.

When collecting small opisthobranchs from large amounts of algae, a shallow glass tray, filled with fresh sea water and covered with a black cloth, can be used. After one hour the snails will rise to the surface and a few drops of a saturated solution of eucaine (more stable than cocaine) or menthol crystals can be sprinkled on the surface. In a matter of thirty minutes to one hour the opisthobranchs will be narcotized and can be placed in Gilson's or hot Susa's fixative for two to three hours.

Larger opisthobranchs, such as the Eolids and Elysiidae, should be placed in fresh sea water until they are expanded. Stovaine (amyl chlorohydrin, 1 percent solution) or $MgCl_2$ is gradually added. The relaxed specimens are then placed in Gilson's fixative for about six hours. Dorididae can be narcotized in $MgCl_2$ and killed with boiling Susa's fixative. Aplysiidae may be narcotized with chloral hydrate (a teaspoon to a medium-sized beaker of water) and placed in liquid of Perényi to harden.

When either Susa's or Gilson's fixatives are used, all traces of the corrosive sublimate must be removed from the opisthobranchs before they are stored in alcohol. This can be accomplished by adding tincture of iodine to 70 percent alcohol containing the specimens. Enough iodine should be added to color the alcohol a port wine shade. The specimens should be placed in changes of fresh alcohol until all traces of the iodine are removed. Do not use metal instruments with either of the above mentioned fixatives; use a paint brush mounted in plastic, or a pipette. For permanent storage 70 percent alcohol should be used. Glycerine can be added in regions of hot weather or when the specimens are to remain packed for some time. This will prevent complete desiccation and decomposition of the specimen in case of evaporation.

Corrosive sublimate (mercuric chloride, bichloride of mercury), as referred to in this article, is a saturated solution in distilled water (about a 7 percent solution). Both Susa's and Gilson's fixatives must be filtered after three days. A list of formulas for the fixatives used in this article is given below.

Susa's Fixative:

$HgCl_2$	45.0 gm.
NaCl	5.0 gm.
Distilled water	800 cc.
Trichloracetic acid	20 gm.
Acetic acid (glacial)	40 cc.
Formalin (40 percent)	200 cc.

Gilson's mercuro-nitric mixture:

Corrosive sublimate	5.0 gm.
Nitric acid	4 cc.
Glacial acetic acid	1 cc.
Alcohol (70 percent)	25 cc.
Distilled water	200 cc.

Liquid of Perényi:

Nitric acid (10 percent)	4 parts
Alcohol (70 percent)	3 parts
Chromic acid (0.5 percent)	3 parts

Books, Periodicals, Pamphlets

A PROPOSED RECLASSIFICATION OF THE GASTROPOD FAMILY VERMETIDAE

by A. Myra Keen

Bull. British Museum (Nat. Hist.)
Zoology, vol. 7, No. 3, pp. 183 - 214,
pl. 54, 33 text figs. London, Feb., 1961.

It is most fortunate that the very difficult family at last has found such masterly treatment; many of the obscure and puzzling points are now cleared up. The student of marine intertidal ecology as well as the shell collector will be greatly benefited by this study.

However, we cannot pass by lightly a circumstance which we must deplore most seriously. For reasons known probably only unto the Trustees of the British Museum, this paper is copyrighted. While generally speaking a copyright may be a desirable thing to protect the rights of the creator of a literary work, it seems completely out of place in scientific writings. We readily grant that copyrights are justified in certain scientific works, such as keys and many of the compilative faunal surveys. However, a ticklish question is raised by the procedure of the Trustees of the British Museum. In this paper Dr. Keen describes a new genus. Since we have not had time to correspond with the Trustees to obtain permission to quote from the paper for the purposes of this review, we are not able to list the new genus! It will also mean that every future worker who has occasion to use the paper — and there will be many of these — will have to obtain permission from the Trustees to quote the new genus name. We wonder if the International Commission on Nomenclature will have to rule that the name in question is not available? And, if this copyright will stand, does it mean that all future authors should be "protected" in a similar fashion? We especially deplore this occurrence because it happened to Dr. Keen, a most generous scientific worker who would never have consented to this, we are convinced, had she had a voice in the matter. This brings to mind that not long ago in a periodical, a copyright had been obtained but when the problems connected therewith were pointed out to the author concerned, the copyright was rescinded promptly and retroactively. Let us hope that the Trustees of the British Museum will follow an equally sensible course.

RS

PELECYPODS FROM TRISTAN DA CUNHA

by T. Soot-Ryen

Results Norweg. Scientif. Exped. to
Tristan da Cunha 1937-1938, No. 49.
47 pp., 3 pls., and 9 text figs. Oslo, 1960.

This is another of the thorough papers by Dr. Soot-Ryen. In it he describes the following new species: Philobrya sivertseni, Ph. insularis, Verticipronus tristanensis, Cyclopecten (Cyclochlamys) perplexus, Notolepton atlanticum, and Rochefortula variabilis.

RS

WEST AMERICAN SPECIES OF THE BIVALVED GASTROPOD GENUS BERTHELINIA

by A. Myra Keen and Allyn G. Smith

Proc. Calif. Acad. Sciences, 4th Ser.,
vol. 30, no. 2, pp. 47-66, 33 figs., 1
color plate. March 20, 1961.

Ever since the exciting discovery that a heretofore "typical" clam was really a snail, much interest has been centered on this group of small gastropods. In the present paper an account is given of the search made for representatives of this group in the southern Gulf of California, and of the success of the search. When one regards the colored plate, one begins to understand why this amazing form has been overlooked for so long by even very experienced collectors.

RS

PECTINIDÉS DU NÉOGÈNE DE LA HONGARIE ET LEUR IMPORTANCE BIOSTRATIGRAPHIQUE

by I. Csepreghy-Meznerics

Mémoires de la Société Géologique de
France, Nouvelle Série, Tome XXXIX,
Feuilles 15 à 18, planches XXXVIII à
LXXII, Mémoire No. 92, pp. 1 à 58,
planches I à XXXV, 1960.

The scope and presentation of this monograph, dealing with the Pectinidae of the late Tertiary of Hungary, is in general similar to the fine European monographs of this family of pelecypods by Deperet and Roman, Roger, and Ugolini. Seventy-one species and subspecies are described, all except one are illustrated; their relationship to other species in the Mediterranean basin is discussed as well as their geologic and geographic range and facies occurrences. Conclusions concerning the biostratigraphic and paleogeographic significance of the species are included.

The species and subspecies are placed in four genera and one subgenus: Pecten (10), Flabellipecten (8), Amussium (3), Chlamys (48), subgenus Camptonectes (2). The following are described as new: Pecten fotensis, n.s., P. promontorensis, n. s., Flabellipecten telegdirothi, n. s., Chlamys scabrella hungarica, n. subsp., C. biaense, n. s., C. rakosense, n. s., C. darnoensis, n. s., C. agriensis, n. s., C. palmata bipartita, n. subsp.

This paper, beautifully illustrated, is a fine addition to the paleontological literature of the Mediterranean basin. LGH

SEA SHELLS OF TROPICAL WEST AMERICA

by A. Myra Keen

Second Printing. xi + 624 pages, over 1700 illustrations. Stanford University Press. $12.50.

In keeping with the modest approach of Stanford University Press, this new edition of the very valuable work by Dr. Keen is called a "second printing" yet there are quite a few changes incorporated, as well as all the comments and corrections of errata which were listed separately on the "Errata" and "Supplementary Errata". There are several new figures and additional figures, as well as a few name changes.

This "second printing" is again a must for the student of the mollusks of the west coast, as well as for the amateur shell collector, be he a beginner or an advanced connoisseur. How important the contribution of Dr. Keen is through the first edition (pardon us, the first Printing) of this splendid work may be assessed through the number of papers that have been appearing since the book was published; the research in the area covered by the book has certainly been stimulated and the result of these investigations will, in due time, necessitate another "Printing" with further additions. In many collections that we have seen in the past number of months, we find labels which bear the "K number" of the shell species, i. e., the number preceding the name in Dr. Keen's book.

It would appear that "Keen number" may come to mean to shell collectors what "Scott number" means to the stamp collectors, a quick, simple, reliable way of communication among the devotees.

Perhaps we should have mentioned that the "second printing" is on a whiter paper than the previous edition, which, to us at least, is more agreeable.

RS

REVISION OF TORNATELLINIDAE AND ACHATINELLIDAE (GASTROPODA, PULMONATA)

by C. Montague Cooke, Jr., and Yoshio Kondo

Bull. 221, Bernice P. Bishop Museum. December 30, 1960.

This comprehensive work was received too late for an adequate review. We expect to report on it in our next issue.

Ed.

CARIBBEAN SEASHELLS A GUIDE TO THE MARINE MOLLUSKS OF PUERTO RICO AND OTHER WEST INDIAN ISLANDS, BERMUDA AND THE LOWER FLORIDA KEYS

by Germaine L. Warmke
Curator of Mollusks
Institute of Marine Biology
University of Puerto Rico

and R. Tucker Abbott
Academy of Natural Sciences
of Philadelphia

This eagerly awaited volume describes 800 species of shells, most of which are not found in any other book on seashells. The superb photographs on 44 plates (some in full color) and the many line drawings make this an indispensable reference book for serious students and hobbyists alike. The unique feature of this new book is an extensive guide to shelling areas of the Caribbean. Each major island, from Bermuda to Trinidad and from Cozumel to St. Croix, is conchologically described, with travel hints, when and where to collect, and how best to clean and ship home specimens.
($8.95 postpaid)

JQB

PRELIMINARY STUDIES ON THE VENOM OF THE MARINE SNAIL CONUS

by A. J. Kohn, P. R. Saunders, and S. Wiener

Ann. New York Acad. Sci., vol. 90, article 3, pp. 706-725, Nov. 17, 1960.

A well documented study of the venom and its effect upon a variety of other animals. Cone species studied were Conus striatus, C. textile, C. aulicus, and C. marmoreus.

RS

THE VELIGER is open to original papers pertaining to any problem concerned with mollusks from the Pacific Region.

This is meant to make facilities available for publication of articles from a wide field of endeavor. Papers dealing with ecological, morphological, anatomical, physiological, distributional, taxonomic, etc. aspects of marine, fresh water or terrestial mollusks from any region bordering on or situated within the Pacific Ocean, will be considered. Even topics only indirectly concerned with mollusks may be acceptable.

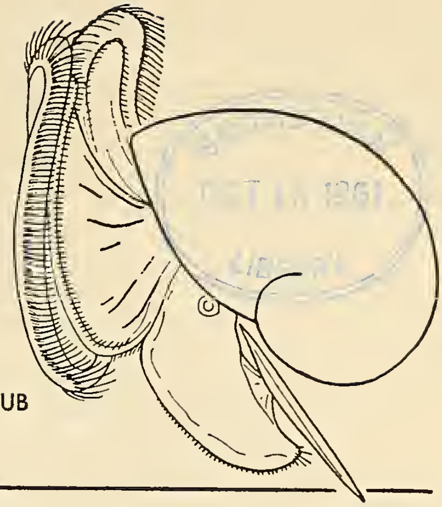
It is the editorial policy to preserve the individualistic writing style of the author; therefore any editorial changes in a manuscript will be submitted to the author for his approval, before going to press.

Short articles containing descriptions of new species or lesser taxa will be given preferential treatment in the speed of publication provided that arrangements have been made by the author for depositing the holotype with a recognized public Museum. Museum numbers of the type specimens must be included in the manuscript. Type localities must be defined as accurately as possible, with geographical longitudes and latitudes added.

Short original papers, not exceeding 500 words, will be published in the column "NOTES & NEWS"; in this column will also appear notices of meetings of the American Malacological Union, as well as news items which are deemed of interest to our subscribers in general. Articles on "METHODS & TECHNIQUES" will be considered for publication in another column, provided that the information is complete and techniques and methods are capable of duplication by anyone carefully following the description given. Such articles should be mainly original and deal with collecting, preparing, maintaining, studying, photographing, etc., of mollusks or other invertebrates. A third column, entitled "INFORMATION DESK," will contain articles dealing with any problem pertaining to collecting, identifying, etc., in short, problems encountered by our readers. In contrast to other contributions, articles in this column do not necessarily contain new and original materials. Questions to the editor, which can be answered in this column, are invited. The column "BOOKS, PERIODICALS, PAMPHLETS" will attempt to bring reviews of new publications to the attention of our readers. Also, new timely articles may be listed by title only, if this is deemed expedient.

Manuscripts should be typed in final form on a high grade white paper , 8½″ by 11″, double spaced and accompanied by a carbon copy.

THE VELIGER



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[CONTINUED]

Note: The various taxa above species are indicated by the use of different type styles as shown by the following examples:

ORDER, Suborder, **DIVISION, Subdivision,** SECTION,
Superfamily, Family, Sufamily *Genus*, *Subgenus*.

A New Doridid Nudibranch from Torquay, Victoria

by

ROBERT BURN

34 Autumn Street, Geelong West, Victoria, Australia

(Plate 15)

The genus Glossodoris Ehrenberg, 1831, is already represented in Victorian waters by five species (Burn, 1957, pp. 16-18). The new species described below differs in colouring from all of these species with one exception but can be separated from that species, G. haliclona Burn (loc. cit., p. 17), by the very different shape of its radular teeth.

According to Odhner (1957) the generic name Glossodoris should not be used, as the type species G. xantholeuca Ehrenberg, 1831, has never been anatomically examined. In place of Glossodoris Odhner proposed to use two names, based upon the rather simple division of the species assigned to the genus according to the shape of the radular teeth. For those species with the teeth hamate and denticulate, he proposed to use Chromodoris Alder and Hancock, 1855; and for those species which have tri- and bi-cuspid teeth he proposed to use the genus Hypselodoris Stimpson, 1855. However, until the question of the anatomy and radula are satisfactorily known in the type of Glossodoris with the probability of one of Odhner's suggested genera becoming a synonym, I prefer to use the older generic name.

Glossodoris arbuta BURN, spec. nov.

(Plate 15, Figures 1 and 2)

The single specimen (holotype) measured alive 22 mm. long and 5 mm. broad. Along either lateral margin of the mantle there are four or five deep indentations, each corresponding to a colour patch on the dorsal surface. The mantle is very little wider than the foot. The foot is grooved for its full length, anteriorly the lateral corners are expanded and form sharp corners, posteriorly the tail is narrow and rounded. The oral tentacles are short and digitiform. The rhinophores have 12 lamellae. The branchiae number 12 simple plumes, they encircle the white-rimmed anus.

The radular formula is 24 x 40.0.40. The teeth are all simply hamate, the cusp of each is unequally bifid. Except for the marginals each tooth has a longer basal plate than cusp.

The body colour is bright pink of a nearly strawberry hue, the rhinophores and branchiae are transparent pale red. The foot is outlined with a row of obscure white dots. About each indentation of the mantle margin is a large rounded patch of yellow; in the midst of these patches is a small number of minute bright red flecks.

Type locality: Point Danger, Torquay, Victoria. Long. 144° 19' East, lat. 38°20' South. (1 specimen, 30 March, 1959, collected by the writer.) It was found crawling on brown seaweed at extreme low tide level.

The specific name arbutus has been chosen in allusion to the wild strawberry tree or Arbutus tree, the colour of which is present on the new species.

Remarks: Three or four pink coloured species of Glossodoris are recorded from the Australasian region, and the new one must be compared with each of them. The Victorian G. haliclona Burn, 1957 (p. 17) does not have the marginal yellow patches on the mantle, the radula has half as many rows of teeth, and the teeth are denticulate instead of bifid as in the present species. The South Australian G. epicuria (Basedow and Hedley, 1905 [p. 153, pl. 7, figs. 1-3]), is larger, has five branchiae as compared with 12 in G. arbuta, the rhinophores carry more lamellae, the foot corners and oral tentacles extend beyond the anterior mantle, and the radular formula is smaller according to the original description while the individual teeth are denticulate. It is probable that the

Glossodoris *sp.* of Allan, 1947 (p. 445) is synonymous with *Chromodoris* (= *Glossodoris*) *australis* Risbec, 1928 (p. 143, pl. 7, fig. 8), but as the description of the former is inadequate and lacks any mention of the radula, the two must be maintained as separate species. As both species have darker red spotting on the mantle and the latter has denticulate radular teeth, neither can be identified with *G. arbuta*.

According to the arguments of Odhner (1957, p. 252), *Glossodoris arbuta* would be classified as a *Hypselodoris*.

The holotype has been presented to the National Museum of Victoria, Melbourne, where it is registered as F 21,272.

The radulae of the three following Victorian species of *Glossodoris* have been examined for comparison with *G. arbuta*. As none of these have previously been fully described or figured from Victorian material, the discrepancies are here made good.

Glossodoris victoriae Burn, 1957 (p.16) Plate 15, figure 3. The radular formula is 36 x 37.0.37. The first lateral is narrow and denticulate on each side of the cusp, one denticle is on the median side and four denticles on the marginal side. The subsequent teeth have five denticles on the marginal side. This species is referable to *Chromodoris* according to the arguments of Odhner (1957, p. 252).

Glossodoris tasmaniensis (Bergh, 1905), (Burn, 1957, p. 17) Plate 15, figure 4. The radular formula is 48 x 40.0.40. The first lateral is very broad, the cusp has two denticles on the median side and three on the marginal side. The subsequent teeth each have three denticles on the marginal side, the marginal teeth have one or two denticles whilst the outermost tooth appears to be bifid at the tip. The exceptionally broad first lateral tooth is a little separated from its neighbour, and for these conditions, i. e., broad lateral tooth and separation from other teeth in half row of radula, the genus *Noumea* Risbec (1928, p. 165) was proposed. In every other way the teeth are typical of *Chromodoris* (Odhner, 1957, p. 252). Pruvot-Fol (1951, p. 147) gives the radular formula of *G. tasmaniensis* as 50 x 150 (= 50 x 75.0.75), which is considerably more teeth per half row than in the present material.

Glossodoris haliclona Burn, 1957 (p.17) Plate 15, figure 5. The radular formula is 12 x 30.0.30. The first lateral is denticulate on both sides, the median side has one denticle and the marginal side, five. The subsequent teeth each have five denticles, that nearest the tip of the cusp is largest and is more like a bifurcation of the cusp than a denticle. The marginal teeth are small and dumpy, each with five denticles. The elements of the labial disk are shallowly curved with one end bifid. This radula approaches closest to *G. hilaris* (Bergh) as figured by Baba (1953, p. 210, fig. 6J), although the labial elements are very dissimilar. As with the previous two species, this one is referable to *Chromodoris* (Odhner, 1957, p. 252).

Literature Cited

Allan, J.
1947. Nudibranchia from the Clarence River Heads, North Coast, New South Wales. Rec. Aust. Mus., 21 (8): 443-463, pls. 41-43.

Baba, Kikutarô
1953. Three new species and two new records of the genus *Glossodoris* from Japan. Publ. Seto Mar. Biol. Lab., 3 (2): 205-211.

Basedow, H., & C. Hedley
1905. South Australian nudibranchs, and an enumeration of the known Australian species. Trans. Roy. Soc. So. Aust., 29: 135-160, pls. 1-3.

Burn, Robert
1957. On some opisthobranchia from Victoria. J. Malac. Soc. Aust., 1: 11-26, pls. 1-3.

Odhner, Nils
1957. *Chromodoris* contra *Glossodoris*, a systematic-nomenclaturial controversy. Proc. Malacol. Soc. London 32 (6): 250-253.

Pruvot-Fol, Alice
1951. Révision du genre *Glossodoris* Ehrenberg. Jour. Conchyliol. 91: 76-164.

Risbec, Jean
1928. Contribution à l'étude des nudibranches Néo-Calédoniens. Faun. Colon. Franç. 2 (1): 1-328, pls. 1-16.

Explanation of Plate 15

Figure 1: *Glossodoris arbuta* Burn, spec. nov. Dorsal view, x 4⅔ Figure 2: Two radular teeth of the same [a - an inner lateral, b - a marginal tooth] Figure 3: *Glossodoris victoriae* Burn. A half row of radular teeth [a - inner lateral, b - side view of a lateral tooth, c - near marginal tooth, d - marginal tooth] Figure 4: *Glossodoris tasmaniensis* (Bergh). A half row of radular teeth [a - inner lateral, b - side view of a lateral, c - near marginal, d - marginal tooth] Figure 5: *Glossodoris haliclona* Burn. A half row of radular teeth and a labial element [a - labial element, b - side view of inner lateral, c - side view of lateral, d - side view of marginal tooth]

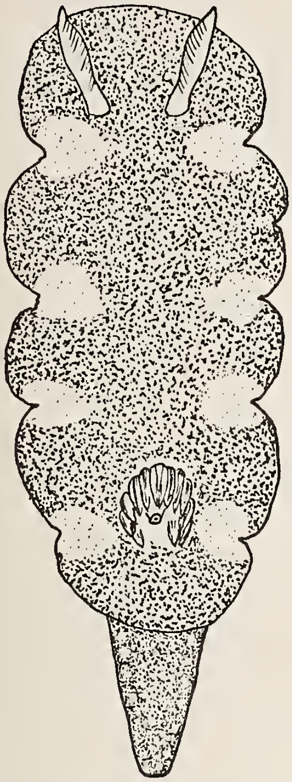


Figure 1

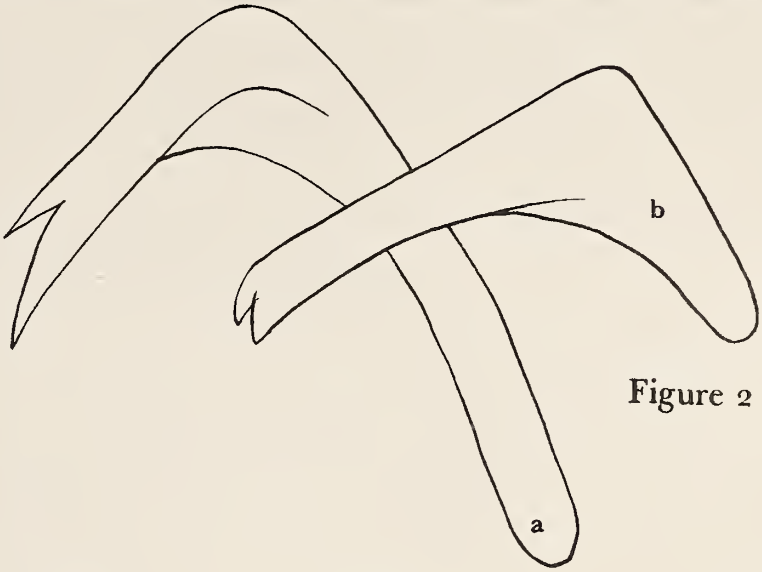


Figure 2

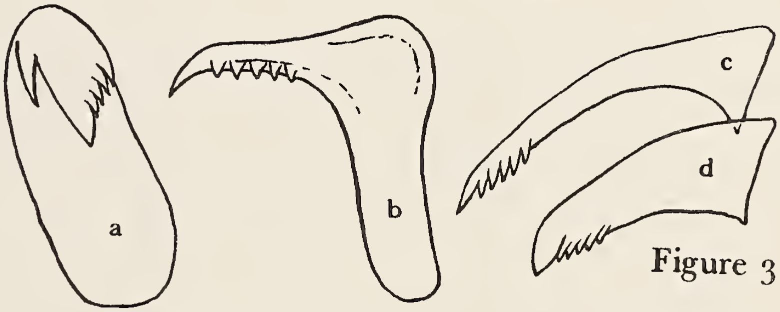


Figure 3

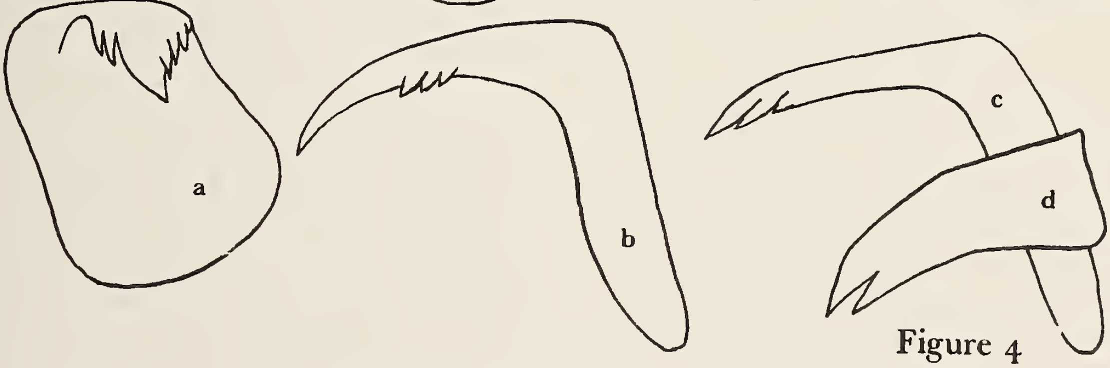


Figure 4

Figure 5

BURN, *del.*

Notes on the Opisthobranchs of the West Coast of North America

I. Nomenclatural Changes in the Order Nudibranchia (Southern California)

by

JOAN E. STEINBERG

850 38th Avenue, San Francisco 21, California

{Editor's Note: In the work preliminary to the preparation of the key to the opisthobranch mollusks of the west coast of North America, Miss Joan Steinberg has encountered a number of problems which she considers, quite rightly, should be dealt with before the key is completed. The present article is concerned with the first few of these; two other papers in this issue may be regarded as also contributing to the solution of some of these problems. - Since there are several serious gaps in our knowledge of this interesting group, gaps concerning assignment of certain species to a particular genus, as well as some others, we think that Miss Steinberg's approach is correct and that our readers will be glad to wait a little longer than originally anticipated for the completion of the keys which will, it is hoped, stimulate intensive further research in this group.}

The recent paper by Marcus (1961) on Opisthobranch Mollusks from California has contributed greatly to our knowledge of this group on the West Coast. However, it is evident that much more work is necessary, especially in those areas where little, if any, systematic collecting has been done, before we will really begin to appreciate the wealth of opisthobranchs in our fauna. For example, the only truly comprehensive list of nudibranchs from the West Coast of North America was prepared by O'Donoghue in 1926. It includes references and synonyms for all species known up to that time. However, O'Donoghue's work was compiled largely from the literature, and it has become apparent that a re-examination of a number of species is necessary in order to determine their validity or their exact systematic positions.

Earlier this year I had several opportunities to discuss systematic problems in the Order Nudibranchia with Mr. James R. Lance (Scripps Institution of Oceanography, La Jolla, California). Of primary concern to us were certain species recorded from Southern California, the systematic status of which was open to question. This paper is the result of our mutual and separate investigations. Mr. Lance has incorporated the nomenclatural changes proposed herein in his forthcoming list of the Opisthobranchs from Southern California. {Ed. Note: See the following paper by J. Lance.}

I am deeply grateful to Mr. Lance for his wholehearted cooperation with my attempts to achieve some standardization of nomenclature for our West Coast opisthobranch fauna.

Primarily, only nudibranchs occurring in Southern California were considered for this paper, although the ranges of many of these extend far northward. Therefore, in certain instances, it has been necessary to examine and compare specimens and descriptions of animals from Washington and Vancouver Island, as well as from Northern California, in order to clarify the issues at hand. I would like to thank the staff and students at both the Friday Harbor Laboratories (University of Washington) and the Hopkins Marine Station (Stanford University) for their assistance. Dr. Leo Hertlein (Geology Department) and the library staff of the California Academy of Sciences were most helpful to me in locating literature.

In 1926, O'Donoghue listed three species of dorid nudibranchs belonging to the Family Dendrodorididae from the West Coast of North America:

Dendrodoris fulva (MacFarland, 1905)
Dendrodoris vidua (Bergh, 1878)
Doriopsilla albopunctata (Cooper, 1863)

Doriopsilla albopunctata (Cooper, 1863) was first described as Doris (?) albopunctata from specimens obtained in deep water near Santa Barbara and from rocks at low water on Santa Catalina Island. In 1870, Cooper published additional distributional information on his species, stating that its range was from Baulines (sic., Bolinas) Bay to San Diego and that it was rare under stones at low water at Santa Cruz. Orcutt (1885) and Yates (1890), in faunal lists of mollusks from San Diego and Santa Barbara, respectively, also record Doris albopunctata but their records are based purely on Cooper's works. Orcutt has been the only author to utilize the information in Cooper's later paper, and it has been overlooked by subsequent workers.

In 1905, Cockerell and Eliot described a new species, Doridopsis reticulata, from San Pedro, which they suggested was probably identical with Cooper's form. O'Donoghue (1922a) later synonymized Cockerell and Eliot's species with Cooper's and, following Eliot's (1906) subsequent work on Cockerell's material, assigned it to the genus Doriopsilla.

However, also in 1905, MacFarland described a dendrodorid from Monterey Bay which he called Doriopsis fulva and which was later (O'Donoghue, 1926) referred to the genus Dendrodoris Ehrenberg, 1831. MacFarland, in his original description stated: "It is very possible that this species is identical with the Doris albopunctata of Cooper ...". He concludes, however, that, aside from similarity in coloration, the brief description contained points which were at variance with his material and that, in the absence of Cooper's type specimens, identification was very difficult.

One point which led Mr. Lance and me to consider the possibility that perhaps we were dealing with two separate species, Dendrodoris fulva in Central California and Doriopsilla albopunctata in Southern California, was that the animals from the Monterey area are nearly always bright yellow, whereas the animals in the San Diego region vary from yellow in the very small animals to a warm brown, tending to yellow near the edge of the notum in the larger individuals. In the latter the white glands which both MacFarland and Cooper mention are quite conspicuous, especially against the darker background, whereas they must sometimes be looked for carefully in living animals from Monterey.

In July, 1961, I collected a number of specimens from Mission Point and Point Pinos on the Monterey Peninsula which matched MacFarland's description and color plate (1906) almost exactly. In addition, I also collected the darkest forms I could find. One specimen from Mission Point was quite orange in general appearance but, under a dissecting microscope, proved to have the white glands typical of MacFarland's species. Furthermore, it bore a great many brown dots dorsally which gave it a dusky orange color. Examination of more typical specimens showed that there is a great variation in the presence of these brown dots. Several of the specimens at either extreme of the color range for the Monterey forms (from bright yellow to dusky yellow) and also varying in size were taken alive by air to La Jolla. The next morning a large number of the larger-darker and smaller-lighter forms was collected at Point Loma. After careful examination of the coloration of animals from both localities, it was concluded that, although the southern forms may get much darker dorsally as the animal grows larger, we are only dealing with a color variation which varies with latitude. Several other nudibranchs on this coast exhibit a similar darkening in color depending on the latitude. [A good case in point is Diaulula sandiegensis (Cooper, 1862). Animals in the Vancouver Island and San Juan Island regions are much darker than animals from San Diego or Monterey, although darker specimens may occasionally be collected in Central California.]

The yellow color of small specimens from both localities does not differ at all. As far as could be determined by dissection, the reproductive systems of both fitted MacFarland's (1906) description, and the central nervous systems, as well as the anterior parts of the digestive systems, were identical with that described by Eliot (1906) for Doriopsilla reticulata. It is my opinion that the two are identical and that Cooper's specific name takes precedence over MacFarland's.

Having established the synonymy of the two forms, the question arises as to which generic name should be used. Dendrodoris is distinguished from Doriopsilla by having the buccal ganglia situated some distance from the central nerve ring in a bend in the esophagus but joined to the central ganglia by a pair of long commissures. In Doriopsilla, the buccal ganglia are located immediately behind the central nerve ring, the two ganglia being joined by a short commissure. Although, as Eliot points out, it is difficult to determine the position of the buccal ganglia in relation to the rest of the nerve ring (except by sectioning), it was possible in the specimens I examined to determine that the position of the buccal ganglia was not as it is in Dendrodoris. The "strands" referred to by Eliot were first thought to be the long commissures to the buccal ganglia, but a more careful examination revealed their true nature.

Pruvot-Fol (1954), on the basis of the condition of the central nervous system, retains Doriopsilla as a distinct genus; however, Baba apparently considers it to be a subgenus of Dendrodoris (e.g., see Baba, 1949). Considering the fact that the central nervous systems of most of the numerous Dendrodorids which have been thus far described have not been investigated, I think that, until a thorough revision of the family has been undertaken on a worldwide basis, it is best to retain our species in the genus Dendrodoris belonging to the subgenus Doriopsilla. Until it can be shown that the condition of the central nervous system may be successfully used in separating genera in this very difficult family, I do not consider it wise to maintain Doriopsilla as generically distinct from Dendrodoris.

The precedence of Dendrodoris over other names has been thoroughly discussed (O'Donoghue, 1926, and Pruvot-Fol, 1954) and will not be repeated here.

I cannot agree with Eliot (1907) that MacFarland's Dendrodoris fulva (now D. albopunctata) is synonymous with Dendrodoris citrina (Cheeseman, 1880) from New Zealand. Apart from the great geographical separation of the two species, the two differ morphologically. Eliot describes the notum of D. citrina as "covered with numerous well-developed tubercules of rather irregular shape and size, and sometimes confluent." The notum of D. albopunctata is only minutely tuberculate. Furthermore, the buccal ganglia in D. citrina are some distance from the central nerve ring whereas, as has been pointed out, they are located directly behind the central nerve ring in D. albopunctata.

Cockerell and Eliot (1905) also described a dendrodorid from La Jolla as Doridopsis vidua (?) Bergh, 1878. The specimens had been sent to Eliot by Cockerell in California (as had his specimens of Dendrodoris albopunctata) and the latter worker believed his material to be a new species. Eliot suggested that, if the species were new, it should take Cockerell's manuscript name, Doridopsis nigromaculata. Cockerell later (1908) listed this form as Doridopsis nigromaculata C & E (vidua Bergh, var. (?), thus suggesting that he was not in full agreement with Eliot's determination.

The only other mention in the literature of this species from California, apart from O'Donoghue's later comments and lists (1922a, 1926, 1927), is in a list by Kelsey (1907) of mollusks collected in San Diego. It is apparent from Kelsey's list that the nudibranch records, at least, were obtained from the literature. I am informed by Mr. Lance that nothing which fits Cockerell and Eliot's description has ever been seen by him in over ten years of intensive collecting in intertidal areas, as well as in deep water, in the San Diego area.

Eliot never commented again on this species, and it is my opinion that, in view of the great geographical separation of the type locality of Dendrodoris vidua (Tahiti) and Cockerell and Eliot's material [later referred to the genus Dendrodoris by O'Donoghue (1926)], it is most probable that, if specimens which can be referred to Cockerell and Eliot's description are eventually found, it will be shown that they are not synonymous with Bergh's species. For that reason I support Cockerell's contention that the name of this species should be Dendrodoris nigromaculata (Cockerell and Eliot, 1905).

Doris (Asteronotus) alabastrina (Cooper, 1862) is known from only one specimen collected by Cooper under stones at San Diego Bay. The description is very brief: "Alabaster white, opaque, form depressed-oval, dorsal tentacles short, acute, branchiae of twelve simple rays expanding in the posterior fifth of the body. Length, four tenth in., breadth, three tenths of an inch." This species was later assigned to the genus Aldisa Bergh, 1878, by O'Donoghue (1926) who commented, "As near as can be judged from the meager description given by Cooper, this animal... probably belongs to the genus Aldisa, as his Doris (Asteronotus) sanguinea is properly Aldisa sanguinea." I cannot agree that such a decision is warranted.

Nothing which could properly be ascribed to Cooper's species has ever been collected by Mr. Lance in the San Diego area, and none of the characters described by Cooper can be considered truly diagnostic. I therefore propose that Doris (Asteronotus) alabastrina Cooper, 1862, be treated as a nomen dubium.

Cabrilla occidentalis Fewkes, 1889, the

type species on which Fewkes based his genus *Cabrilla* Fewkes, 1889, is definitely allied to the genus *Triopha* Bergh, 1880, as O'Donoghue (1926) suggested. It is known from a single specimen obtained by Fewkes on a buoy chain in Prisoner's Harbor, Santa Cruz Island. The illustration which Fewkes provides does not really resemble any of the described species of *Triopha*, nor does the description of the color (greenish brown covered with light green spots). As no description of the radula or of the internal anatomy was included in the description, it is impossible to decide this form's exact systematic position. I suggest, therefore, that *Cabrilla occidentalis* Fewkes, 1889, be considered a *nomen dubium*.

The species comprising the genus *Triopha* need to be studied more thoroughly in order to determine how many species actually exist on our coast. Marcus (1961) lists seven species and tabulates the radular characteristics of each. An eighth species, *Triopha catalinae* (Cooper, 1863), the radula of which is unknown, is discussed below.

A ninth species, omitted from Marcus' list, is *Triopha elioti* O'Donoghue, 1921, described from the Vancouver Island region. O'Donoghue believed his species to be identical with a *Triopha sp.* described by Cockerell and Eliot in 1905. In 1922, O'Donoghue (1922b) discovered that Cockerell in 1908 had given the name *Triopha aurantiaca* to his material from San Pedro, California. O'Donoghue then applied Cockerell's name to his specimens. O'Donoghue was quite specific in stating that his animals were white with orange or red markings and compared this coloration to *T. carpenteri* (Stearns, 1873) which is white to yellowish white with orange and red markings. He apparently ignored completely the fact that Cockerell, in naming his species, stated clearly that his specimens were orange.

In the museum at the University of Washington laboratory at Friday Harbor, Washington, are two specimens belonging to the genus *Triopha*. I had the opportunity to examine them briefly in August, 1960, and found that the smaller specimen (approximately 40 mm.), which was grayish white in formalin, had a radula which was identical with that described for *T. elioti*. The number of rows in the radula was not counted but the radula formula was 8-9.4.2.2.4.8-9.

In order to determine the original color of this animal, I contacted the collector, Mr. Michael Marsh (Department of Zoology, University of California, Berkeley) who kindly provided me with the information that the coloration was like *Triopha carpenteri*.

The second specimen referred to above was collected during my stay at the Laboratory. It measured over 150 mm. in length. The color was yellowish with many dark brown flecks scattered over the notum, producing a dirty yellow. The dorso-lateral processes were orange-red, and there were more velar processes than MacFarland (1906) figures for *Triopha carpenteri*. Again, the number of rows in the radula was not counted, but the radular formula was 9.9-10.2.2.9-10.9. This fits the lower limit for the number of lateral and marginal teeth recorded for *T. carpenteri*.

As no orange *Triophas* are known from the Friday Harbor or Vancouver Island regions, it is evident that O'Donoghue's specimens are not referable to Cockerell's *Triopha aurantiaca*, although the radulae are similar. Further investigation will be necessary in order to determine the relationship of *T. elioti* to *T. carpenteri*.

As was mentioned above, the radula of *Triopha catalinae* (Cooper, 1863) is not known. The color described for this form resembles that of *T. carpenteri* and *T. elioti* as well as that of *T. scrippsiana* Cockerell, 1915. *Triopha catalinae* was first described from Santa Catalina Island, and later Cooper listed its range as being from Baulines (*sic.*, Bolinas) Bay to Catalina Island, stating also that it was rare on stones at Santa Cruz. This range approximates the range for *T. carpenteri* which is known from Bodega Bay to Laguna Beach. Cooper's description is quite brief and offers no characters by which his species may be definitely allied to *T. carpenteri*. Moreover, his description could easily be applied to *T. elioti* or *T. scrippsiana*, although neither are known to occur within the range of *T. catalinae*. Marcus (1961) suggests that *T. catalinae* may have priority over *T. carpenteri* or *T. aurantiaca* (which he believed to be identical with *T. elioti*). I do not consider Cooper's description as adequate enough to permit definite identification of *T. catalinae* or to allow it to be compared with the other three species in this genus which it appears to resemble. I propose, therefore, that *Triopha catalinae* (Cooper, 1863) be considered a *nomen dubium*.

The only orange Triophid occurring in Southern California may possibly be *Triopha* aurantiaca if Cockerell's species from La Jolla may be shown to be distinct from T. maculata MacFarland, 1905. Mr. Lance informed me that, although the specimens of Triopha in Southern California greatly resemble immature T. maculata, he has never seen anything resembling a mature T. maculata in either intertidal or deep water collections. Triopha maculata was recorded by O'Donoghue in 1927 as occurring at Laguna Beach, but he states that his specimens "... were orange or tawny in color, and covered with few or many small white spots. The processes on the sides of the dorsum and the oral veil, the tips of the branchiae and rhinophores were orange red." He describes the radula as having four to five lateral teeth and seven to eight marginal teeth on a side in each row, but figures only the first three lateral teeth and nine marginal teeth, the outermost one being quite small. It is, therefore, quite difficult to compare his description with T. maculata as it is known in Central California.

In July, 1961, I took with me to La Jolla several living specimens of Triopha maculata collected at Point Pinos on the Monterey Peninsula. The largest of these, about 25 mm. in length, was beginning to show the darker color typical of mature forms. The dots on its notum and sides were white. The other animals were uniformly orange-red. Ten specimens of the southern Triopha were collected the next morning at Point Loma and the material from both collections was compared.

Nine of the animals from Point Loma were small (averaging about 10 mm.) and were nearly identical in color and in size with the small specimen from Point Pinos, except that several of the Point Loma animals had grayish dorsolateral processes which were only tipped with orange-red.

The tenth specimen from Point Loma was about 35 mm. in length. The ground color was pale orange with white spots and darker dusky orange dorso-lateral and velar processes and branchiae. The notum and sides were speckled with tiny brown flecks everywhere between the white spots. These brown flecks were much lighter than the brown flecks which caused the darker color in the largest specimen from Point Pinos.

All of the specimens from both localities were identical morphologically except for the velar processes which varied in number from nine to 13. All bore five dorso-lateral processes on a side, and all had four small tubercles arranged longitudinally down the midline of the notum as MacFarland figures for a mature Triopha maculata (1906, pl. XVIII, fig. 18).

Of the four small specimens from Point Loma whose radulae were examined, all had three hamate lateral teeth on a side in the complete rows and a fourth lateral tooth which had a poorly developed hook. The largest specimen had five hamate lateral teeth.

All of the specimens from Point Pinos had four lateral teeth on a side, the outermost lateral being well developed.

In view of the obvious absence of specimens from Southern California which are clearly referable to MacFarland's Triopha maculata as he described and figured it, I cannot now synonymize the Southern California form with that which occurs in Central California. It seems obvious that much additional work is necessary in order to separate clearly the species in this genus.

Marcus (1961) has pointed out that the number of lateral teeth increases and the number of marginal teeth decreases as the animal gets larger and describes the origin of the spurious rachidian teeth. I believe, as his discussion seems to point out, that this can happen only to a certain extent in a given species. In considering the genus as a whole, it appears that the radula may be of only secondary importance in identifying species. I suggest that some other set of characters must be selected for use in separating species in this genus.

It is apparent from O'Donoghue's list (1926) that he was unaware of the exact nature of Lateribranchia festiva Stearns, 1873, as he placed it with the phanerobranch dorids. It is correctly placed in the genus Tritonia by Marcus (1961) and has been known by workers on this coast variously as Duvaucelia or Sphaerostoma festiva since 1927 when Johnson and Snook published a short description and a colored figure of Tritonia festiva, presumably placing this species in its correct systematic position on the advice of Dr. MacFarland [see also Smith and Gordon, 1948; Steinberg (in Light, et al.), 1954].

The coloration of Tritonia festiva varies in California from completely translucent white to dull orange (occasionally light brown) and translucent white with opaque white markings. The variation of color does not seem to be consistent within a given geographical range. A careful comparison of the description of Sphaerostoma undulata O'Donoghue, 1924, with a number of specimens from both Northern and Southern California reveals no differences other than that O'Donoghue encountered no specimens which exhibited the orange coloration commonly seen in California. The rachidian teeth of the largest animal in my collections (35 mm. in length, preserved, from Moss Beach, San Mateo County, California) resemble those described and figured by O'Donoghue for a specimen 48 mm. in length. The lateral cusps of the teeth are very much reduced. However, in a preserved 10 mm. long animal from the same locality, the lateral cusps of the rachidian teeth are much more prominent. I cannot find any characters which distinguish S. undulata from T. festiva and therefore synonymize the two, with T. festiva (Stearns, 1873) taking priority.

In treating the nudibranchs from Southern California, several comments on some of the species described by Guernsey (1912) from Laguna Beach must be included.

a. Her Chromodoris sp. is, as O'Donoghue (1926) suggested, Glossodoris californiensis (Bergh, 1879).

b. Mr. Lance informs me that specimens which conform to the illustration and to the coloration described for her Genus and Species (?) occasionally occur in great numbers on the kelp of the San Diego region. He considers them to belong to the genus Polycera Cuvier, 1816, and is in the process of describing this form as a new species.

c. Guernsey's Doriopsis fulva MacFarland and Doris sp. are both Dendrodoris albopunctata (Cooper, 1863).

d. O'Donoghue (1926) synonymized her Cuthonia (sic.) sp. with a species described by him (1922b) from Vancouver Island as Cuthona concinna (Alder and Hancock, 1843) without comparative material from both localities. It will be necessary to obtain specimens from both areas for comparison before the exact systematic position of each may be ascertained.

e. Hervia sp. ? Guernsey, 1912, was given the name Hervia lagunae by O'Donoghue (1926). The genus Hervia Bergh, 1871, is now considered to be a synonym of Facelina Alder and Hancock, 1855 (see MacNae, 1954). Guernsey's description does not permit her species to be assigned to any of the genera to which other species, previously considered to belong to the genus Hervia, are now allocated. As O'Donoghue's name for this form was based only on Guernsey's description, I suggest that the name Hervia lagunae O'Donoghue, 1926, be considered a nomen dubium.

f. Spurilla sp. Guernsey, 1912, was more completely described by O'Donoghue (1927) as Eolidina orientalis. This species has subsequently been synonymized, rightly, with Spurilla chromosoma Cockerell and Eliot, 1905, by Marcus (1961).

Neither the description of Facelina stearnsi Cockerell, 1901, in the original description of material from San Pedro nor in the subsequent description by O'Donoghue (1927) of a form from Laguna Beach which he somewhat tentatively considered to be Cockerell's species, give any characters by which these specimens may be assigned definitely to the genus Facelina, as it is now defined. The same holds true for Facelina hiltoni O'Donoghue, 1927. Additional collecting in the San Pedro and Laguna Beach regions may reveal specimens which may be referable to either or both of these species but, in such an event, further research will be necessary in order to determine their exact systematic position.

Coryphella cooperi Cockerell, 1901, appears to belong to the genus Coryphella and is compared to other species of the genus by Marcus (1961). However, it will be necessary to collect further in the San Pedro area, in the hope of obtaining specimens comparable to Cockerell's description, before this species may be compared fully with others in the genus.

Literature Cited

Baba, Kikutarô
1949. Opisthobranchia of Sagami Bay collected by His Majesty, the Emperor of Japan. 4+2+194+7 pp., pls. 1-50. Iwanami Shoten, Tokyo.

Bergh, (Ludwig S.) Rudolph
1878. Malakologische Untersuchungen, Band 2. In: C. Semper, Reisen im Archipel der Philippinen. Zweiter Teil: Wissenschaftliche Resultate, Heft 14: 603-645, i-l, pls. 66-68.

——, ——
1879. On the nudibranchiate gasteropod mollusca of the North Pacific Ocean. Part I. Proc. Acad. Nat. Sci. Phila. 71-132, pls. 1-8.

——, ——
1880. Idem, Part II. Ibid.: 40-127, pls. 9-16.

Cockerell, Theodore Dru Alison
1901. Three new nudibranchs from California. Jour. Malacol. 8 (3): 85-87.

——, ——
1908. Mollusca of LaJolla, California. Nautilus 21(9): 106-107.

——, ——
1915. The nudibranchiate genus Triopha in California. Jour. Ent. Zool. Pomona Coll. 7 (4): 228 - 229, 2 textfigs.

Cockerell, T. D. A., and Charles Eliot
1905. Notes on a collection of Californian nudibranchs. Jour. Malacol. 12 (3): 31-53, pls. 7-8.

Cooper, James Graham
1862. Some genera and species of California mollusca. Proc. Calif. Acad. Nat. Sci. 2: 202-207.

——, ——
1863. On new or rare mollusca inhabiting the Coast of California. Proc. Calif. Acad. Nat. Sci. 3: 56-60.

——, ——
1870. Notes on mollusca of Monterey Bay, California. Amer. Jour. Conchol. 6: 42-70.

Eliot, Charles N. E.
1906. The genus Doriopsilla Bergh. Jour. Conch. 11: 366-367.

——, ——
1907. Nudibranchs from New Zealand and the Falkland Islands. Proc. Malacol. Soc. London 7: 327 to 361, pl. 28.

Fewkes, J. Walter
1889. New invertebrata from the coast of California. Bull. Essex Inst. 21: 99-146.

Guernsey, Mabel
1912. Some of the mollusca of Laguna Beach. Pomona Coll. Rep. Marine Lab. 1: 68-82, figs. 32-43.

Johnson, Myrtle E., & H. J. Snook
1927. Seashore animals of the Pacific coast. 659 pp., illus. New York, MacMillan.

Kelsey, F. W.
1907. Mollusks and brachiopods collected in San Diego, California. San Diego Soc. Nat. Hist. 1(2): 31-55.

MacFarland, Frank Mace
1905. A preliminary account of the Doriidae of Monterey Bay, California. Proc. Biol. Soc. Washington 18: 35-54.

——, ——
1906. Opisthobranchiate mollusca from Monterey Bay, California, and vicinity. Bull. U. S. Bur. Fish. for 1905, 25: 109-151.

MacNae, William
1954. On the status of the generic names of the nudibranch genera Catriona, Cratena, Hervia, Rizzolia and Trinchesia. Proc. Malacol. Soc. London 31 (2): 52-55.

Marcus, Ernst
1961. Opisthobranch mollusks from California. Veliger 3 (Suppl., pt. 1): 1-84, pls. 1-10.

O'Donoghue, Charles H.
1921. Nudibranchiate mollusca from the Vancouver Island region. Trans. Roy. Canad. Inst. 13: 147 to 210, pls. 7-11.

——, ——
1922a Notes on the taxonomy of nudibranchiate mollusca from the Pacific coast of North America. Proc. Malacol. Soc. London 15: 133-150.

——, ——
1922b Notes on the nudibranchiate mollusca from the Vancouver Island region. III. Trans. Roy. Canad. Inst. 14: 145-167, pls. 5-6.

——, ——
1924. Notes on the nudibranchiate mollusca from the Vancouver Island region. IV. Trans. Roy. Canad. Inst. 15 (1): 1-33, pls. 1-2.

——, ——
1926. A list of the nudibranchiate mollusca recorded from the Pacific coast of North America, with notes on their distribution. Trans. Roy. Canad. Inst. 15 (2): 199-247.

——, ——
1927. Notes on a collection of nudibranchs from Laguna Beach, California. Jour. Ent. Zool. Pomona Coll. 19: 77-119, pls. 1-3.

Orcutt, Charles Russell
1885. Notes on the mollusks of the vivinity of San Diego, California, and Todos Santos Bay, Lower California. Proc. U. S. Nat. Mus. 8: 534-552, pl. 1.

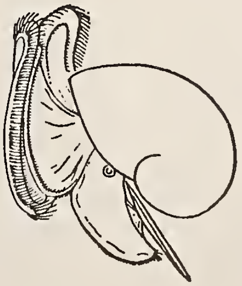
Pruvot-Fol, Alice
1954. Mollusques opisthobranches. Faune de France, 58: 460 pp., 173 textfigs., 1 pl. Paul Lechevalier, Paris.

Smith, Allyn G., & MacKenzie Gordon, Jr.
1948. The marine mollusks and brachiopods of Monterey Bay, California, and vicinity. Proc. Calif. Acad. Sci., ser. 4, 26 (8): 147-245, pls. 3-4.

Stearns, Robert E. C.
1873. Descriptions of a new genus and two new species of nudibranchiate mollusks from the coast of California. Proc. Calif. Acad. Sci. 5 (1): 77-78.

Steinberg, Joan E.
1954. Key to the more common opisthobranchs. In: Light, S. F., Ralph I. Smith, et al. Intertidal Invertebrates of the central California coast. 264 to 270. Univ. Calif. Press, Berkeley.

Yates, L. O.
1890. The mollusca of Santa Barbara County. Bull. Santa Barbara Soc. Nat. Hist. 1 (2): 37-45.



A Distributional List of Southern California Opisthobranchs

by

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The opisthobranch fauna inhabiting the intertidal regions along the coast of California has become comparatively well known. The early species descriptions of Cooper (1862, 1863), Bergh (1879, 1894), and Cockerell (1901-1915), while of a rather cursory nature, form the basis upon which more precise investigations by later workers have been carried out. Outstanding among these reports are the excellent anatomical accounts by MacFarland (1905-1929) of Central California forms. The publication of a distributional list of all the known species from the Pacific Coast of North America up to 1926 (O'Donoghue) has also contributed greatly to our knowledge of these mollusks. Of more recent date is a list by Smith and Gordon (1948) of species from the Monterey area, and a key by Steinberg (1954) to the Central California forms. Marcus (1961) has described 12 new species from this coast and provided anatomical details for 38 others.

In view of additional data obtained by various observers and from my own collections along the coasts of California and Baja California, Mexico, during the past several years, it seems appropriate to offer a synopsis of the bathymetric and geographic ranges of Southern California opisthobranchs as they are now known. Miss Joan Steinberg has kindly provided me with information regarding the northern ranges of many species, and for bathymetric observations I am indebted to the late Conrad Limbaugh, to Mrs. Limbaugh, and to Mrs. Homer Rydell.

The marine province of Southern California is here geographically defined as that region between Point Conception and the Mexican border. Excluding the cephalaspideans and pteropods, all the regional species for which there exist descriptions sufficient to permit identification are included. In view of the chaotic taxonomic state of the genus Triopha, it was deemed advisable to include the names of all the species reported from Southern California although probably only two distinct forms occur.

The systematic arrangement here followed is that of Odhner (1939). For convenience, the habitats are divided into (1) bays, lagoons, and estuaries with their associated boat landings, pilings, wharfs, buoys, etc.; (2) intertidal; (3) subtidal; and (4) the kelp canopy which, within the limits of these observations, consists exclusively of the giant brown kelp, Macrocystis pyrifera, and grows in 20-100 feet of water. The quantitative observations are based on some 140 field trips over the past 10 years, principally to Mission and San Diego Bays, Point Loma, the Coronados Islands, and the kelp beds off La Jolla and San Diego.

The degrees of abundance are arbitrarily designated as (1) common, which, for example, in the case of Corambella sp., may number as many as 140 individuals per square foot of kelp surface; (2) uncommon, such as Crimora coneja, one or two specimens of which may be observed every second or third trip to Point Loma; and (3) rare, indicating that very few individuals have ever been collected.

Examples of prey-predator associations such as that which exists between Armina californica and the sea pansy, Renilla koellikeri, are noted. The substrata for the intertidal and subtidal habitats are rocky unless stated otherwise.

The new ranges are followed by the old in parentheses. A species name preceded by a single asterisk (*) indicates that I have never collected that form. Two asterisks (**) are used to signify new species whose descriptions will shortly appear in this journal. A list of positions for the geographic points mentioned is included.

ALASKA		
Sitka	57° 03' N	135° 20' W
BRITISH COLUMBIA		
Nanaimo, Vancouver Island	49° 10' N	123° 56' W
CALIFORNIA		
Humboldt Bay	40° 45' N	124° 14' W
Gualala	38° 48' N	123° 30' W
Bodega Bay	38° 18' N	123° 03' W
Dillon Beach	38° 14' N	122° 58' W
Tomales Bay	38° 14' N	122° 59' W
San Francisco Bay	37° 47' N	122° 27' W
Moss Beach	37° 32' N	122° 31' W
Santa Cruz	36° 58' N	122° 01' W
Pacific Grove	36° 38' N	121° 55' W
Monterey	36° 37' N	121° 53' W
Cayucos	35° 26' N	120° 54' W
Pismo Beach	35° 09' N	120° 38' W
Point Conception	34° 27' N	120° 28' W
Santa Barbara	34° 25' N	119° 41' W
Santa Cruz Island	34° 01' N	119° 41' W
San Pedro	33° 44' N	118° 16' W
Corona del Mar	33° 36' N	117° 54' W
Newport Bay	33° 36' N	117° 54' W
Laguna Beach	33° 32' N	117° 44' W
Catalina Island	33° 29' N	118° 36' W
Doheny Beach	33° 27' N	117° 39' W
La Jolla	32° 52' N	117° 15' W
San Diego	32° 42' N	117° 11' W
Point Loma	32° 40' N	117° 14' W
MEXICO		
Los Coronados Islands	32° 24' N	117° 14' W
Bahia Todos Santos	31° 52' N	116° 38' W
Bahia de Los Angeles	28° 55' N	113° 32' W
Isla Cedros	28° 22' N	115° 12' W
Punta Eugenia	27° 51' N	115° 05' W
La Paz	24° 10' N	110° 19' W
Cabo San Lucas	22° 52' N	109° 53' W
FLORIDA		
Manatee Bay	27° 30' N	82° 35' W
CHILE		
Isla de Chiloé	41° 52' S	73° 50' W

ANASPIDEA

Aplysiidae

Aplysiinae

Aplysia californica Cooper, 1863.

Common intertidally and subtidally to 40 feet. Bodega Bay to the Gulf of California.

* *Aplysia juliana* Quoy & Gaimard, 1832.

Cosmopolitan in warm seas. Coast of California.

Aplysia vaccaria Winkler, 1955.

Common intertidally. San Pedro to Point Loma (San Pedro to Doheny Beach).

Dolabriferinae

Phyllaplysia zostericola McCauley, 1960.

Common in bays and lagoons on the eelgrass, Zostera marina. San Juan Island to San Diego Bay (San Juan Island to Newport Bay).

NOTASPIDEA

Umbraculacea

Tylodinidae

Tylodina fungina Gabb, 1865.

Locally abundant intertidally and in bays on the yellow sponge, Verongia thiona. Cayucos to Todos Santos Bay (Santa Barbara Island to San Diego).

Pleurobranchacea

Pleurobranchidae

* *Pleurobranchus californicus* Dall, 1900.

Crescent City to San Diego (San Pedro to San Diego).

* *Pleurobranchus digueti* Rochebrune, 1895.

San Pedro to the Gulf of California.

SACOGLOSSA

Elysiacea

Elysiidae

Elysia hedgpethi Marcus, 1961.

Seasonally common intertidally, July through September. Tomales Bay to La Jolla.

Hermaeidae

Hermaeinae

Hermaeina smithi Marcus, 1961.

Seasonally common intertidally, January through June. San Juan Island to San Diego (Tomales Bay).

NUDIBRANCHIA

Doridacea

EUDORIDACEA

Cryptobranchia

Dorididae

Glossodoridinae

Cadlina flavomaculata MacFarland, 1905.

Uncommon intertidally and subtidally to 65 feet. Vancouver Island to Point Eugenia (Vancouver Island to San Diego).

Cadlina marginata MacFarland, 1905.

Common subtidally to 150 feet; not known from the intertidal. Vancouver Island to Point Eugenia (Vancouver Island to San Diego).

Cadlina sparsa (Odhner, 1921).

Rare intertidally and subtidally to 131 feet. San Diego to the Juan Fernandez Islands, Chile.

** *Cadlina sp.*

Rare subtidally to 140 feet. La Jolla to the Coronados Islands.

Glossodoris californiensis (Bergh, 1879).

Uncommon intertidally and subtidally to 100 feet. Monterey to the Coronados Islands (Monterey to San Diego).

Glossodoris macfarlandi (Cockerell 1902),

Uncommon intertidally at the southern end of its range; rare subtidally to 30 feet in the north. Monterey to the Coronados Islands (San Pedro to San Diego).

Glossodoris porterae (Cockerell, 1902).

Uncommon intertidally. Monterey to Cedros Island (Monterey to San Diego).

Subfamily *incertae sedis*

* *Glossodoridiformia alba* O'Donoghue, 1927.

Intertidal. Laguna Beach.

Thorunninae

Rostanga pulchra MacFarland, 1905.

Uncommon intertidally and subtidally to 60 feet. Vancouver Island to Chile; Japan.

* *Aldisa sanguinea* (Cooper, 1862).

Rare intertidally. Bodega Bay to San Diego; Japan.

Archidoridinae

Archidoris montereyensis (Cooper, 1862).

Rare intertidally and uncommon subtidally to 150 feet. Alaska to San Diego.

Discodoridinae

Anisodoris nobilis (MacFarland, 1905).

Common on bay boat landings and pilings and subtidally to 100 feet; rare intertidally. Vancouver Island to the Coronados Islands (Vancouver Island to Laguna Beach).

Diaulula sandiegensis (Cooper, 1862).

Uncommon intertidally; common subtidally to 120 feet. Japan to Cape San Lucas (Japan to San Diego).

* *Discodoris heathi* MacFarland, 1905.

Rare intertidally. Vancouver Island to Laguna Beach.

Platydoridinae

* *Platydoris macfarlandi* Hanna, 1951.

Subtidal to about 516 feet. Pismo Beach.

Phanerobranchia

NONSUCTORIA

Notodorididae

Aegires albopunctatus MacFarland, 1905

Seasonally common intertidally, March through August; common subtidally to 100 feet. Vancouver Island to the Coronados Islands (Vancouver Island to San Diego).

Polyceridae

Polycera atra MacFarland, 1905.

Seasonally common in bays on boat landings and pilings, April through August; rare intertidally and subtidally. San Francisco Bay to the Coronados Islands (Monterey to San Diego).

** *Polycera sp.*

Seasonally common on offshore kelp, June through September. Laguna Beach to the Coronados Islands.

Laila cockerelli MacFarland, 1905.

Sporadically common intertidally in the spring, at other times absent; uncommon subtidally to 110 feet. Vancouver Island to Cape San Lucas (Vancouver Island to San Diego).

Triophidae

* *Triopha aurantiaca* Cockerell, 1908.

Laguna Beach to La Jolla.

Triopha carpenteri (Stearns, 1873).

Rare subtidally to 80 feet. Dillon Beach to San Diego; Japan (Dillon Beach to Laguna Beach; Japan).

* *Triopha catalinae* (Cooper, 1863).

Santa Cruz to Catalina Island.

* *Triopha grandis* MacFarland, 1905.

Monterey to Laguna Beach.

Triopha maculata MacFarland, 1905.

Seasonally common intertidally; rare subtidally to 60 feet. Bodega Bay to San Diego.

* *Triopha scrippsiana* Cockerell, 1915.

La Jolla.

Crimora coneja MARCUS, 1961.

Uncommon intertidally. Point Loma.

SUCTORIA

ONCHIDORIDIDAE

Acanthodoris lutea MACFARLAND, 1925.

Very rare intertidally in the southern part of its range; seasonally abundant at Moss Beach. Moss Beach to Point Loma (Moss Beach to Cayucos).

Acanthodoris rhodoceras COCKERELL & ELIOT, 1905.

Seasonally common intertidally, April through July; rare subtidally to 60 feet. Dillon Beach to the Coronados Islands (Dillon Beach to San Diego).

GONIODORIDAE

Hopkinsia rosacea MACFARLAND, 1905.

Common intertidally; rare subtidally to 20 feet. Eureka to Point Loma (Gualala to Point Loma).

Ancula pacifica MACFARLAND, 1905.

Very rare intertidally. Moss Beach to Point Loma (Monterey to La Jolla).

Trapania velox (COCKERELL, 1901).

Seasonally common on bay boat landings and pilings, July through October. San Francisco Bay to San Diego Bay (La Jolla).

CORAMBIDAE

Corambe pacifica MACFARLAND & O'DONOGHUE, 1929.

Seasonally common on colonies of the bryozoan, Membranipora serrilamella, growing on offshore kelp, January through September; at other times absent. Vancouver Island to Point Eugenia (Vancouver Island to Monterey).

***Corambella sp.*

This species shares the same habitat with the above form. Although their seasonal appearance coincides, Corambe pacifica seems to reach its maximum population density in March and April while Corambella sp. is most abundant during June and July. Vancouver Island to the Coronados Islands.

POROSTOMATA

DENDRODORIDAE

Dendrodoris albopunctata (COOPER, 1863).

Common intertidally and subtidally to 150 feet. Monterey to Point Eugenia (Monterey to Point Loma).

Dendronotacea

TRITONIIDAE

**Tritonia exsulans* BERGH, 1894.

Intertidal and subtidal to 1'020 feet. Coast of Japan to Baja California (26° 14' N; 113° 13' W); Manatee Bay, Florida.

Tritonia festiva (STEARNS, 1873),

Uncommon intertidally and subtidally to 80 feet. Vancouver Island to the Coronados Islands (Tomales Point to Corona del Mar).

* *Tritonia palmeri* COOPER, 1862.

San Pedro.

**Tritoniopsis aurantia* MATTOX, 1955.

Catalina Island.

HANCOCKIIDAE

Hancockia californica MACFARLAND, 1923.

Uncommon intertidally at the northern end of its range, rare on floating kelp at the southern extremity; unknown from any intermediate point south of Monterey. Dillon Beach to Baja California (26° 43' N; 114° 29.5' W) (Monterey).

DENDRONOTIDAE

Dendronotus frondosus (ASCANIUS, 1774).

Rare intertidally and subtidally to 1'312 feet; uncommon on offshore kelp. Cosmopolitan in the Northern Hemisphere.

Dendronotus iris COOPER, 1863.

Rare subtidally to 85 feet. Vancouver Island to the Coronados Islands (Vancouver Island to Santa Barbara).

PHYLLIROIDAE

Cephalopyge trematoides (CHUNN, 1889).

Rare; pelagic. Usually collected accidentally in plankton tows. Cosmopolitan.

TETHYIDAE

Melibe leonina (GOULD, 1853).

Seasonally common on offshore kelp, March through September; at other times rare or absent. Alaska to La Paz Bay (Alaska to La Jolla).

Arminacea

EUARMINACEA

ARMINIDAE

Armina californica (COOPER, 1862).

Locally common subtidally on sandy and muddy bottoms to 289 feet in association with the sea pansy, Renilla koellikeri, upon which it feeds; rare intertidally. Vancouver Island to Panama.

PACHYGNATHA

Antiopellidae

Janolus barbarensis (Cooper, 1863).

Seasonally common intertidally and in bays and lagoons, May through August. Santa Barbara to Point Loma (Santa Barbara to La Jolla).

Dironidae

* *Dirona albolineata* Cockerell & Eliot, 1905.

Rare intertidally and subtidally to 115 feet. Vancouver Island to Laguna Beach.

Dirona picta Cockerell & Eliot, 1905.

Seasonally common intertidally, June through August; at other times absent. Dillon Beach to Point Loma (Dillon Beach to La Jolla).

Eolidacea

PLEUROPROCTA

Coryphellidae

* *Coryphella cooperi* Cockerell, 1901.

San Pedro.

Coryphella piunca Marcus, 1961.

Uncommon intertidally and on boat landings; seasonally common on offshore kelp, April through June. Dillon Beach to the Coronados Islands (Dillon Beach to Point Pinos).

Flabellinidae

Flabellina iodinea (Cooper, 1862).

Uncommon intertidally; common subtidally to 120 feet. Vancouver Island to the Coronados Islands (Vancouver Island to San Diego).

ACLEIOPROCTA

Eubranchidae

Capellinia rustya Marcus, 1961.

Seasonally common on offshore kelp, February through August. San Francisco Bay to Bahia de Los Angeles (Monterey).

Fionidae

Fiona pinnata Eschscholtz, 1831.

Seasonally uncommon on floating wood, algae, buoys, etc., April through August. If present at all, there are often large numbers of individuals on the floating object. Cosmopolitan.

CLEIOPROCTA

Facelinidae

Hermissenda crassicornis (Eschscholtz, 1831).

The most common nudibranch in Southern California, intertidal and subtidal to 120 feet. Also common in bays and lagoons on mud flats, boat landings, and pilings. Sitka, Alaska, to Point Eugenia (Sitka, Alaska, to San Diego).

Phidianidae

** *Phidiana sp.*

Uncommon intertidally; common subtidally to 120 feet. Monterey to the Coronados Islands.

Aeolidiidae

Aeolidia papillosa (Linnaeus, 1761).

Seasonally rare intertidally and subtidally to 2'493 feet, February through May. Cosmopolitan.

Spurillidae

Spurilla chromosoma Cockerell & Eliot, 1905.

Rare intertidally. San Pedro to Point Loma.

Literature Cited

Bergh, (Ludwig S.) Rudolph
1879. On the nudibranchiate gasteropod mollusca of the North Pacific ocean. Part 1. Proc. Acad. Nat. Sci. Phila. 71-132, pls. 1-8.
——, ——
1894. Die Opisthobranchien. Bull. Mus. Comp. Zool. Harvard, 25 (10): 125-233, pls. 1-12.
Cockerell, Theodore Dru Alison
1901a. Three new nudibranchs from California. Jour. Malacol. 8 (3): 85-87.
——, ——
1901b. Notes on two Californian nudibranchs. Jour. Malacol. 8 (3): 121-122.
——, ——
1901c. A new Tethys (ritteri) from California. Nautilus, 15: 90-91.
——, ——
1908. Mollusca of La Jolla, California. Nautilus 21 (9): 106-107.
——, ——
1915. The nudibranchiate genus Triopha in California. Jour. Ent. Zool. Pomona Coll. 7 (4): 228-229, 2 textfigs.
Cockerell, T. D. A., & Charles Eliot
1905. Notes on a collection of Californian nudibranchs. Jour. Malacol. 12 (3): 31-53. pls. 7-8.
MacFarland, Frank Mace
1905. A preliminary account of the Doriidae of Monterey Bay, California. Proc. Biol. Soc. Washington 18: 35-54.
——, ——
1906. Opisthobranchiate mollusca from Monterey Bay, California, and vicinity. Bull. U. S. Bur. Fish. for 1905, 25: 109-151.
——, ——
1912. The nudibranch family Dironidae. Zool. Jahrb. Suppl., 15: 515-536, pls. 30-32.
——, ——
1923. The morphology of the nudibranch genus Hancockia. Jour. Morphol. 38: 65-104, pls. 1-6.

——, ——
1924. Expedition of the California Academy of Sciences to the Gulf of California in 1921. Opisthobranchiate mollusca. Proc. Calif. Acad. Sci., ser. 4, 13 (25): 389-420, pls. 10-12.

——, ——
1925-1926. The Acanthodorididae of the California coast. Nautilus 39 (2, 3): 49-65, 94-103, pls. 2, 3.

Marcus, Ernst
1961. Opisthobranch mollusks from California. Veliger 3 (Suppl., pt. 1): 1-84, pls. 1-10.

Odhner, Nils
1939. Opisthobranchiate mollusca from the western and northern coasts of Norway. Kgl. Norske Vidensk. Selsk. Skr. No. 1, 93 pp.

O'Donoghue, Charles H.
1926. A list of the nudibranchiate mollusca recorded from the Pacific coast of North America, with notes on their distribution. Trans. Roy. Canad. Inst. 15 (2): 199-247.

Smith, Allyn G., & MacKenzie Gordon, Jr.
1948. The marine mollusks and brachiopods of Monterey Bay, California, and vicinity. Proc. Calif. Acad. Sci., ser. 4, 26 (8): 147-245, pls. 3, 4.

Steinberg, Joan E.
1954. Key to the more common opisthobranchs. In: Light, S. F., Ralph I. Smith, et. al. Intertidal Invertebrates of the central California coast. Univ. Calif. Press, Berkeley. pp. 264-270.

A New Commensal Polyclad from Panama

by

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(Plate 16)

While collecting prosobranch gastropods along the sea wall in Balboa Park, Panama City, Panama (9°0'N., 79°30'W.), an acotylean polyclad was found in the mantle cavity of *Nerita (Ritena) scabricosta ornata* Sowerby, 1823. The classification of the snail was determined by comparison with the text and figures of A. Myra Keen (1958, p. 266, figs. 81, 81 a). The gastropods were lodged in rock fissures in the supralittoral zone. The polyclads were seen in the shell aperture when the *Nerita* were removed from the substratum. When the snails were disturbed, the flatworms returned to the mantle cavity before the operculum closed the shell aperture. Some of the gastropods had as many as eight to ten large polyclads within the mantle cavity. As stated in an earlier paper (Smith, 1960, p. 385), the micro-plankton or detritus which enter the mantle cavity could hardly serve as food for a carnivorous polyclad. Since the polyclads were observed outside of the feeding gastropods, it would seem that the polyclads only used the snail's mantle cavity as a retreat after feeding and for the protection offered by a closed operculum.

Hoploplana luracola E. H. Smith, spec. nov.

The living form is elongate, becoming slightly circular after preservation (Plate 16, figure 1). The largest preserved specimen measured 6.0 mm. by 3.0 mm. However, most of the animals are of about the same size (average of six measured specimens, 5.5 mm. by 3.0 mm.). The dorsal surface is smooth with a pair of short tentacles anteriorly.

The over-all color of the polyclad is light brown with slightly darker dots covering all of the dorsal surface. A dark brown stripe runs the length of the animal, mid-dorsally.

The tentacular eyes occur in groups around the bases of the tentacles and some appear to occur within the tentacles (Plate 16, figure 3). Each group consists of 14 to 16 tentacular eyes. The cerebral eyes number 19 to 33 in each cluster and form two irregular rows on opposite sides of the mid-dorsal line. The eye clusters extend both anteriorly and posteriorly from the tentacles.

In cleared specimens, eyes, ruffled pharynx, spermiducal bulbs, and uteri can be seen (Plate 16, figure 2).

The copulatory apparatus (Plate 16, figure 4) lies immediately behind the ruffled pharynx. The spermiducal bulbs are slightly muscular, lie ventrally and nearly transverse to the longitudinal axis of the body. The thin walled ejaculatory duct leaves the spermiducal bulb ventrally, coursing dorsally, and turns anteriorly to meet the male copulatory apparatus. The duct enters the prostatic vesicle from the ventral side. The stylet is straight and occupies nearly the entire length of the male antrum which is well defined and quite large.

The female genital pore lies directly behind the male opening and opens into a simple vagina which curves posteriorly. Scattered cement glands surround the vaginal region near the female gonopore.

Occurrence: Southern middle Panama, Pacific coast, Balboa Park. Panama City, in the pallial cavity of Nerita (Ritena) scabricosta ornata at low water-level; December 1960. 25 specimens. Holotype: One whole mount deposited in the American Museum of Natural History, New York, A.M.N.H. Cat. No. 501. Paratypes are in the U. S. National Museum, Washington, D. C. and the author's collection.

The word luracola is a Latin substantive in apposition and means sack dweller. The name was chosen to denote the fact that the polyclad lives within the mantle cavity of the snail.

Discussion of Hoploplana luracola

Since the original five species assigned to the genus Hoploplana by Bock (1913), there have been eight more added including one from the Pacific coast of North America. Inasmuch as the copulatory apparatus is very similar throughout the genus (Hyman, 1953, p. 346), external characters become important taxonomically. Hoploplana luracola is distinguished from its closest geographic neighbor H. californica Hyman, 1953, by lacking a papillate dorsal surface and having cerebral eyes extending behind the tentacles and a longer stylet. The nearest morphologically related species seems to be H. deanna Kato, 1939, from Mutsu Bay, Japan. This species can be distinguished from H. luracola by the different arrangement of the cerebral eye clusters and the number of tentacular eyes.

Literature Cited

Bock, S.
1913. Studien über Polycladen. Zool. Bidr. Uppsala, 2: 31-344, pls. 3-10.

Hyman, Libby H.
1953. The polyclad flatworms of the Pacific coast of North America. Bull. Amer. Mus. Nat. Hist. 100 (2): 265-392.

Kato, K.
1939. The Polyclads of Mutsu Bay. Sci. Rep. Tohoku Univ. ser. 4, 14 (4): 143-153, pls. 8-9.

Keen, A. Myra
1958. Sea shells of tropical west America; marine mollusks from Lower California to Colombia. Stanford, Calif., Stanford Univ. Press; xi + 624 pp., illus.

Smith, Edmund Hobart
1960. On a new polyclad commensal of prosobranchs. An. Acad. Brasil. Cienc. 32 (3, 4): 385-390, pl. 1.

Explanation of Plate 16

Haploplana luracola E. Smith, spec. nov. Figure 1: Dorsal view of living worm. Figure 2: Dorsal view of clarified worm. Figure 3: Antero-dorsal part of body, showing eye patterns. Figure 4: Diagram of copulatory apparatus (reconstructed).

a - male antrum, c - cement gland, d - pharynx, e - ejaculatory duct, f - female genital pore, g - granule glands, h - spermiducal bulb, i - eyes, j - sperm, k - uteri, l - dark brown dorsal area, m - male genital pore, o - lighter brown dots, p - prostatic vesicle, s - stylet, t - tentacle, v - vagina, y - sperm duct.

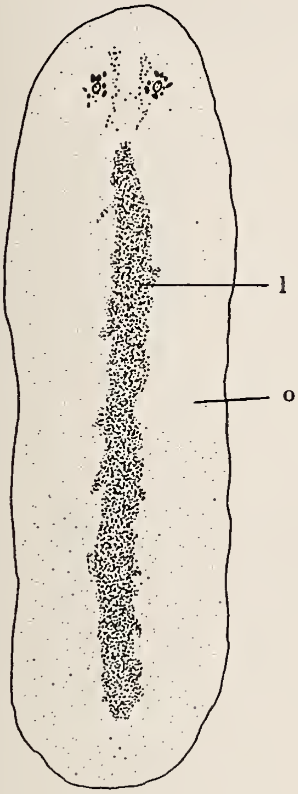
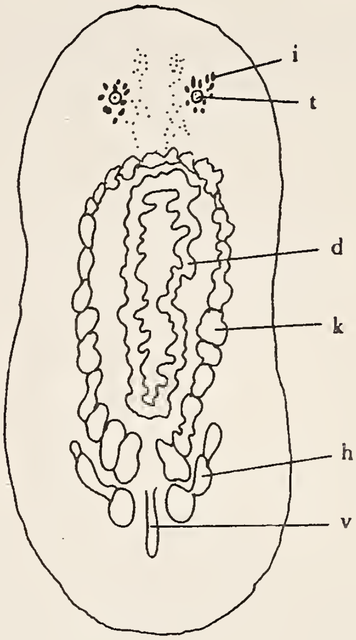


Figure 1

Figure 2



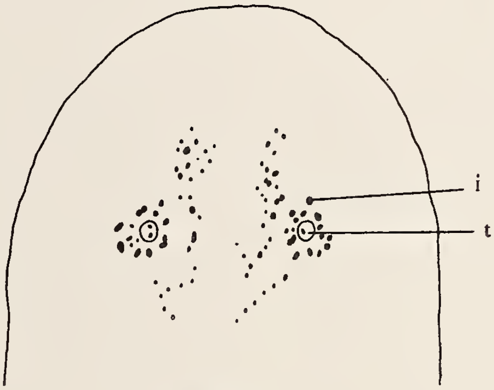


Figure 3

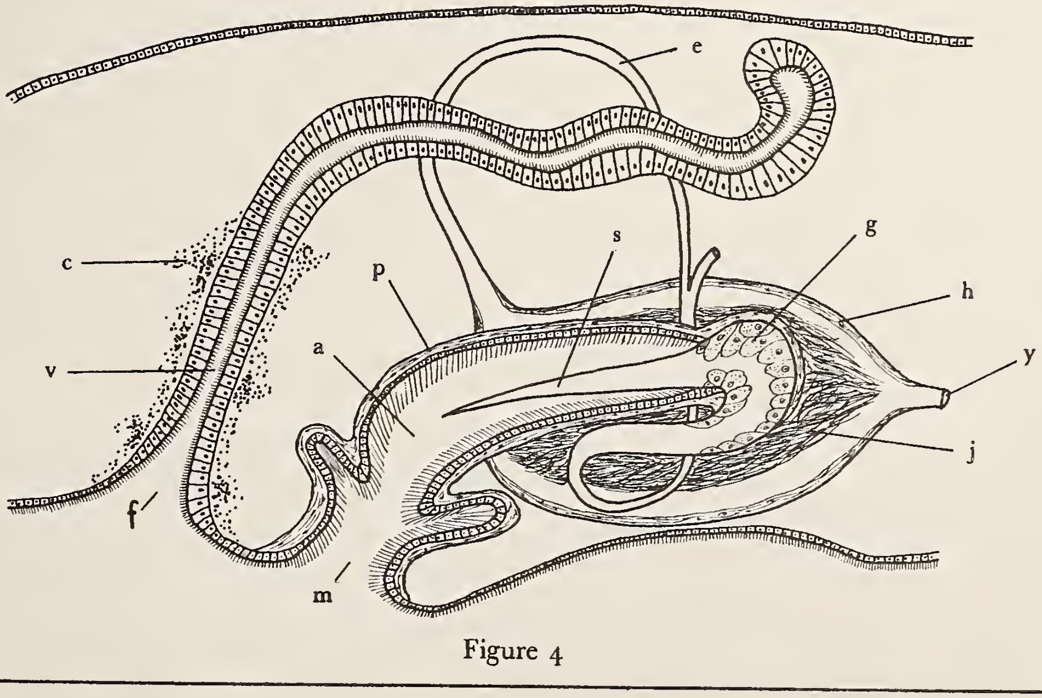


Figure 4

SMITH, *del.*

A New Subgenus and Species of Coral-Inhabiting Barnacle from the Gulf of California

by

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(Plate 17, 2 Textfigures)

The balanomorph barnacle genera Creusia Leach, 1817, and Pyrgoma Leach, 1817, which occur embedded in the coralla of anthozoan and milleporine corals, have traditionally been considered derivatives of Balanus DaCosta, 1778, through loss and concrescence of various compartmental plates of the shell. The gradational aspect of the series Balanus (shell with six compartmental plates)-Creusia (shell with four compartmental plates)-Pyrgoma (shell formed of a single plate) has been recognized for some time. Darwin (1854, p. 375) was reluctant to consider Creusia apart from Pyrgoma stating that "had not this genus already been adopted by several authors, I should not, I think, myself have formed it. . .". Elsewhere he (Darwin, loc. cit., p. 359) observed that "the subgenus Creusia is closely, perhaps too closely, allied to Pyrgoma". Species variously referred to Creusia and Pyrgoma are known which are characterized by an intermediate stage in the concrescence of the compartmental plates and appear to form "connecting links" between typical Creusia and typical Pyrgoma. Recently, on the basis of these intermediate forms, Brooks and Ross (1960, p. 361) concluded that Darwin's uncertainty was justified and synonymized Creusia with Pyrgoma.

Withers (1926, 1929, 1935) has discussed the phylogeny of these coral-inhabiting barnacles in respect to their fossil record and concluded that "Pyrgoma is, no doubt, a derivative from Creusia, but certain Miocene forms of similar coral-living barnacles have six compartments like Balanus (Withers, 1929, p. 560), so that in this little group alone there is a transition from forms having six compartments to a single shell" (Withers, 1935, p. 38). Evidence of the transition from forms having six compartmental plates to those having four, however, has been lacking. Apparently the Creusia condition was derived through the loss of the carinolaterals of the Balanus ancestor (Withers, 1935, p. 38). However, the six-plated Miocene species, Balanus duvergieri (de Alessandri), discussed by Withers (1929, p. 560) is a Balanus in all respects but habitat and no form is known that exhibits any indication of reduction of the carinolaterals toward the Creusia condition. Withers (1935, p. 38) presents Acasta sporillus Darwin as an example of an intermediate form in which "the carinolaterals do not reach to the basis and appear to be on their way to being crowded out". However, the loss of carinolaterals in A. sporillus need not necessarily have a direct relationship to the development of Creusia from Balanus.

The discovery of a new coral-inhabiting barnacle in the Gulf of California lends added strength to the hypothesis of the derivation of the Creusia condition from a Balanus ancestor. Both fossil and living specimens of this barnacle have been found embedded in coralla of the hermatypic stony coral Porites californica Verrill from several localities throughout the Gulf (textfigure 2). This barnacle is creusoid in all respects (e. g., the cup-shaped to sub-cylindric basis, the exterior ornamentation of the parieties, the extension of the sheath nearly to the basal margin and the continuous lower edge of the sheath, the plate-like nature of the internal ribs or longitudinal septa, and the creusoid nature of the opercular valves) except that it has a shell composed of six plates as in the genus Balanus. For this reason a new supraspecific taxon, here considered as a subgenus of Balanus, is erected for this species.

Cirripedia

THORACICA DARWIN
Balanomorpha PILSBRY
BALANIDAE GRAY
Balaninae GRAY
Balanus DA COSTA
Hexacreusia ZULLO, subgen. nov.

DIAGNOSIS

Compartmental plates six; shell depressed; parieties solid; radii broad, solid, with thick, septate edges; sheath extending nearly to basal margin; lower edge of sheath free, continuous; basis calcareous, solid, cup-shaped to subcylindric; opercular plates as in Creusia; appendages and mouth parts balanoid.

TYPE SPECIES

Balanus (Hexacreusia) durhami Zullo, spec. nov.

ADDITIONAL SPECIES

Possibly Balanus duvergieri (de Alessandri).

GEOLOGIC RANGE

? Early Miocene (Balanus duvergieri); late Pliocene to Recent (Balanus durhami).

HABITAT

Living in the coenosteum of the coral Porites.

REMARKS

This new subgenus is created to include a species which in every respect, excepting the number of compartmental plates in the shell wall, could be assigned to the genus Creusia. At least some forms included within Creusia appear to have developed from an hexacreusoid ancestry. The creusoid shell morphology either resulted through the loss of the carinolaterals or through their concrescence with the laterals or, possibly, the carina. The available evidence, although negative, favors the loss of the carinolaterals, as there have been no records, either extant or fossil, of intermediate stages of fusion between the six- and four-plate condition.

The conclusions reached by Brooks and Ross (1960) regarding the classificatory significance of the presence of separate compartmental plates or sutures in the shell wall as the distinguishing feature in the separation of Creusia from Pyrgoma could also be extended to Hexacreusia. However, where they regard the presence of intermediate stages in the development of the concrescence of the shell as indicating that the genera Pyrgoma and Creusia should not be separated, I would interpret these intermediate stages in development as indicating a phylogenetic relationship between the two: Creusia with the shell of four, unfused compartmental plates giving rise to Pyrgoma with a shell composed of fused plates. Any closely-linked, phylogenetic series should be expected to include forms of intermediate nature, but these forms do not govern the validity of recognizing and delimiting categories (in this case the end members) within the series.

This latter concept is exemplified by Hexacreusia. In synonymizing Creusia with Pyrgoma, Brooks and Ross (1960, p. 361) modified the diagnosis of Pyrgoma "to include all the obligate, epizoic, tetramerous barnacles with their basis invaginated in the corallum of live corals". Application of the criteria used by Brooks and Ross (loc. cit., pp. 359-362) to the relationship of Pyrgoma to Balanus in view of the new six-plate, creusoid species here described would result in the suppression of Pyrgoma inasmuch as these genera differ only by the number of compartmental plates in the shell wall.

Presently, Hexacreusia is definitely represented only by the type species. However, the specimens from the Miocene of Bordeaux, which had been assigned by Withers (1929, p. 560) to Balanus (Balanus) duvergieri (de Alessandri) are possibly referable to Hexacreusia. Withers' assignment of this species to the subgenus Balanus was based on the irregularly porous nature of the parieties of some of the specimens. The parieties of the remaining specimens were noted as being solid. These pores are probably homologous with those in some individuals of Creusia described by Darwin (1854, p. 377) and interpreted to represent spaces left by the incomplete filling of the internal rib interspaces, and are not, therefore, homologous with the parietal tubes in the subgenus Balanus. Withers (1929, pp. 565-566) considered Balanus duvergieri as representing an early stage in the development of Creusia.

Balanus (*Hexacreusia*) *durhami* Zullo, spec. nov.
(Textfigure 1: Plate 17)

DIMENSIONS

of Holotype, University of California Museum of Paleontology (hereafter referred to by the abbreviation UCMP) No. 34'689, height (excluding elongate basis) 0.7 mm., carinorostral diameter of orifice 0.9 mm., carinorostral diameter of base 3.0 mm. The height of the shell including the elongate basis may be as much as 4.5 mm.

DESCRIPTION

Shell small, depressed conic; orifice small, subtrigonal to diamond-shaped, not toothed; parieties solid; surface of parieties pink in color, somewhat regularly ribbed; ribs project from base of compartmental plates, giving stellate appearance to shell; radii broad, glossy, lighter pink in color than parieties or white, vertically striate; summits of radii horizontal; sutural edges of radii thick, with primary and secondary denticulae; alae thin; sheath long, extending nearly to basal margin, lower edge free, continuous; interior of parieties ribbed; ribs plate-like in appearance, continuing underneath edge of sheath; basis cup-shaped or conical, up to three and one-half times as long as height of compartmental plates, solid, radially ribbed; ribs and alternating furrows of basis correspond to ribs and furrows of parieties; ribs on interior of basis finely beaded.

Scutum white with pink-tinged, beaked apex; tergal part reflexed at right angles to rest of plate; exterior ornamented by thin, closely-spaced growth lines; irregular, longitudinal furrow divides exterior of plate in position of (adductor ?) ridge on interior; basal margin sinuous, longer than tergal margin; occludent margin straight, toothed; articular ridge high, almost as long as tergal margin; articular furrow narrow, shallow; thin ridge (adductor ?) extends from middle of scutum to basal margin and continues along basal margin to basioccludent angle; shelf continuous with occludent margin and occludent side of the articular ridge projects out over half the interior of the scutum leaving a deep pocket beneath it; free (basal) edge of shelf sinuous; shelf widest in apical part, narrowing towards and terminating in basioccludent angle; pit for depressor muscle small, deep, situated on edge of basal margin at point of reflection of tergal part of scutum; "rostral tooth" suggested by intersection of occludent shelf and basal margin at basioccludent angle.

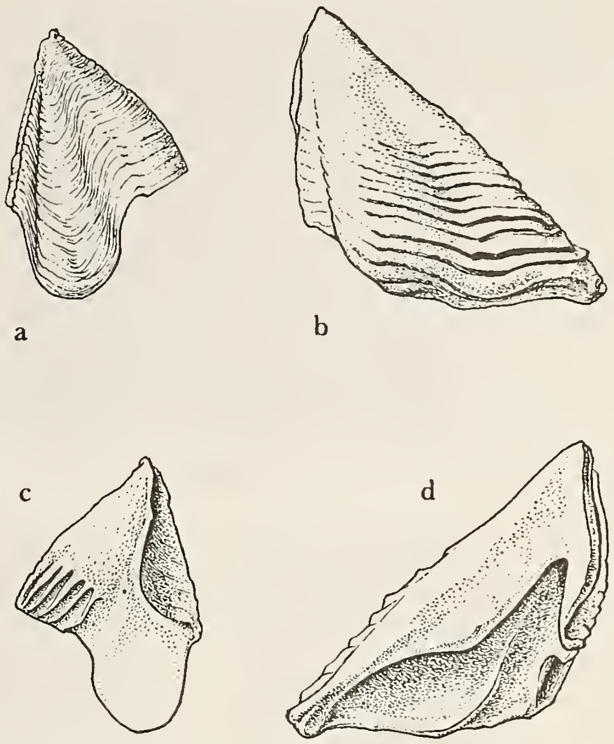


Figure 1: Opercular plates of *Balanus* (*Hexacreusia*) *durhami* Zullo, spec. nov., x 25. a - exterior of tergum, paratype UCMP no. 34691; b - exterior of scutum, paratype UCMP no. 34690; c - interior of tergum, paratype UCMP no. 34691; d - interior of scutum, paratype UCMP no. 34690.

Tergum white in color, tinged pink at apex; carinal part of tergum curving inwardly; articular ridge low, thin; articular furrow broad, shallow; depressor muscle crests well developed; scutal and carinal margins straight; spur broad, one-half width of basal margin, situated close to, but differentiated from, the basiscutal angle; spur long, length approximating width; end of spur broadly rounded; spur furrow not sharply differentiated.

Labrum deeply notched with three prominent, blunt, triangular teeth and one or two smaller teeth on each side.

Palpi with numerous, closely clustered, short, curved, pectinate spines arranged in two parallel rows along superior margin; a few long spines situated on inner margin.

Mandibles with five teeth including inferior angle; first, second, and third teeth large, distinct; second and third teeth bifid; fourth and fifth teeth smaller than preceding; fourth tooth bifid; fifth tooth trifid; distance between first and second tooth one and one-half times greater than distance between second and third tooth;

first, second, and third teeth occupying nearly three-fourths entire cutting-edge; inferior margin of mandible and posterior surface of mandible hirsute.

Inner maxillae with irregular, nearly straight cutting edge; rudimentary notch located below uppermost two large spines; two small spines situated in notch; five large spines with a few smaller spines situated below notch; lowermost two of the large spines as large as the large spines above notch; large spines followed by approximately five small spines; edge below inferior angle bearing several small spines.

Outer maxillae of two lobes (as figured by Hoek, 1913, pl. 27, fig. 8; and Nilsson-Cantell, 1921, textfig. 79e), bearing numerous pectinate bristles.

Rami of Cirrus I unequal, densely setose; outer ramus about one-third again as long as inner ramus, curved posteriorly in opposing direction from all other rami.

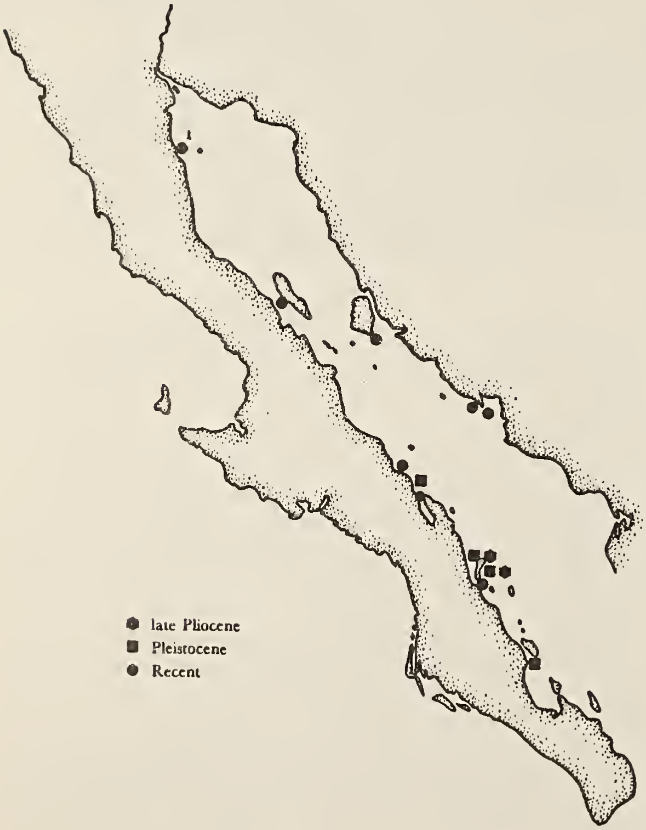


Figure 2: Late Cenozoic distribution of *Balanus* (*Hexacreusia*) *durhami* Zullo, spec. nov. embedded in *Porites californica* Verrill in the Gulf of California.

1: northernmost occurrence of *Porites californica* (CAS locality 36745)

Rami of Cirrus II similar in structure to those of Cirrus I, densely setose, unequal, with outer ramus being longer.

Cirrus III more similar in structure to Cirri I and II than to Cirri IV to VI; rami of Cirrus III not as densely setose as those of Cirri I and II, subequal with outer ramus longer; articles 1 through 6 on outer ramus (counting distally from pedicel) bearing teeth on posterior and upper margins.

Cirri IV through VI with subequal rami, inner rami slightly longer than outer rami; intermediate segments of rami bearing one to three pairs of setae on posterior margins.

The number of articles on the individual cirri (paratype California Academy of Sciences No. 12'372) are as follows:

Cirrus:	I	II	III	IV	V	VI
Outer Ramus:	10	7	7	10	13	13
Inner Ramus:	6	5	6	10	14	14

HOLOTYPE

UCMP No. 34'689, from UCMP locality A-3652. Paratypes: UCMP Nos. 34'690, 34'691, from UCMP locality A-3640; UCMP No. 34'692, from UCMP locality A-3642; California Academy of Sciences No. 12'372, from CAS locality 36'745.

OCCURRENCE

(Textfigure 2)

Late Pliocene, Gulf of California, UCMP localities A-3519, A-3534; Pleistocene, Gulf of California, UCMP localities A-3525, A-3547, A-3582, A-3584, A-3596; Recent, Gulf of California, UCMP localities A-3640, A-3642, A-3646, A-3652, A-3653, A-3654, A-3663, California Academy of Sciences locality 36'745.

RANGE

Late Pliocene to Recent, Gulf of California.

REMARKS

Balanus durhami differs from all known species of *Balanus* and *Creusia* in the possession of an occludent shelf on the interior of the scutum (textfigure 1d). The tergum somewhat resembles that of *Creusia spinulosa* var. *breviterga* Hiro (1938, p. 397) but can be distinguished by its longer, narrower spur (textfigures 1a, 1c). The opercular plates of *B. durhami* do not appear to be as variable in form as those described by Hiro (1938).

Figure 1

Figure 2

Figure 3

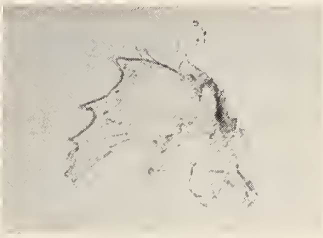


Figure 4

Figure 5

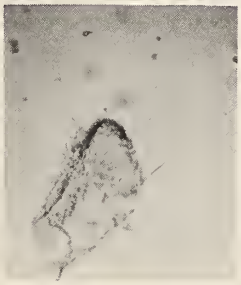


Figure 6

Figure 7

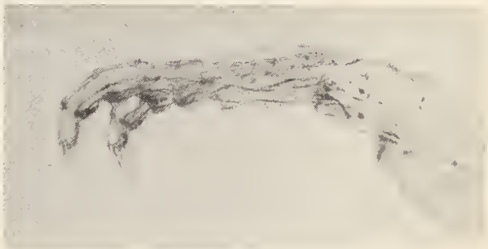


Figure 8

Balanus (*Hexacreusia*) *durhami* ZULLO, subgen. et spec. nov.

Figure 1: Holotype UCMP no. 34689, x 2.5 (center specimen); Figure 2: Paratype UCMP no. 34692 and associated individuals embedded in the coenosteum of *Porites californica* VERRILL from UCMP locality A-3642, x 1. Figures 3 to 8: Mouth parts and appendages of paratype CAS no. 12372, x 70. Figure 3: Labrum (teeth partially obscured); Figure 4: Right mandible; Figure 5: Right inner maxilla; Figure 6: Right outer maxilla; Figure 7: Right labial palp; Figure 8: Right Cirrus III (outer ramus above).

ZULLO, *phot.*

The mouth parts and appendages of species of Creusia and Pyrgoma have seldom been figured. In the case of Balanus durhami the mouth parts and appendages of only a single specimen (paratype California Academy of Sciences No. 12'372, Plate 17, figures 3-8) were available as the corals from other localities had been cleaned in sodium hypochlorite, destroying the bodies of the barnacles. Comparison of the mouth parts and appendages of B. durhami with figured specimens of Creusia and Pyrgoma failed to uncover any significant difference, except in the possession of teeth on the third cirrus of B. durhami.

Balanus durhami resembles species of the subgenus Armatobalanus and some species of the subgenus Balanus in bearing teeth on the cirri. However, the teeth are borne only on the anterior margins of segments of the outer ramus of Cirrus III in B. durhami, whereas teeth are found only on Cirrus IV in species of Armatobalanus, and on both Cirri III and IV in B. trigonus Darwin and B. perforatus Bruguière. Broch (1927, p. 30) noted the presence of teeth on the basal seven segments of Cirrus IV in specimens of Pyrgoma anglicum Sowerby from the Moroccan coast.

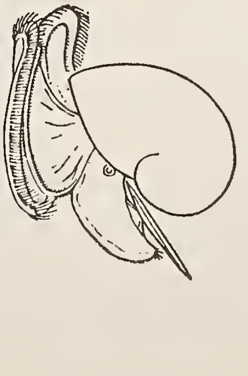
Balanus durhami is found embedded in the coenosteum of the coral Porites californica Verrill. The parieties of large individuals are completely encrusted by the coenosteum; a small hole marks the position of the buried orifice. The presence of B. durhami is usually indicated by a slightly raised mound on the surface of the corallum. This mound is bounded by a fracture zone where the overlying coenosteum has been fractured by the upward growth of the barnacle. This fracture zone corresponds to the basal margin of the parieties.

This species is named in honor of Dr. J. Wyatt Durham of the Department of Paleontology, University of California.

I would like to thank Mr. William A. Newman of the Department of Zoology, University of California, for his advice in the preparation of this paper and for the dissection of the mouth parts and appendages of Balanus durhami. The illustrations of the opercular plates were prepared by May Blos.

Literature Cited

Broch, H.
1927. Studies on Moroccan cirripeds (Atlantic coast). Bull. Soc. Sci. Nat. Maroc. 7: 11-38, pls. 1-4, textfigs. 1-10.
Brooks, H. K., & A. Ross
1960. Pyrgoma prefloridanum, a new species of cirriped from the Caloosahatchee marl (Pleistocene) of Florida. Crustaceana 1 (4): 353-365, pls. 5, 6, textfigs. 1-4.
Darwin, Charles
1854. A monograph on the sub-class Cirripedia. Balanidae, Verrucidae. Ray Soc. London, pp. 1-684, figs. 1-11, pls. 1-30.
Hiro, F.
1938. Studies on the animals inhabiting reef corals, II. Cirripeds of the genera Creusia and Pyrgoma. Palao Trop. Biol. Stat. Stud. no. 3: 391-416, figs. 1-13, pl. 1.
Hoek, P. P. C.
1913. The cirripedia of the Siboga-Expedition, B. Cirripedia sessilia. Siboga-Exped. Monog. 31 b: xxv + 129-275, figs. 1, 2, pls. 11-27.
Nilsson-Cantell, C. A,
1921. Cirripedien Studien. Zur Kenntnis der Biologie, Anatomie und Systematik dieser Gruppe. Zool. Bidrag fr. Uppsala 7: 75-395, textfigs. 1 to 89, pls. 1-3.
Withers, T. H.
1926. Barnacles of the Creusia - Pyrgoma type from the Pleistocene of Barbados. Ann. Mag. Nat. Hist., ser. 9, 17: 1-6, pl. 1, figs. 1-11.
——, ——
1929. The phylogeny of the cirripedes Creusia and Pyrgoma. Ann. Mag. Nat. Hist., ser. 10, 4: 559 to 566, pls. 10, 11.
——, ——
1935. Catalogue of fossil cirripedia in the Department of Geology, II. Cretaceous. Brit. Mus. (Nat. Hist.) London, i-xvi, 1-434, figs. 1-64, pls. 1-50.



A Discussion of *Vexillum regina* (Sowerby, 1825) and Related Species, With Description of a New Subspecies

by

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(Plates 18, 19, 20; 1 Textfigure)

In the study necessary to ascertain that Vexillum coloscopulus J. Cate, 1961, was a hitherto undescribed species, I realized through an analysis of the works of many authors that at least five additional closely related species were included in the same complex; all are similar enough to have been either confused with one another or placed in synonymy. However, a careful diagnosis of the most outstanding characters of each species brought out that these six forms are confused chiefly because of their similarity of color, whereas the morphological differences, considered separately, provide a sufficient basis for separating them into six different categories.

It became apparent that a further study of the entire group was necessary in order to clarify the confusion encountered at every turn; I shall attempt here to outline the results of this study and illustrate the identifying features of each species in the hope that other collectors who have been similarly puzzled by this group may be able to identify their specimens without question.

The first species encountered in the study was Vexillum regina (Sowerby, 1825), as this was the name incorrectly applied to the specimen which is now the holotype of V. coloscopulus J. Cate, 1961. The next species to be considered in the course of comparing these shells was V. compressum (Sowerby, 1874), which at first glance appears to be a dwarf form of V. regina. Two additional species, V. taeniatum (Lamarck, 1811) and V. vittatum (Swainson, 1821), which are perhaps the two most difficult to separate, were included in the study because of their similarity in color and pattern and their superficial resemblance to V. regina. The final species, from the type locality of V. coloscopulus, is an intermediate form between that species and V. regina; this had been erroneously figured by Reeve, Sowerby, and Tryon as Mitra melongena Lamarck, 1811. This last form will be described here as a new subspecies of V. regina.

The important illustrated works on Mitridae are unfortunately few; the most complete of these, in chronological order, are by Kiener (1839); Küster (1841); Reeve (1844-45); Chenu (1860); Sowerby (1874); and Tryon (1882). There are also several helpful papers on the Mitridae of various Indo-Pacific localities, for example, Dautzenberg and Bouge (1922, 1933), and Dautzenberg (1935), but the approach in these papers is more in the nature of annotated geographical faunal lists rather than a complete monograph of the family, and consequently they do not include all the species under discussion here. Nevertheless, these are the most modern works on the group at the present time and provide much useful information. Other than the above-mentioned references and three or four important papers describing many new species but without illustrations, the only sources of information available on the worldwide Mitridae are scattered locality records or occasional descriptions of new species.

These works, therefore, formed the basis of the present study. Although numerous other references were consulted, those listed here were the only ones to contribute any information pertaining to the differences or similarities among the six species.

Vexillum regina (Sowerby, 1825)

(Plate 18, figures 1a, 1b; Plate 19, figure 1)

Type locality: China Seas

The original citation of Vexillum regina presents no technical description of any sort. In Genera of Shells Sowerby (1825) figured the ventral aspect of this species as one of eight typical representatives of the genus Mitra; the only mention of its name appears in the caption to Plate 250 (op. cit.), merely as "4. Mitra Regina". This original figure, however, is an excellent illustration of the species and leaves no doubt as to its identity.

Kiener (loc. cit.) published fairly good likenesses of both dorsal and ventral views, although with some exaggeration as to the shell's specific characters; he included, however, a very complete description and cited the type locality as "China Seas".

Küster (loc. cit.) figured Vexillum regina rather well as compared with many of the other species in his "Conchylien-Cabinet", the chief fault with his illustration being a somewhat foreshortened last whorl which makes the spire appear exaggeratedly high. Küster's description is complete enough and cites the type locality as "The Chinese and Indian Oceans".

Reeve (loc. cit.) published only one view (this time the dorsal side) of the species, slightly more obese than normal but reasonably typical and well colored; his brief description is adequate except for ignoring the coarse, heavy surface ornament which is one of the species' most distinguishing features. Reeve correctly pointed out that Vexillum regina could be distinguished from V. taeniatum (Lamarck) "by the angular structure of the ribs near the sutures".

Chenu (loc. cit.) included a good representation of the species, correctly identified.

Nearly fifty years after the original publication of the species, Sowerby figured the ventral aspect of Vexillum regina in Thesaurus Conchyliorum, this time using a different, more perfect specimen for his illustration which reveals more brilliant colors than the original figure. He dismissed the species with only a brief reference to Genera of Shells and still furnished no written description but added the type locality as "Moluccas".

Tryon (loc. cit.) merely copied the second Sowerby figure, described the colors of the stripes on the shell, and mentioned its size and locality.

Vexillum regina may be readily recognized by its heavy, coarse sculpture, its slender, turriculate form with attenuated spire, its gradate sutural ramp, angular outlines, and constricted lip. This species has been recorded from Zanzibar and from the Andaman Islands, in addition to the Moluccas.

Vexillum compressum (Sowerby, 1874)

(Plate 18, figures 2a, 2b; Plate 19, figure 2)
Type locality: Moluccas

This species is encountered in the works of Chenu and Reeve prior to its description by Sowerby in 1874, though it is not recognized as distinct. Chenu indicated two different species under the name Vexillum taeniatum (Lamarck); one of these is V. compressum, the other a typical V. taeniatum. Reeve considered V. compressum merely the young state of V. taeniatum, though remarking at the same time upon its different form and recurved base; he based his judgment on the similarity of color and on its being found in the same locality. Tryon also included this species with V. taeniatum as a narrower, juvenile form.

Sowerby first recognized this small, rare form as a separate species, stating "it is much narrower and more attenuated and laterally compressed than M. regina, narrowed and recurved anteriorly." Examination of actual specimens of Vexillum compressum gives validity to Sowerby's convictions; the shells are almost like miniatures of V. regina, though a close inspection reveals the following differences: V. compressum is adult at about one-half to two-thirds the size of a typical adult specimen of V. regina; unlike that of V. regina, the spire of V. compressum is shorter than the last whorl, and there are many more raised labral lirae than in the typical V. regina. Its sutural ramp is more rounded, its early whorls are comparatively larger than those of V. regina despite its smaller size, the axial costae of the adapical whorls are smooth, not nodose, and finally the siphonal canal is more acutely curved in V. compressum and inclined in a different direction.

The Kiener and Küster monographs do not refer to the species.

Vexillum compressum has been recorded from the Philippine Islands, although the records are somewhat ambiguous in the light of its having been considered a synonym of V. taeniatum. Specimens included in the present study, however, were collected at Subic Bay, Davao, and Mindoro in the Philippines, giving some credence to the earlier records.

Vexillum coloscopulus J. Cate, 1961

(Plate 18, figures 3a, 3b; Plate 19, figure 3)
Type locality: Balabac Island, Philippines

This species differs from Vexillum regina in the following ways: the surface ornament is smoother and is continuous over the axial costae; the sutural ramp is rounded instead of gradate; the shape is more fusiform than turriculate; the aperture is straight, not constricted; there is no pseudumbilicus; there are several faint labral lirae instead of only a few raised ones, and the pattern arrangement and color are different. There is no central thread on the white band, the black areas are wide zones rather than narrow borders outlining the white band as in V. regina, and the white band, narrower than in the other compared species, is centrally placed on the adapical whorls.

No reference or illustration for this species was found in the early literature. It is presently known from only four specimens, the holotype from Balabac, two hypotypes which were collected in the Sulu Archipelago and at Zamboanga, and an additional specimen whose locality is given only as "Philippine Islands".

Of the three remaining species in the complex, the first rough scrutiny made it possible to divide the available specimens, on the basis of spire ornament, into two main groups. Certain of the specimens were seen to have many very closely-spaced, well-defined axial costae on the upper whorls, and fewer, flatter costae on the last whorl; the others possessed approximately the same number of axial costae on the last whorl as on the upper ones, and these were all equally sharply defined. After the two groups had been separated, it was interesting to note that the specimens with closely-spaced adapical costae had all been collected in Queensland, Australia, while the shells in the second group were all from the southern Philippines, mainly from Balabac Island or the adjacent Sulu Sea. It is the Philippine group which I consider a subspecies of Vexillum regina.

Further study after the first separation revealed additional morphological differences between the two groups; the Queensland shells were more obese, their spires proportionately shorter and less turriculate, their axial costae less pronounced and less regularly spaced, their colors less variable, and so on.

The next step was to identify the Queensland species; close study of this large group brought out two subgroups which could be separated from one another, first, by the interstitial striae present in one but lacking in the other; also by the more obese form and by the flatter, more numerous axial costae of one of these. It was then apparent that these two Queensland forms are the species respectively described as Vexillum taeniatum (Lamarck, 1811) and V. vittatum (Swainson, 1821). Vexillum vittatum has been considered a synonym of V. taeniatum by some workers, yet the diagnostic morphological characters of both seem clearly separable. The question remained as to whether these separating characters are sufficiently strong and numerous to define separate species.

Vexillum taeniatum (Lamarck, 1811)

(Plate 18, figures 4a, 4b; Plate 19, figure 4)
Type locality: Indian Ocean

Lamarck's original description of Vexillum taeniatum is somewhat sketchy, though his reference to a figure in the Encyclopédie Méthodique and one phrase in his description definitely separate this species from the others: this is his reference to "petites côtes longitudinales, obtuses, fréquentes, peu élevées, et de stries transverses qui ne paroissent bien qu' entre les côtes". This is the only species of the six under consideration which possesses transverse interstitial striae; in the other species the spiral ornament is continuous, even though in V. regina this ornament is nodose where it intersects the costae. Therefore, one of the two Queensland species can be definitely identified as V. taeniatum. All of the available study specimens which I have assigned to this species agree closely with the original description, and with the figure in the Encyclopédie Méthodique referred to by Lamarck. Other separating features include a more obese form, more closely-spaced, flatter axial costae on the last whorl, and a rounded sutural ramp.

Kiener illustrates dorsal and ventral views of what may have been Lamarck's holotype of Vexillum taeniatum, clearly showing emphasis on the obese form and interstitial striae which are its most important diagnostic features.

Reeve's two illustrations labelled Vexillum taeniatum leave much to be desired: one (Conch. Icon., fig. 52a) represents a fine specimen of V. compressum (Sowerby), the other (ibid., fig. 52b) adequately indicates the general shape of V. taeniatum but fails to show the interstitial striae. Reeve considered V. compressum merely a juvenile example of V. taeniatum, apparently overlooking the several morphological differences between these two species.

Küster illustrated this species with exaggerated drawings but fortunately emphasized the important characters.

Chenu followed Reeve's error in considering Vexillum taeniatum and V. compressum synonymous; he illustrated both species very

Fig. 1 a
Vexillum r. regina

Fig. 2 a
V. compressum

Fig. 3 a
V. coloscopulus

Fig. 4 a
V. taeniatum

Fig. 5 a
V. vittatum

Fig. 6 a
V. r. filiareginae

Fig. 1 b

Fig. 2 b

Fig. 3 b

Fig. 4 b

Fig. 5 b

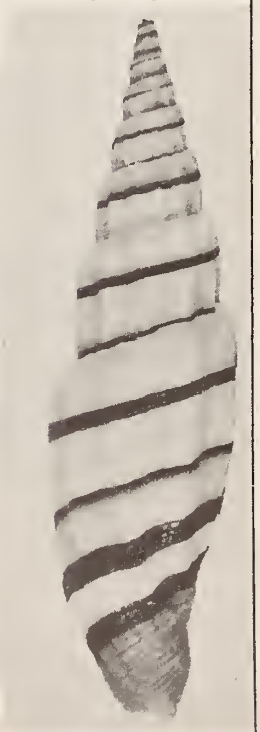

Fig. 6 b

Pierson, Oswald, & Pierson, *photo.* except Figures 1a & 1b: Courtesy of Stanford University

Figure 1
Vexillum r. regina (Sowerby)

Figure 2
Vexillum compressum (Sowerby)

Figure 3
Vexillum coloscopulus J. Cate

Figure 4
Vexillum taeniatum (Lamarck)

Figure 5
Vexillum vittatum (Swainson)

Figure 6
Vexillum r. filiareginae subsp. nov.

Photographic enlargements showing distinctive sculpture

Pierson, Oswald, & Pierson, *photo.*

well but applied the name V. taeniatum in both instances.

Sowerby's Thesaurus Conchyliorum is the only monograph to illustrate four of the discussed species in accordance with their original descriptions; two of these four are Sowerby species, but the excellent color plates also clearly point out the differences between Vexillum taeniatum and V. vittatum.

Tryon's contribution will be covered under the section on Vexillum vittatum; he considered all the species in this complex synonymous, with the exception of V. regina.

Vexillum taeniatum has been recorded from Madagascar; Bombay; Moluccas; Mindoro, Masbate, and Cebu in the Philippines; Maurice Island, and Queensland.

Vexillum vittatum (Swainson, 1821)
(Plate 18, figures 5a, 5b; Plate 19, figure 5)
Type locality: Pacific Ocean

Swainson's original description of this species mentions "interstices with slender, crowded, transverse grooves", but the accompanying poorly-colored figure of the holotype does not indicate these, nor are they visible in two out of three of Reeve's poor figures, in Kiener's, Küster's, Sowerby's, nor in Dautzenberg's (1935) excellent illustration, the only actual photograph of this species to appear in the literature. All these monographers represent Vexillum vittatum with continuous spiral sculpture over the high points of the costae.

Küster's stylized ventral view presents a recognizable illustration of Vexillum vittatum and his description is adequate.

Tryon placed Vexillum vittatum in synonymy with V. taeniatum, along with V. compressum (Sowerby), V. coccineum (Reeve), and V. taylorianum (Sowerby), copying the obviously different type figures of all these species but asserting that they are identical.

Dautzenberg (1935) nearly arrived at the solution to the problem of separating Vexillum vittatum from V. taeniatum, saying "if it is true that these species resemble one another by the disposition of their pattern and their coloration, they differ considerably by the form and the sculpture; M. vittata having more angled whorls, the latter whorl larger; the axial folds are much heavier and more projecting on the last whorls." However, he then included in his illustration of V. vittatum both that species and V. taeniatum under the same name, thereby confusing the issue even more than before. Instead of illustrating the species V. vittatum as he intended, his figures afford a fine comparison of V. vittatum (Dautzenberg, 1935, Pl. 4, fig. 3) with V. taeniatum (ibid., Pl. 4, fig. 4). On the same plate Dautzenberg also illustrated V. coccineum (Reeve, 1844) under the questionable combined name of V. taeniatum coccineum (Reeve) — a combination difficult to understand when both names apply to separate, established species, thereby further complicating the problem of identifying the typical V. taeniatum.

The basic differences between Vexillum vittatum and V. taeniatum are few but easily enough defined if one disregards the similarity of color and pattern, as may be seen by the accompanying black-and-white photographs on Plate 19, figures 4 and 5. While the adapical whorls of both species indicate interstitial striae, in V. vittatum these striae become continuous on the last whorl (sometimes on the penultimate whorl as well) and are not interrupted by the axial costae. Vexillum vittatum is more shouldered and the base is more angulate than in V. taeniatum. The closely spaced adapical costae become more distant with maturity in V. vittatum, reducing in number from approximately 20 on the antepenultimate whorl to about six on the last whorl; in V. taeniatum the number of costae remains more or less constant on all the whorls. The tendency among the specimens studied seems to be for the spire length to be about equal to the last whorl in V. vittatum, slightly shorter than the last whorl in V. taeniatum, though this characteristic cannot be considered definitive in view of the small number of specimens studied.

The lack of spiral ornament just below the sutures which is so apparent in the enlarged photograph (Plate 19, figure 5) should be disregarded as a diagnostic character as it is not constant among the specimens studied, nor is it as prominent on the photographed specimen as the photograph indicates.

With the above five species adequately identified, a sixth group remained which possessed certain traits common to several of the others but still did not fit all of the characteristics of any one of them, nor was it encountered in the literature except as a wrongly labelled figure. Since a fairly large sample (34 specimens) of this particular group was available for study, all consistently exhibiting the same morphological features exclusive of color, this form is considered a separate taxon and is here described as a new subspecies.

VOLUTACEA
MITRIDAE
Vexillinae
Vexillum RÖDING, 1798
Vexillum regina (SOWERBY, 1825)
Vexillum regina filiareginae J. CATE, subspec. nov.

(Plate 18, figures 6a, 6b; Plate 19, figure 6;
Plate 20, figures 1a - 10a, 1b - 10b)

Shell long, straight, slender, turriculate-fusiform; spire about as long as the last whorl. Protoconch lacking; (three to four postnuclear whorls eroded by acid in the holotype); teleoconch of about nine straight-sided oblique abutting whorls; shoulders obtusely rounded. Axial sculpture of raised equidistant collabral costae (about 12 on the penultimate whorl) whose ridges and valleys are of about equal depth, forming a regular, zigzag pattern when viewed from the apex; costae not regularly aligned between sutures; proportionately the same number of costae on adapical whorls as on last whorl. Spiral ornament of low cords, rounded, crenulate, narrow and crowded below the sutures, flattened into wider bands at periphery, again becoming rounded, narrower and wrinkled at lower part of neck; all spiral cords separated by smooth, shallow impressed striae and crossed by faint, irregularly spaced orthocline rugae. Aperture straight, siphonal canal slightly recurved; labrum thickened, constricted (adapical edge chipped in holotype); number of labral lirae variable (usually three to six raised lirae and several faint abapical lirae present). Parietal ridge present; columella straight; three to five oblique columellar folds, greatly diminishing in strength abapically; peristome continuous, pseudumbilicus and siphonal fasciole faintly produced.

Color of holotype white, with four narrow black spiral bands on last whorl; neck of shell below abapical band orange (Maerz & Paul Dictionary of Color, 1st Edition, 1930; Plate 12, J-12). Color of paratypes variable; numbers 1-4 and 10-13 similar to holotype, but neck and one narrow spiral band sometimes dark orange to dark gray. Paratypes 5-8 and 14-32 predominantly orange-brown, with one wide and one narrow white spiral band on last whorl; Paratype 9 is black with two white bands. In all specimens the wide white spiral band is contiguous to abapical sutures and approximately six cords wide; the narrower band, about half as wide, is always immediately above the adapical columellar fold adaxially and borders the upper part of the neck; a central yellow thread present on wide white band in about half the specimens. Aperture color white to cream; color pattern visible through translucent labrum.

Animal of the species unknown.

Measurements of the holotype: Height, 66.4 mm.; Greatest diameter, 18.1 mm.; Length of aperture, 34.9 mm.

The type locality of Vexillum regina filiareginae is here designated as Cape Melville, Balabac, Philippine Islands (7° North Latitude, 117° East Longitude).

The name filiareginae means "daughter of the queen", or princess — a name considered suitable for a species closely related to Vexillum regina. Since V. regina filiareginae has so long been confused with the older, more familiar V. regina, it was made a subspecies of this form rather than of the new species V. coloscopulus, to which it is as closely related.

When the preliminary study for this paper was nearing completion and the photographs of the first ten specimens listed below had been taken, an additional shipment of 22 newly collected specimens of Vexillum regina filiareginae from Balabac was sent to me by Mr. Fernando Dayrit of Manila. Still later one important additional specimen was discovered in the collection of Mr. and Mrs. John Q. Burch, this shell having been unavailable earlier. The Burch specimen is identical with the orange-colored paratypes from Balabac, particularly resembling Paratype 6 (Plate 20, figures 7a, 7b). Its locality, however, is reported as Mozambique, East Africa — approximately 8° of latitude southward and 77° of longitude westward, or a distance of roughly 5,500 statute miles in a southwesterly direction from the type locality. This locality record would seem to establish a tentative range for the subspecies from Mozambique to Zamboanga. An even wider range may come to light as more specimens are reported.

The latter 23 specimens were included in the study and designated as paratypes, though they do not appear in the photograph on Plate 20 as they were received too late for processing.

The most variable of the six taxa under discussion, Vexillum regina filiareginae combines some of the morphological features of V. coloscopulus and some of those of V. regina and may be a link between these two species

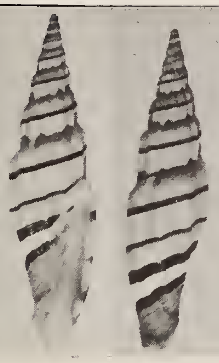

Figure 1
Holotype

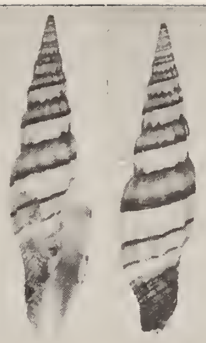

Figure 2
Paratype 1

Figure 3
Paratype 2

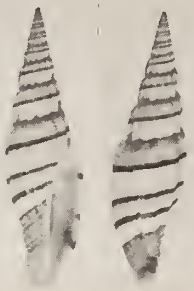

Figure 4
Paratype 3

Figure 5
Paratype 4

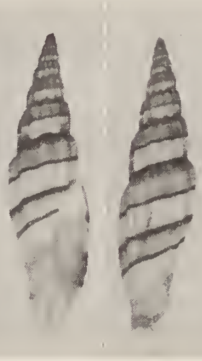

Figure 6
Paratype 5

Figure 7
Paratype 6

Figure 8
Paratype 7

Figure 9
Paratype 8

Figure 10
Paratype 9

Holotype and nine Paratypes of *Vexillum regina filiareginae* subspec. nov.

PIERSON, OSWALD, & PIERSON, *photo.*

although itself possessing enough constant morphological characters to be considered a separate taxon. Its greatest variability lies in its color; except for a slight fluctuation in obesity and a certain amount of flattening-out of the ribs on the last whorl in some instances (apparently always in the orange-colored specimens rather than in the predominantly white ones), its other features seem well established. It appears to be the least rare of the six members of its complex.

In arrangement of its color pattern, the new subspecies resembles Vexillum taeniatum and V. vittatum; the wide white band is contiguous to the abapical sutures, bordered in most instances by narrow black lines instead of wide black zones as in V. coloscopulus, and frequently (but not always) with a central yellow thread.

The color ranges from predominantly white with gray and black areas, as in the holotype and paratypes 1-4 (Plate 20, figures 1-5) and 10-13, through various shades, amounts, and combinations of orange; one specimen (paratype 9, Plate 20, figure 10) exhibits a reversed arrangement of the holotype's color and is largely black with white zones. Paratypes 8 (Plate 20, figure 9), 14, 15, 17, 18, and 19 reveal a tendency toward dark blackish-orange zones rather than the more sharply defined narrow black bordering lines of the other specimens; these are the most closely related to Vexillum coloscopulus but remain distinct from that species because of the much wider white band, the presence of two white bands on the last whorl, by the sharper and more frequent axial costae on the last whorl, and by the placement of the wide white band adjacent to the abapical sutures.

A central yellow thread is present in about half the specimens studied, while the others have simply a plain white band without adornment.

Vexillum r. filiareginae has a slightly more gradate sutural ramp than V. coloscopulus, though it is considerably less angled than in V. regina. Its spiral ornament is smoother than that of V. regina and consists mostly of flat, continuous spiral cords similar to those of V. coloscopulus. The chief distinguishing characteristic of V. r. filiareginae (especially true of the holotype and paratypes 1, 2, 4, 10-13) is its regular, closely-spaced axial costae which for the most part do not diminish as they approach the labrum and maintain proportionately the same number on each whorl.

Synonymy:

1844 Mitra melongena Reeve (pars) not Lamarck, 1811. (Conch. Icon., fig. 47c)
1874 Mitra melongena Sowerby (pars) not Lamarck, 1811. (Thes. Conch., fig. 132)
1882 Mitra melongena Tryon (pars) not Lamarck, 1811. (Man. Conch., Pl. 49, fig. 401)

It is impossible for the present subspecies to be the same as Mitra melongena Lamarck, 1811, since according to the original description M. melongena is a smaller shell, 38-40 mm. long instead of 55-67 mm.; its color is described as similar to M. lyrata Lamarck, 1811, which is basically a grayish-brown; and most importantly, Vexillum regina filiareginae has no resemblance to the illustration cited by Lamarck as the type figure of M. melongena (Encyclopédie Méthodique, Pl. 373, fig. 9). Reeve apparently based his conclusions solely on that part of Lamarck's written description of M. melongena which refers to a "whitish background, ornamented with several transverse zones, some of a very brownish-red, others a livid tawny color".

Sowerby, and later Tryon, copied Reeve's erroneous figure, thus compounding the error and confusing several generations of conchologists; each of these authors illustrated three obviously different species under the name of Mitra melongena, only one of which in each case approaches a similarity to Lamarck's type figure.

Relative importance of some diagnostic characters used to separate the species

Some of these morphological features are more reliable than others in identifying certain Mitrid species; their relative importance here is based on observation of the most outstanding features of all the subgenera and over 300 recognized species which are presently available to me for study.

The relative width and placement of the pattern-stripes appear to be constant in those species where they are present, such as Vexillum caffrum (Linnaeus, 1758); V. gruneri (Reeve, 1844); V. plicarium (Linnaeus, 1758); V. lyratum (Lamarck, 1811); several species of Imbricaria, Swainsonia, etc. It therefore seems reasonable to assume that this character will be a constant factor in the species discussed here also, and it is one of the bases for separating V. coloscopulus from the other members of the complex.

Table showing measurements (in millimeters) of the holotype and paratypes, the collecting localities and present distribution of these specimens

Vexillum regina filiareginae J. Cate, subspec. nov.

	Length	Width	Length of Aperture	Locality	
Holotype	66.4	18.1	34.9	Balabac	Stanford Univ. Paleo. Dept. Type Coll., No. 8623
Paratype 1	64.6	15.4	33.3	Balabac	Calif. Acad. Sci. Geol. Dept. Type Coll., No. 12 366
Paratype 2	55.4	15.0	29.7	Balabac	C. N. Cate Collection
Paratype 3	56.2	15.4	29.8	Balabac	A. d'Attilio Collection
Paratype 4	62.7	16.3	30.7	Balabac	F. Dayrit Collection
Paratype 5	62.3	16.7	32.5	Laminusa	C. N. Cate Collection
Paratype 6	67.4	17.5	34.6	Zamboanga	A. d'Attilio Collection
Paratype 7	65.2	15.4	31.5	Zamboanga	A. d'Attilio Collection
Paratype 8	57.0	15.0	29.0	Balabac	F. Dayrit Collection
Paratype 9	62.9	16.9	31.6	Balabac	C. N. Cate Collection
Paratype 10	54.9	14.6	29.6	Balabac	F. Dayrit Collection
Paratype 11	60.8	15.8	30.9	Balabac	F. Dayrit Collection
Paratype 12	57.4	14.1	27.8	Balabac	F. Dayrit Collection
Paratype 13	60.2	14.9	29.9	Balabac	F. Dayrit Collection
Paratype 14	57.3	14.2	29.4	Balabac	C. N. Cate Collection
Paratype 15	60.7	14.8	30.1	Balabac	C. N. Cate Collection
Paratype 16	57.0	13.8	28.3	Balabac	C. N. Cate Collection
Paratype 17	64.3	15.6	31.6	Balabac	C. N. Cate Collection
Paratype 18	67.0	17.3	32.6	Balabac	C. N. Cate Collection
Paratype 19	71.5	17.9	34.6	Balabac	F. Dayrit Collection
Paratype 20	70.8	17.6	36.0	Balabac	F. Dayrit Collection
Paratype 21	66.9	15.9	32.7	Mozambique	J. & R. Burch Collection
Paratypes 22 to 26				Balabac	C. N. Cate Collection
Paratypes 27 to 28				Siasi, Sulu	C. N. Cate Collection
Paratypes 29 to 32 (juveniles)				Balabac	C. N. Cate Collection

The following paratypes will be deposited as indicated:

Paratype 22	U. S. National Museum
Paratype 23	Museum of Comparative Zoology
Paratype 24	British Museum (Natural History)

The relative amounts and various kinds of surface ornament and the angle of the sutural ramp are also reliable characters for species separation.

The two least reliable diagnostic characters are the number of columellar folds and the color of the shell. The columellar fold-count, long supposed to be a valid reference point for Mitrid species, is not a constant factor. When large series of shells of the same species are examined, the number of folds is seen to vary from half a fold to several folds; therefore, this character should be used only on the generic or subgeneric level to indicate a general trend. Among species and subspecies it is not sufficiently constant to be relied upon. Also, since the strength of these folds may vary somewhat from one specimen to the next, it has been demonstrated that the count will be interpreted differently by different workers. A weak anterior fold may be counted by some, disregarded entirely by others.

Color is an extremely variable feature among the Mitridae and must be one of the last physical characters to be considered in identifying a species. This is more true of some species than others, but until one knows which ones may be relied upon to be constant, color should be avoided as a diagnostic feature.

Conclusions

It is my belief that the six forms discussed in this paper are separate, well-defined taxa, heretofore confused through the similarity of color and of pattern arrangement, with *Vexillum taeniatum* and *V. vittatum* the most closely

Table 1

Chart Showing Distinguishing Characters of *Vexillum regina* (Sowerby, 1825) and Related Forms

Diagnostic Characters	*V. regina*	*V. r. filiareginae*	*V. coloscopulus*	*V. compressum*	*V. taeniatum*	*V. vittatum*
Spire	longer than last whorl	about as long as last whorl	longer than last whorl	shorter than last whorl	shorter than last whorl	shorter than last whorl
Shell shape	slender turriculate	slender fusiform, sides straight	slender fusiform, sides convex	slender fusiform - turriculate	obese fusiform, sides convex	slender fusiform, sides angled
Labrum	constricted	constricted	straight	constricted	constricted	constricted
Labral lirae	about 3, raised	variable; usually 3-6 raised lirae and several faint abapical lirae	about 12 faint lirae	12 to 15 raised lirae	about 12 raised lirae	more widely spaced, strong, about 6 to 9 lirae
Siphonal canal	sharply recurved	slightly recurved	slightly recurved	sharply recurved	very slightly recurved	nearly straight
Columellar folds	4	3 to 5	4	4	4 to 5	4 to 5
Pseudumbilicus	faintly produced	usually faintly produced	lacking	faintly produced	very faintly produced	faintly produced
Axial costae	extremely coarse, elevated, nodulose	widely spaced, well defined, smooth	smooth, somewhat flattened	coarse, elevated, nodulose	close, faintly raised, fewer on last whorl than on spire	few, heavy, more projecting
Sutural ramp	angular, gradate	moderately angled	rounded	rounded	smoothly sloping, hardly defined	slightly angled
Parietal lip	well defined	variable	lacking	moderately well defined	variable	variable
Spiral ornament	coarse, rough	smooth	smooth	coarse	smooth	smooth
Spiral sculpture	continuous	continuous	continuous	continuous	transverse interstitial striae	continuous
Neck of shell	roughly granulate	nearly smooth	nearly smooth	roughly granose	wrinkled	wrinkled
Adult shell length	long: 75 mm.	57 to 68 mm.	long: 55 to 80 mm.	short: 48 mm.	65 to 70 mm.	45 to 65 mm.
Peristome	entire	entire	discontinuous	discontinuous	entire	entire
Shell color	bright orange, or blackish	variable	brick-red	orange	orange	orange
White bands	one wide, one narrow	one or two	one narrow band only	one	one white, one pale orange	one white, one pale orange
White band placement	contiguous to abapical sutures	contiguous to abapical sutures	central on adapical whorls	contiguous to abapical sutures	contiguous to abapical sutures	contiguous to abapical sutures
White band bordered by:	narrow black lines	narrow black lines	wide black zones	narrow black lines	narrow black lines	narrow black lines
White band ornamentation	central yellow thread	variable; some with yellow thread, some without	lacking	yellow thread present	yellow thread present	yellow thread present
Aperture color	white	white to cream	cream to dark ivory	white	white	white

related and most difficult to separate. The relative sizes of adult specimens and differences in spiral ornament separate *V. regina* from *V. compressum*; surface ornament and pattern placement define *V. coloscopulus*; axial costae differences make *V. r. filiareginae* distinct; transverse interstitial striae set *V. taeniatum* apart; and *V. vittatum* is characterized by a shorter spire, wider shoulders, and a less attenuate last whorl.

Using a goniometer, the spire angles of all six forms were measured, as it was hoped an additional basis for separating them could be established in this way. The imbalance in numbers of specimens of each species makes such a study somewhat ineffective, as there were available at the time the measurements were made only two specimens of *Vexillum compressum* and *V. coloscopulus*, respectively; four each of *V. taeniatum* and *V. vittatum*; five of *V. regina*; and 29 of *V. r. filiareginae*, the others having been returned to their owners. A comparison of such figures would be inconclusive except as a general indication of the trend. However, as shown in the accompanying bar diagram (textfigure 1), it will be seen that while the angle measurements overlapped in some of the species, the mean spire angle of each is relatively distinct from the others, with *V. compressum* having the most acutely angled spire, and *V. vittatum* the most obtuse.

No work has been recorded on the anatomies or radulae of any of the six species.

For easy identification of the various forms, I offer the following brief key based on morphological differences exclusive of color, and an expanded chart (Table 1) tabulating all the characteristics of each species.

1. Costae interrupted by interstitial striae; shell obese . . . . . . *taeniatum*
Costae not interrupted by interstitial striae; shell slender 2
2. White spiral band wide, contiguous to abapical sutures 3
White spiral band narrow, centered on adapical whorls . . . . *coloscopulus*
3. Regular, sharply angled costae . . . 4
Widely spaced, infrequent costae. . . . . *vittatum*
4. Axial costae nodulose 5
Axial costae smooth . . *r. filiareginae*
5. Adult shell short (48 mm.), sutures rounded . . . . *compressum*
Adult shell long (75 mm.), sutures with gradate ramp . . . . *regina*

The rarity of these shells is probably partly responsible for the fact that the confusion in their identities has not been corrected earlier; it is seldom, indeed, that all six of these magnificent species may be seen at one time for comparative work.

I was extremely fortunate in having access to loaned specimens of those species lacking in my own collection. For the courtesies extended in this regard I am indebted to Dr. Myra Keen, the late Dr. Howard R. Hill, Mr. George Kanakoff, Mr. Anthony d'Attilio, Mr. and Mrs. John Q. Burch, Mr. E. W. Ulrich, Mr. James Bailey, and Mr. Fernando Dayrit. A special word of appreciation is also directed to Dr. Rudolf Stohler who translated the references by Küster. The long hours necessary for the preparation of this paper would not have been available without the patience and helpfulness of Crawford Cate in many practical ways, for which I am deeply grateful.

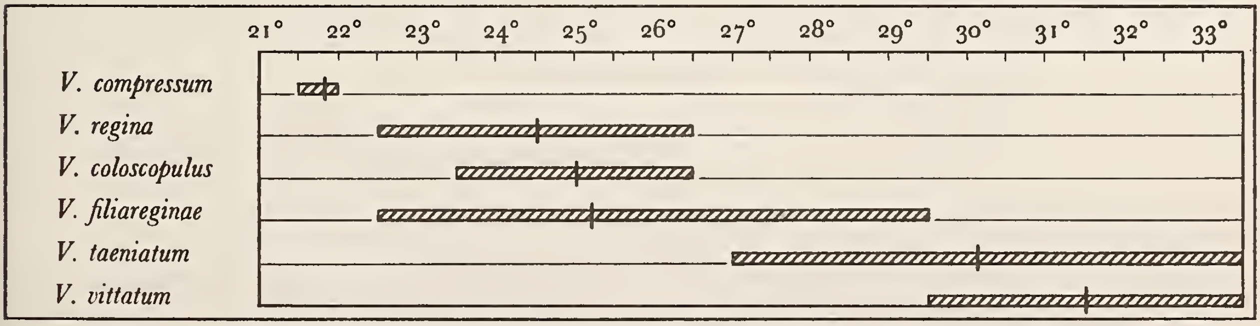

Figure 1: Bardiagrams showing the relationships among various forms under discussion based upon measurements of apical angles.

Number of Specimens	Locality	In the Collection of
Vexillum regina (Sowerby, 1825)		
2	Moluccas	Stanford University, No. 1'660
1	Zanzibar	Anthony d'Attilio, Valley Stream, New York
1	Moluccas	Los Angeles County Museum, No. A2'777
1	Andaman Islands	E. W. Ulrich, Long Beach, California
1	China	James Bailey, Los Angeles, California
2	Madagascar	C. N. Cate, Los Angeles, California
1	Philippine Islands	American Museum of Natural History
9	Moluccas	American Museum of Natural History
5	Madagascar	American Museum of Natural History
4	Madagascar	Academy of Natural Sciences of Philadelphia
1	Philippine Islands	F. K. Hadley, West Newton, Massachusetts
Vexillum compressum (Sowerby, 1874)		
1	Lubang, Mindoro, P. I.	George P. Kanakoff, Los Angeles, California
2	Davao, Philippines	Howard R. Hill, Los Angeles, California
1	Philippine Islands	American Museum of Natural History
2	Moluccas	American Museum of Natural History
1	locality unknown	American Museum of Natural History
1	Subic Bay, Philippines	Academy of Natural Sciences of Philadelphia
1	Philippine Islands	F. K. Hadley
Vexillum coloscopulus J. Cate, 1961		
1 (type)	Balabac, Philippines	Calif. Acad. Sciences, Geol. Dept. Type Coll. No. 12'363, San Francisco, California
1	Sulu Archipelago	Mr. and Mrs. John Q. Burch, Los Angeles
1	Zamboanga, P. I.	Anthony d'Attilio
1	Philippine Islands	F. K. Hadley
Vexillum taeniatum (Lamarck, 1811)		
1	Cooktown, Australia	E. W. Ulrich
1	Cooktown, Australia	James Bailey
1	North Queensland	Howard R. Hill
1	Fort Douglas, Australia	C. N. Cate
2	Gubbins Reef, Queensland	C. N. Cate
2	Queen's Beach, Bowen, Queensland	Mr. and Mrs. John Q. Burch
1	Queensland	F. K. Hadley
Vexillum vittatum (Swainson, 1821)		
1	Cooktown, Australia	E. W. Ulrich
1	North Queensland	C. N. Cate
2	Gubbins Reef, Queensland	C. N. Cate
1	Masbate	American Museum of Natural History
10	Moluccas	American Museum of Natural History
Vexillum r. filiareginae J. Cate, subspec. nov.		
2	Zamboanga, P. I.	Anthony d'Attilio
8	Balabac, Philippines	Fernando G. Dayrit, Manila, Philippines
1	Balabac, Philippines	Anthony d'Attilio
18	Balabac, Philippines	C. N. Cate
3	Laminusa, Siasi, Sulu	C. N. Cate
1	Mozambique, East Africa	Mr. and Mrs. John Q. Burch
1	Philippine Islands	F. K. Hadley

The photographs of Vexillum regina (Plate 18, figures 1a, 1b) were furnished through the courtesy of Stanford University. The remaining photographs are by Pierson, Oswald and Pierson.

An unexpected trip east after this manuscript had been completed made it possible to visit the collections of Mr. and Mrs. F. K. Hadley, the American Museum of Natural History, and the Academy of Natural Sciences of Philadelphia. All specimens of the six discussed species in these collections were measured and recorded as part of the study, and I am grateful to Dr. William K. Emerson, Mr. William E. Old, Jr., Virginia Orr, and Mr. and Mrs. Hadley for their kindness in providing this opportunity.

Literature Cited

Cate, Jean M.
1961. A new Vexillum (Mitridae) from the Philippine Islands. Veliger 4 (1): 4-8, pls. 1, 2, 1 textfig.

Chenus, J. C.
1859. Manuel de Conchyliologie. I: 1-507. Paris.

Dautzenberg, Ph.
1935. Résultats scientifiques du voyage aux Indes Orientales Néerlandaises. 2 (17) Gastéropodes marins. 2. Famille Mitridae 44-208, pls. 2-4.

Dautzenberg, Ph., & L.-J. Bouge
1922. Mitridés de la Nouvelle Calédonie et de ses dépendances. Jour. Conchyl. 67: Famille Mitridae, 83-259, pl. II.

——, —— & ——, ——
1933. Les mollusques testacées marins des établissements français de l'Océanie. Jour. Conchyl. 77: Famille Mitridae, 152-199.

Encyclopédie Méthodique
1797. Vers, coquilles, mollusques et zoophytes. pls. 189-390.

Kiener, L. C.
1839. Iconographie des coquilles vivantes. Vol. 4, Mitra. pp. 1-120, pls. 1-34, Paris.

Küster, H. C.
1841. Die Familie der Walzenschnecken (Volutacea Menke). Nürnberg. Mitra: pp. 33-150, pls. 7-17e.

Lamarck, J.-B. P.
1811. Annales du Muséum d'Histoire Naturelle, vol. 17. Mitra: 195-222. Paris.

Reeve, Lovell Augustus
1844-1845. Conchologia Iconica. Monograph of the genus Mitra. pls. 1-39.

Sowerby, George Brettingham
1874. Thesaurus conchyliorum. Vol. 4, Monograph of the genus Mitra: 1-46, pls. 1-28.

Sowerby, James, & George Brettingham Sowerby
1825. The genera of recent and fossil shells. Vol. II: 159-279. London.

Swainson, William
1822. Zoological illustrations, vol. 2, pls. 9-119. London.

Tryon, George W., Jr.
1882. Manual of conchology, 4 (Mitridae): 106-200; pls. 32-58. Philadelphia.

Observations on the Biology of *Hermaeina smithi*, a Sacoglossan Opisthobranch from the West Coast of North America

by

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(13 Textfigures)

Introduction

This work concerns a member of the Opisthobranch fauna of the west coast of North America, Hermaeina smithi Marcus 1961 (Order Sacoglossa), probably the most common sacoglossan of this coast and certainly widely distributed. The Sacoglossa are very poorly known on the coasts of North America, and the major purpose of this study is to present various aspects of the biology of this common form which aid in understanding the principal features of its organization and its relationships with the habitat. The species was described from a single specimen, so that it is also intended to serve as a description of the salient features of the species. Moreover, in none of the ten described species in the genus has the internal anatomy been studied adequately. It is hoped that this description will enable the place of the genus within the sacoglossa to be evaluated at a later time when adequate information is available about other members of the very difficult Stiliger-Hermaea group.

This study began as a comparison between the feeding biology of this typical form and the more specialized Olea hansineensis Agersborg, but it soon became evident that more information had been gathered than is usually available about members of this poorly known group so that it was considered worthwhile to present this information separately. A similar study of Olea is being prepared.

I would like to gratefully acknowledge the support given to me by the Department of Zoology and the Friday Harbor Laboratories of the University of Washington. Part of this work was done during the tenure of a National Science Foundation graduate fellowship. The kindness of Joan E. Steinberg, James R. Lance, and W. Patrick Milburn made the examination of material from California localities possible.

Habitat

Hermaeina smithi Marcus, 1961, has been repeatedly found intertidally on San Juan Island, Washington, in Argyll Lagoon and in Garrison, Wescott, and Mitchell Bays. These bays are very similar and the first two share a common mouth, while the third is located near the other two. Both these bays and the smaller Lagoon are quiet, shallow mud-bottomed embayments, with extensive meadows of Zostera from the lowest intertidal level toward the center of the bays, and with bare mud flats in the higher intertidal zones. In summer the mud flats are often partially covered by patches of green algae, principally Ulva and Enteromorpha. It is in and near such algal mats at approximately 0 tide level that this sacoglossan may be found, at times in large numbers.

In California Hermaeina smithi has been found intertidally in upper Newport Bay by W. P. Milburn; in Tomales Bay (type locality; Marcus, 1961) and Bodega Bay by J. E. Steinberg. These bays generally resemble the muddy bays of San Juan Island. However, it has also been collected by J. R. Lance from small rocky pools among large boulders on the exposed beach at La Jolla, California, and by Miss Steinberg from high pools at Duxbury Reef, Bolinas, California, so that it cannot be said to be restricted in habitat entirely to the muddy bays of the Pacific coast. It has not been seen in dredgings in the San Juan Islands.

Adults and great numbers of egg masses have been found in the Enteromorpha tangles on San Juan Island from early April through September from 1954 through 1959. The animals are easily maintained in the laboratory on sections of the Enteromorpha mat. Examination demonstrated that the masses of Enteromorpha had finer filaments intermingled with the strands of the principal alga. These were identified as Rhizoclonium and Urospora spp. Tests were undertaken to determine the food species of the opisthobranch. Animals were removed from the algal mat and kept in clean dishes with running water for two days. After this period of starvation the animals were in good condition, actively moving about and making "seeking" motions with the head. When placed in dishes containing algae, these animals were quickly attracted to the filaments. Feeding began immediately on Rhizoclonium and Urospora (both Cladophorales-Cladophoraceae) but Enteromorpha (Ulvales-Ulvaceae) was never fed upon, even after prolonged starvation. Individuals that had rejected Enteromorpha readily fed upon Rhizoclonium. Both Urospora and Rhizoclonium have a thallus of slender, septate filaments, and the cells of the Urospora species used are of greater diameter than those of the Rhizoclonium. The tubular, multicellular thallus of Enteromorpha varies in diameter, with some strands of the same width as those of Rhizoclonium. The effect of filament diameter on food selection was investigated. Equal numbers of filaments of Enteromorpha and Rhizoclonium of the same width were selected, washed, and placed together in a container with circulating sea water. Starved animals were added, and it was observed that the sacoglossans quickly "examined" the filaments with the oral lobes and mouth region (never the rhinophores) and selected the Rhizoclonium for feeding. Microscope observations revealed that the animals would "examine" the filaments of Enteromorpha and even occasionally clasp them, just as they would the filaments of Rhizoclonium but would always quickly release the Enteromorpha and wander away. Feeding is described later. [Mr. J. R. Lance has observed this species feeding on Chaetomorpha sp. (Cladophoraceae) in southern California (personal communication).]

Habitus

This species is a slender form, which varies in size at maturity, but most individuals are about 10 mm. long, with some attaining 15 mm. Figure 1 depicts a living animal crawling on a flat surface. The rhinophores are held out laterally at a slight angle to the substrate. The anterior margins of the foot are extended on the surface and can be seen dorsally. The plump cerata are held curved dorsally over the back, at times interdigitating, but when the animal is disturbed they are extended out straight, giving a "bushy" appearance. To the unaided eye most individuals appear uniformly black except for the whitish rhinophore and cerata tips. The intensity of pigmentation of all parts of the body varies greatly in the local populations, and examination of large numbers of individuals reveals much variation. Some individuals are intensely pigmented so that even the white areas appear dark grey. Other individuals are so lightly pigmented that the animals appear brownish or even yellowish due to the color of the gonad. In many of the very lightly pigmented animals the usual pigment pattern becomes further obscured since the cream-colored areas do not contrast strongly with the darkly pigmented areas, just as it is obscured in dark forms by the light areas being invaded by dark pigment. The pattern described here is that of individuals in which the contrast is most distinct.

External Morphology

The cerata are not scattered but arise from two well-defined dorso-lateral zones. They are roughly arranged in obliquely transverse rows, with the smaller cerata located anteriorly, ventro-laterally, and posteriorly, a typical arrangement in this Opisthobranch group. The cerata number increases with size of individual, but the usual number is from 8 to 15 oblique rows, with two, three, or even four cerata in each row. A 10 mm. long mature specimen may have only about 16 cerata on each side, while a large specimen may have about 40, including many very small ones. In life the cerata are spindle shaped, abruptly widening close to the base and tapering distally toward the blunt point (figure 7). The side held against the back and against other cerata is somewhat flattened so that the larger cerata, about 2 to $2\frac{1}{2}$ mm. long, are ovoid in cross section and may be somewhat flattened toward the ends. In preserved material the cerata seldom retain life-like proportions; they usually change to a slender, evenly tapering form, circular in cross section. In life the cerata are contractile, with well-developed longitudinal muscle strands arranged in a loose cylinder around the digestive diverticulum (see figure 7 B).

The cerata tips are light in color, usually creamy-white while the lateral cerata surface, that usually exposed to view, is black. Lightly pigmented cerata show minute white dots, especially clustered at the tip (figure 7 B); these can be identified in sections as large mucus gland cells. The proximal half of the inner, hidden surface (figure 7A) is creamy-white and shows the dendritic pattern of vessels as described for Hermaeina orientalis, H. nigra, and H. toyamana by Baba (1949, 1959). These veins are not easily seen in preserved material and may also be difficult to detect in many lightly pigmented live animals.

Other structures visible on the dorsal surface are the very slightly elevated anus, located just to the right of midline, near the second and third cerata, a black spot near it, and the renal aperture. In intensely pigmented individuals, the back is solid black, and these structures cannot readily be found. In many animals the black pigment of the back is broken up by irregular unpigmented streaks, and in these, a clear area is usually present around the anus and the renal pore. The black spot seen near the anus is the location, just under the surface, of a small vesicle which has an intensely pigmented wall and a short duct opening to the surface well away from the anus so that this structure could not contribute a solidifying secretion to the feces. The renal aperture is tiny but can often be located in the center of a clear spot to the right of the heart area at the level of the fifth or sixth cerata row (figure 1).

The foot is prolonged posteriorly so that it extends behind as a slender tail (figure 1). It is widest anteriorly, and this end often shows slight bilobation in a crawling animal (figure 2) (see description of feeding). The anterior end of the foot projects forward under the head and between this anterior margin of the foot and the head above is a shallow median pit. Into this pit above the end of the foot opens a large number of small whitish foot glands (figure 4 fg). In the living animal the foot is not sharply set off from the sides by any groove or ridge but rather by color. The foot is much lighter than the sides. The foot margin is often a pure cream color, while the center of the sole is usually streaked and marbled by black pigment (figure 2). This is quite variable; in a few individuals the sole was virtually pure cream color, but in most there is some streaking vaguely arranged into two parallel longitudinal bands down the foot reminiscent of the bold pattern on the foot of Hermaeina minor (Baba, 1959).

The non-pigmented areas of the head produce a characteristic "masked" pattern. Dorsally, the eyes are surrounded by ovoid clear areas, and this zone extends anteriorly up along the lateral edges of the rhinophores (set off by dotted lines in figure 1). Paralleling this is a similar non-pigmented strip on the anterior rhinophore edge, leaving a black strip running up the middle. This black strip widens across the width of the rhinophore near the tip, which is cream colored. The trough-like underside of the rhinophore is not pigmented. The width of the rhinophore is constant almost to the rounded tip.

The rhinophores are auriculate, with both the median and the lateral borders rolled in slightly toward the middle. These margins are mobile and may be unrolled and the flat surface presented anteriorly. The antero-median border is extended as a rhinophoral lobe (figure 2, r l) about one-third of its length from the base. This extension is folded across the rhinophore and extends past the postero-lateral border so that it is visible dorsally (see figure 1).

Figure 1: Dorsal view of living animal, crawling

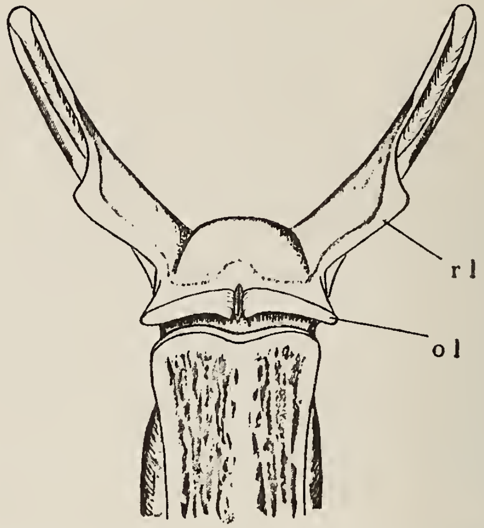

Figure 2: Ventral view of head of living animal (black pigment shaded)

r l - rhinophoral lobe
o l - oral lobe

The mouth is directed downward on the ventral surface of the head. It is flanked by two highly mobile lips, or oral lobes (figure 2, or l), which extend tab-like from near the rhinophore bases downward. These oral lobes are usually extended downward as in figure 2 and are repeatedly touched to the substrate as the animal crawls. The lobes are extended directly anterior and their median edges incurved in feeding (figure 3). The sides of the lobes are cream colored, usually with a median black streak down their length. Their ventral edges and part of their anterior faces are also cream colored, while their posterior faces are black. The ventral surface of the head thus displays an unpigmented pattern extending onto the rhinophore lobes, around the mouth, and on the oral lobes, which is indicated in figure 2.

Feeding

The animals crawl onto an algal filament and, grasping it with the anterior margin of the foot and the oral lobes, begin to feed (figure 3). No sticky secretion, such as observed by Fretter (1941) in feeding Elysia, was seen. The oral lobes are extended anteriorly and their inner margins clasped across the filament. The

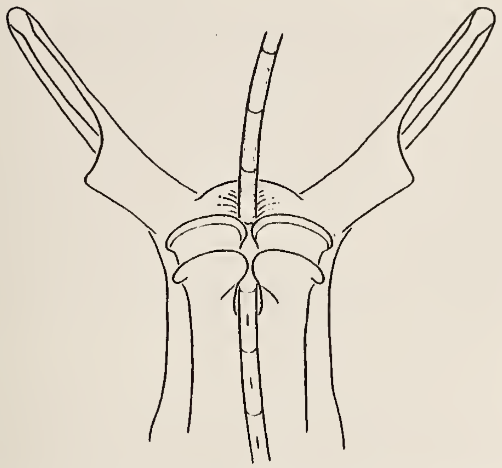

Figure 3: Ventral view of head of feeding animal (note slits in cells)

anterior margin of the foot is extended in a bilobate fashion and these lobes also grasp the filament. This holds the filament securely and bends it in toward the mouth. An algal cell is slit with the radula and the contents quickly evacuated; the animal then moves to the next cell of the filament. The action of the radula could be seen in animals feeding on Rhizoclonium. The radula is extended outward and back, pressed against the cell, then pulled inward and forward, producing a fine slit (see cells in figure 3) in the cell wall. Observation of details was difficult, but it appeared that only one tooth was used in the cutting action.

This general mode of feeding is the typical sacoglossan method and has been previously described by Rao (1937) for Stiliger gopalai, by Fretter (1941) and MacNae (1954) for Elysia, by Gascoigne (1956) for Limapontiids, and by Gonor (1961) for Lobiger serradifalci. In addition, both MacNae and Gascoigne observed a grasping action of the foot margin and the lateral lips similar to that described here.

Internal Anatomy

Features of external form and color serve to differentiate species of Sacoglossa, although sometimes imperfectly, but are of little aid in grouping species or understanding relations within the group. The major features of internal anatomy are given here as an effort toward these ends. Both dissections and serial sections were examined, but histology will not be given except where necessary.

Figure 4, a ventral view of a dissection, indicates the topographic relations of the major internal structures. In this figure the gonad is displaced to the right and many of the fine tubules of the albumen gland are removed.

The slit-like mouth was described above. In dissections the stout buccal bulb (figures 4, 5, and 6) can be seen to be surrounded at its oral end by a mass of small bulbular multicellular buccal glands (figures 4, 5, b g) with short necks that open ventrally into the oral cavity. The buccal bulb is lined inside by a smooth cuticle. The muscle of its wall is not striated as is that of Hermaea dendridica (Fretter, 1941). From the side and ventral view the well-developed ascus (figure 5, as, figure 4) can be seen to be almost as large as the buccal mass proper. The posterior edge of the ascus is keel-like so that the posterior end appears pointed. There are a pair of stomato-

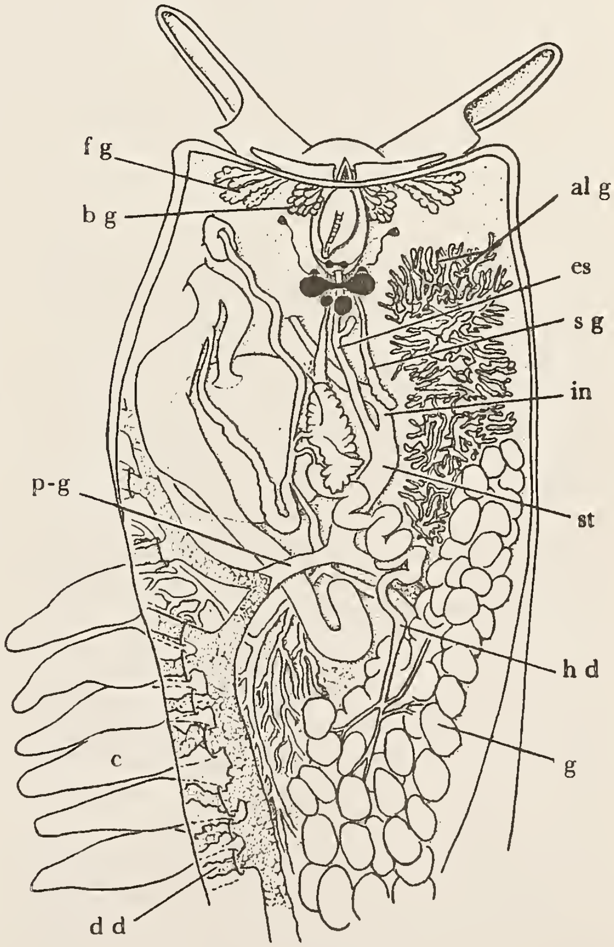

Figure 4: Dissection, ventral view

al g	- albumen gland		s g	-	salivary gland
es	- esophagus		f g	-	foot glands
in	- intestine		b g	-	buccal glands
st	- stomach		d d	-	digestive diverticulum in a
h d	- hermaphroditic duct		c	-	ceras
g	- gonad		p-g	-	pre-glandular portion of digestive diverticulum

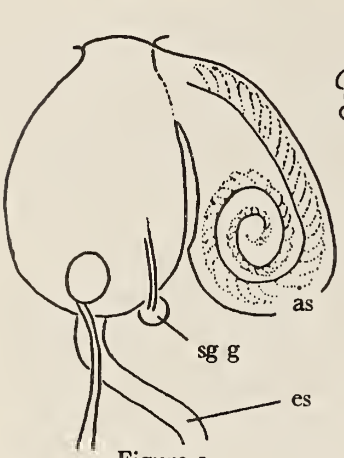

Figure 5

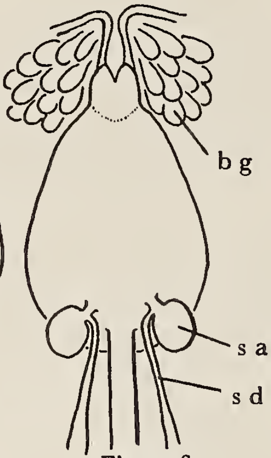

Figure 6

Figure 5: Lateral view of Buccal bulb

as - ascus
sg g - stomatogastric ganglion
es - esophagus

Figure 6: Dorsal view of Buccal bulb

b g - buccal glands
s a - salivary ampulla
s d - salivary duct

gastric ganglia (figure 5, sg g) closely attached to the posterior and ventral surface of the buccal mass. Two slender salivary glands (figure 4, s g) extend from the posterior end of the buccal mass, near the esophagus, through the nerve ring. They widen posteriorly but remain strap-like and do not branch. The ciliated salivary ducts (figure 6, s d) do not directly enter the bulb but on its dorsal surface join the very short ducts of two small, rounded vesicles, or salivary ampullae (figure 6, s a) with thin, muscular walls. These salivary ampullae are apparently reservoirs which can forcibly eject their contents into the posterior parts of the buccal bulb. Cyerce elegans has a similar arrangement of salivary glands and ampullae (Hoffmann, 1938, p. 1065), and Limapontia has similar salivary vesicles on the salivary duct itself (Gascoigne, 1956).

The long and slender esophagus arises dorsally from the buccal bulb (figures 4, 5, es) and extends posteriorly for about one-fourth the length of the animal before joining the Y-shaped stomach area near the place where the intestine (figure 4, in) leaves it. About midway along the length of the esophagus is located a small diverticulum (see figure 4) which extends antero-dorsally. Its structure is not different from that of the rest of the esophagus. The stomach area gives rise to two nonglandular arms (figure 4, p-g, preglandular portion of digestive glands) extending laterally, each to bifurcate into an anterior and posterior extension of the brown digestive gland, running dorsally under the cerata rows. The digestive diverticula (figure 4, d d) come off from these extensions and run into the cerata (figure 4, c) where they are moderately lobate or branched (figure 7B). The diverticula narrow as they pass through the body wall, and there is present here a sphincter reminiscent of that described by Marcus (1959) for the same situation in Hermaeina brattstroemi.

The intestine runs antero-dorsally from the stomach to open as the anus dorsally, and just to the right of the midline, posterior to the level of the first few cerata. The lining epithelium of the intestine is ciliated and thrown into folds but is nonglandular, unlike that of Hermaea dendridica (Fretter, 1941).

The older portion of the radular ribbon retains its organization and can be seen coiled in the ascus, making up to three turns (figure 5, as). As the ribbon moves into the ascus a cuticular membrane is laid down around it so that the radula is enclosed within a very thin, tubular casing, indicated in figure 8C. This casing does not dissolve in potassium hydroxide and can be seen in radular preparations, rather closely applied to the teeth. The figure of the radula of Phyllobranchopsis enteromorphae given by Cockerell and Eliot (1905) shows a similar membrane. The coiling of the old portion of the radula is not simply due to the rib-

Figure 7: Cerata
A Median side, appearanc of surface in life
B Median side, internal structure

bon being mechanically forced into the confines of the ascus. Radulae isolated from both fresh and preserved material by maceration in a weak detergent solution and freed from all tissue and membranes still exhibit coiling. All parts of these radulae are very springy and recoil tightly when straightened with needles. The coiling seems inherent in the basal ribbon for the ascending arm of the radula, not yet coiled in the ascus and held almost straight by tissue, also bends into a tight curve when freed from the tissue.

The number of teeth varies with the size of individual. Most local animals are about 10 mm. long and have tooth numbers ranging from 33 to 49, but a large specimen had a radula of 88 teeth. These numbers include the first four or five teeth, which are very small and rudimentary, consisting mostly of the flat basal portion. The maximum length of unused teeth in the usual radulae varied from 125 to 170 microns.

The base of the radular tooth is rectangular, with thickened lateral edges and a slightly excavated surface attached to the basal ribbon. From the base rises the crown or middle portion of the tooth, which is thickened down the center. The middle portion bears distally the rounded tooth tip, a very thin, discoidal lamina which is the principal cutting portion, judging from the extensive wear it shows in old teeth. The middle portion of the tooth bears, on its leading (cutting) edge, two serrate lamina flanking a longitudinal excavation in the face of the tooth into which fits a humped keel on the back of the preceding tooth in the series. The sharply pointed denticulations of the serrate edge are directed slightly inward. They show only occasional wear in old teeth. These denticulations are tallest in the center of the laminae and evenly spaced. Near the middle of the largest teeth the denticulations are about 2.5 to 3 microns high and spaced about 5 or 6 teeth per 10 microns of lamina edge, with 2 micron spaces between their tips. This is twice the number given by Marcus for denticles in the type specimen, otherwise his description and figure is identical to the one here. However, a radula with 50 teeth, from a 7.5 mm. long (live) specimen from La Jolla, California, had 3 denticulations per 10 microns of edge at midlength of the serrate lamina, in teeth 150 microns long, corresponding to the figure of Marcus (1961) for the type specimen. A specimen from the type locality (Tomales Bay) 11 mm. long (preserved) with a radula of 40 teeth had 3 to 4 denticles per 10 microns length in teeth 170 microns in heighth. Differences between other details of the teeth of the California material and the teeth of the Washington material are no greater than differences between teeth in the same radula or between two Washington individuals. This minute difference is the only one noted between the morphology of California specimens and local ones and is not considered of specific importance.

The predominant feature of the back of the tooth is a large median humped ridge, slightly excavated at the sides, with a rounded edge. Distally, between this ridge and the tooth tip is a prominent indentation into which fits the tip of the succeeding tooth. There is a pair of low laminae running on either side of the large median keel, which start as faint lines near the middle of the ridge and rise slowly as they proceed distally. They are widest on either side of the indentation in the tooth back and end on the tooth tip. The denticulate edges of the succeeding tooth fit closely inside these laminae, further interlocking the teeth. The close interlocking of the teeth and the tension of the basal ribbon would seem to afford the necessary rigidity to hold the tooth being used in position while in action.

The cutting tip of the teeth shows marked effects of wear; the thin, broadly ovoid tip of unused teeth wears down so that the used teeth have a truncated end. The teeth within a radula show considerable differences in the amount of wear to which they have been subjected. Smaller and medium sized teeth are relatively more severely worn down than larger ones in the same radula, and the cutting edge of some of the smaller teeth may be completely worn off. Comparison of large and small radulae reveals the same type of difference between teeth in analogous positions. Figure 8 demonstrates the differences between unused (A, A1) and used (B, B1) teeth. The difference between the amount of wear of larger teeth and smaller teeth of the same radula can be seen by comparing A with C, while the comparison of A and A1 indicates the difference between used teeth of small and large radulae, respectively.

The dusky yellow gonad, the largest internal structure, lies ventral to the other viscera (figure 4, g). The gonad is elongate, extending at maximum development from the far posterior limit of the haemocoele at the base of the tail anteriorly to more than three fourths the length of the body. It is composed of many well separated ovoid lobules which are joined only by ducts. Each lobule produces both eggs and sperm. The small collecting ducts from each lobule join a narrow duct that runs through the center of the gonad. From the latter duct, about at the middle of the gonad, runs the common hermaphroditic duct (figures 4, 9, h d). The hermaphroditic duct is narrow at its origin but quickly enlarges, and the tightly coiled portion is swollen to form a sperm storage organ (ampulla). Shortly before joining the other reproductive structures, the hermaphroditic duct again narrows to a fine tube which, like the ampulla region, has a ciliated epithelium, but the muscle layer in its wall is thicker than that in the ampulla. The male portion of the rest of the genital tract will be described first. The vas deferens (or efferent duct) (figure 9, v d) arises from the hermaphroditic duct very near the common junction of the latter and several other structures. The first portion of the vas deferens is a fine tube leading to a yellow, multilobulate prostate gland (figure 9, pr g) which is appended to the vas deferens by a short duct leading from its cavities. After the junction of the prostate gland and vas deferens, the latter is a larger, ciliated tube with muscular walls. It runs anteriorly to enter the penis (figure 10, v d) without change in structure. The male atrium, or eversible penis sac (figure 10, w p s wall, penis sac) opens to the exterior on the right side, below and just posterior to the level of the eye, as the male aperture. When the penis is extended (figure 9, p)

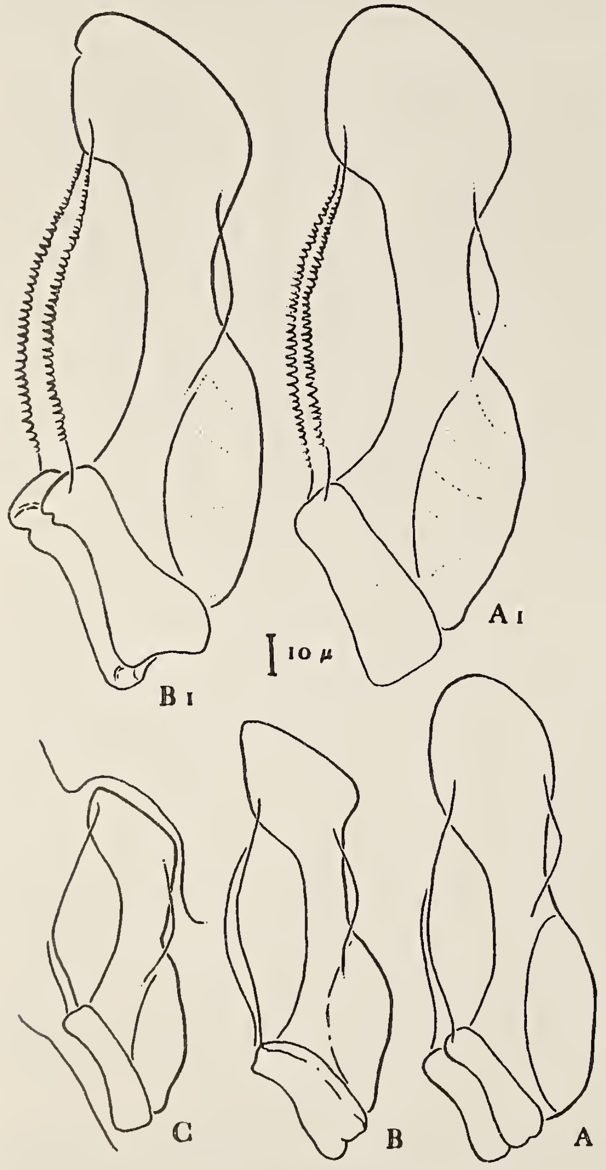

Figure 8: Teeth from small (A to C) and large (A1 to B1) radulae (camera lucida)

A Unused tooth from small radula
B Used tooth, same radula (first preceding tooth in use)
C Used tooth, same radula (9th preceding tooth in use)
A1 Unused tooth from large radula
B1 Used tooth, same radula (first preceding tooth in use)

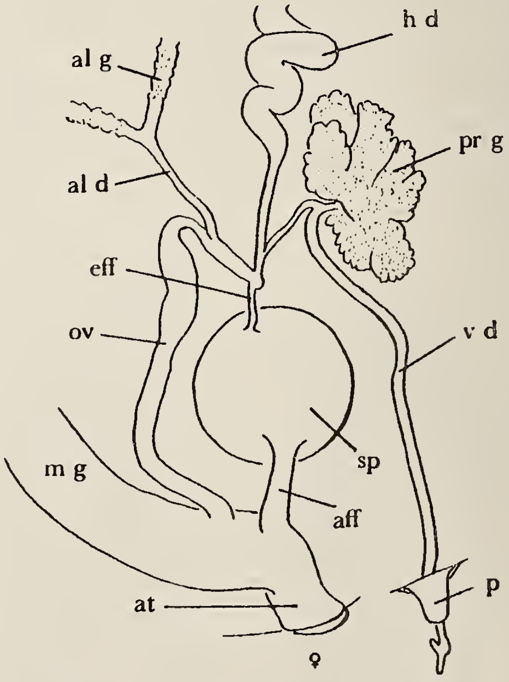

Figure 9: Genital System (Dissection)

al g - albumen gland
al d - albumen duct
ov - oviduct
m g - mucus gland
aff - afferent spermathecal duct
eff - efferent spermathecal duct
pr g - prostate gland
s - spermatheca
h d - hermaphroditic duct
v d - vas deferens
p - penis

it appears as a cone-shaped base surmounted by the small, unarmed muscular penis proper, which projects straight out. The penis is a barb-shaped structure when everted, with a blunt, tapered tip or penial tentacle (figure 10, t) and a small, blunt backward projecting arm bearing the orifice of the vas deferens (figure 10, o v d). When the penis is retracted the conical penis base is inverted (figure 10, c p b). When the penis is extended, the penial tentacle becomes filled with body fluid and distended straight out (figure 10B). There is a single female orifice (figure 9, ♀) just posterior to the male aperture, rather than separate vaginal and uterine openings. The female orifice leads into a short, wide female atrium (figure 9, at) which is partially partitioned by folds into uterine and nidamental portions. The truly common portion of the atrium is nonglandular and ciliated. Leading from the anterior side of the female atrium is the large ciliated afferent duct (figure 9, aff) of the spermatheca. The spermatheca (figure 9, sp) is a large, spherical brownish organ and, when filled with sperm and secretion of the prostate, may be enormously enlarged and form a bulge in the right side of the body. The epithelium of the spermathecal wall is glandular except for a small area on the postero-ventral portion. Here it is ciliated and in the center of this area is located the opening of a short, thin ciliated duct (figure 9, eff, efferent duct of spermatheca). This duct contains sperm apparently collected from the spermathecal contents. It leads to the area of junction of the albumen gland duct (figure 9, al d), the distal oviduct (figure 9, ov), and the hermaphroditic duct (figure 9, h d). This is probably the site of fertilization. This common female section is ciliated and has a thick muscular wall, which could act as a valve to regulate the entry of eggs from the hermaphroditic duct and exclude the animal's own sperm. The ciliated nonglandular albumen duct and an efferent oviduct are connected near each other, at the posterior end of the chamber, opposite to the hermaphroditic duct. The albumen duct extends posteriorly a short distance, where it receives at once the two branches of the albumen gland (figure 9, al g). The albumen gland is a very extensive structure (figure 4, al g), apparently basically composed of two bilateral portions which ramify and branch so extensively that they cannot be separated except at their junctions with the common albumen duct. The extensive dendritic branches of the albumen gland are mostly located dorsally and to the sides, under the heart and kidney but above the other structures. The fine translucent tan tubules composing the gland extend into all parts of the haemocoele, between the organs, even into the head, but do not enter the cerata or rhinophores.

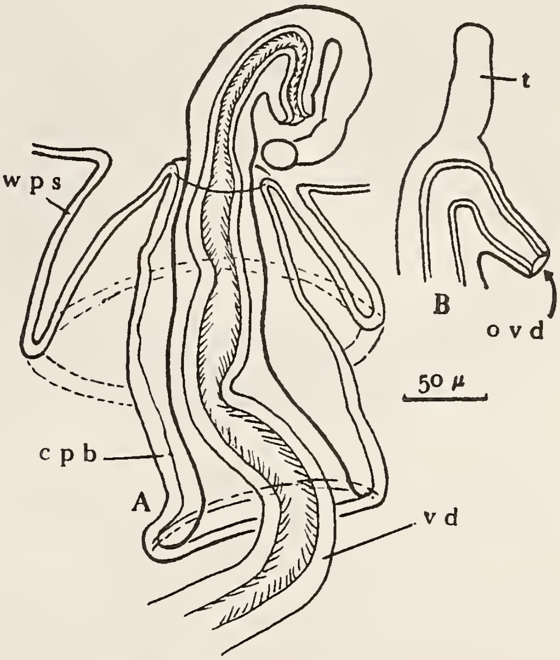

Figure 10: Penis and duct
(total preparation, camera lucida)
A Completely retracted penis
B End of penis, extended state

w p s - wall of penis sac (male atrium)
c p b - involuted conical penis base
v d - vas deferens
o v d - orifice of vas deferens
t - penial tentacle

A large, ciliated oviduct (figure 9, ov) leaves the common female chamber and runs anteriorly toward the female atrium on the right. A short portion of its end connected to the chamber is muscular, while most of its length contains mucus gland cells. The oviduct joins the large, pale yellow mucus gland (figure 9, m g) just posterior to the junction of the latter with the female atrium. The oviduct opens into the base of a crease in the wall of the mucus gland which runs in the median side of that gland posteriorly to its tip. This crease partially partitions off a nonglandular ciliated track of the mucus gland in a manner strikingly similar to the way the mucus gland of bulloid tectibranchs is partitioned. Figure 11 depicts a diagrammatic transverse section of the mucus gland. Apparently eggs are carried in this ascending groove (figure 11, asc) to the tip of the gland, and then pass back down anteriorly

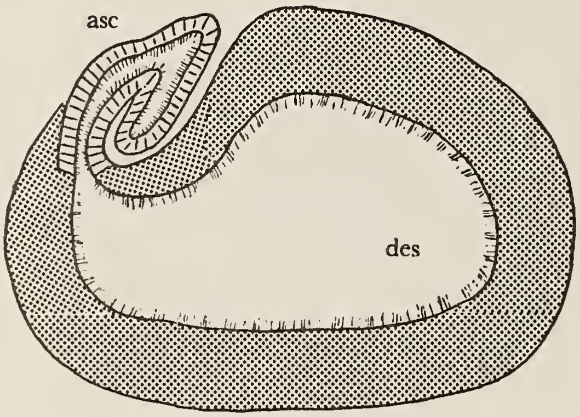

Figure 11: Diagram of transverse section of mucus gland (mucus cells indicated by shading)

asc - ascending ciliated channel
des - descending channel

through the descending glandular section (figure 11, des), propelled by the heavy ciliation of the latter region, to emerge from the female aperture enclosed in the mucus layers of the egg mass.

Individuals spawn repeatedly in the laboratory, attaching the egg masses to any of the algae in the Enteromorpha mat as in the field but also to the sides of the containers. The egg masses are elongate, flattened ribbons, usually about 12 to 20 mm. long, attached by one flat side and usually curved into a "C" shape. They are about 1.5 mm. wide, the width of about 20 egg capsules and about one-half as deep. The closely packed eggs are lemon-yellow when laid, later becoming paler as development proceeds. They are very much like the egg masses described for many other Sacoglossans (see Rao, 1937; Rasmussen, 1951; Baba and Hamatani, 1952; and Hamatani, 1960), and for that reason they are not described in detail or figured here. The larvae emerge as free-swimming veligers and do not settle in dishes in the laboratory, so apparently have a long planktonic feeding phase.

The relative size and position of the ganglia of the central nervous system is frequently of use in comparing different species of opisthobranchs and in assessing relationships. To provide information for this purpose, a brief description of the ganglia will be given here, omitting all considerations of the nerves arising from them. The nerves are largely omitted in figures 12 and 13 for clarity. The terminology used is that of Russell (1929).

The cerebropleural ganglia (figure 12, cp) are ovoid as seen from above, with their long axes running antero-posteriorly. The pedal ganglia (figure 12, pe) are also ovoid, but their long axes are at right angles to those of the pair above. The cerebropleurals extend anteriorly a little further than the pedals, and both pairs of ganglia are well separated, joined by distinct commissures so that they lie to either side rather than directly above and below the esophagus. The connectives joining the cerebropleurals to the pedals are quite short and broad. The statocysts (figure 13, st) are located on the posterior ventral surface of the pedals and project above that surface. The stomatogastric ganglia (figure 5, sg g) are not closely united to the cerebropleurals but joined to them by a commissure as in Elysia.

On the left side a small sub-intestinal ganglion (figure 12, sbi) can be seen between the left cerebropleural and the large abdominal ganglion, joined to each by a short connective. The abdominal ganglion (figure 12, ab) is only slightly smaller than the pedal ganglion. It is displaced somewhat to the left of midline. On the right the supraintestinal ganglion (figure 12, su-i) can be seen to be joined to the right cerebropleural and to the abdominal by short, equal connectives. The supraintestinal ganglion has appended to it a small satellite ganglion (figure 12, sat) of undetermined homology, which in part may represent the right parietal

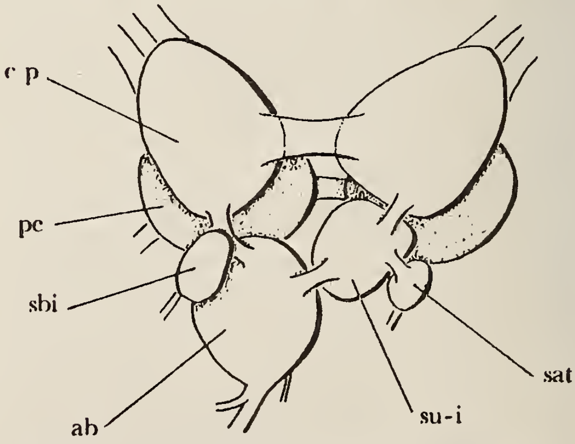

Figure 12: Central nervous system, dorsal view (total preparation, camera lucida)

cp - cerebropleural ganglion
pc - pedal ganglion
sbi - sub-intestinal ganglion
ab - abdominal ganglion
su-i - supra-intestinal ganglion
sat - satellite ganglion

ganglion of the tectibranchs. It gives rise to a single small nerve that runs directly posterior but which could not be traced to its ending.

In general, the central nervous system of this species is notable for the lack of fusion and the distinctiveness of the ganglia. Except for the small satellite on the supraintestinal, it is remarkably like the nervous system of Elysia viridis described by Russell (1929). It differs from that of Stiliger gopalai (Rao, 1937, textfig. 1) and other Stiliger species (Hoffmann, 1936, p. 757) as well as from Hermaea dendritica (Hoffmann, 1936, p. 755, Fig. 530C, from Vayssière, 1888), in that the small sub-intestinal ganglion is distinct and not fused into the abdominal. Apparently this fusion has occurred independently several times in the Sacoglossan group, since the seven ganglia are distinct in otherwise diverse forms such as Elysia viridis (Russell, 1929), Cyerce iheringi (= Lobifera crystallina) (Pelseneer, 1894), Oxynoe olivacea (Hoffmann, 1936, p. 756), and in the present case.

The pericardial bulge is not prominent on the dorsal surface but low and gently rising. The pericardial cavity and heart are, however, large, occupying the middle of the dorsal surface starting at a point about one-third of the body length from the head, just anterior to the renal pore. The kidney is an extensive flat sac extending under most of the dorsal surface, lying just under the dorsal epithelium but not applied to it. Its walls consist of a simple, nonfolded epithelium. The anterior end of the kidney is at the level where the intestine emerges from the stomach. It is narrow and mid-dorsal here; posteriorly it widens, and in front of the pericardial cavity it extends across the width of the back. It is narrow at the level of the heart, placed almost completely to the right of the pericardial cavity but overlaps it slightly. The renal pore leads from the anterior part of the narrowed portion. More posteriorly, where the kidney is closely applied to the side and part of the dorsal surface of the pericardial membrane, is found the renopericardial aperture. The kidney is widened and again middorsal behind the heart. It narrows and ends just anterior to the tail region. The kidney, in partially surrounding the heart, resembles that of Stiliger gopalai (Rao, 1937) but is more extensive anteriorly than in that species.

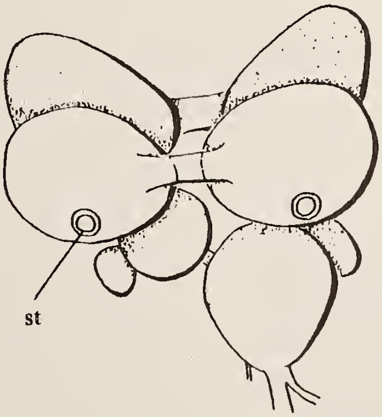

Figure 13: Ventral view of central nervous system (camera lucida)

st - statocyst on pedal ganglion

Discussion

Ecology: The habitat of this species on the coast of California and Washington was discussed earlier. It is becoming firmly established that the Sacoglossa are typically restricted, as it has been shown here for Hermaeina smithi, in habitat and feeding to one or a few closely related species of algae. MacNae (1954) has discussed the association of many Elysia species with Codium (Siphonales); Gascoigne (1956) has established experimentally that two species of Limapontiids are restricted to Cladophora species, while a third is restricted to Vaucheria (Siphonales); Rao (1937) found that Stiliger gopalai will feed only on Chaetomorpha; and Gonor (1961) has reviewed the association of the Oxynoids with Caulerpa species (Siphonales). This type of information can greatly aid faunistic and zoogeographical investigations and may in time, through clarifying ecological specializations, assist in the understanding of the interrelationships within the Sacoglossa. For example, knowledge of the relation of Bosellia mimetica, a cryptic species, with the alga Halimeda tuna (Siphonales) enabled Portmann (1958a, 1958b) to rediscover this form and greatly extend its known range; and the association of the Tamanovalvidae with Caulerpa species has permitted the collection of this very interesting group in Australia (Burn, 1960a, 1960b) and Baja California (Smith, 1961). The constancy of such associations is bórne out by the findings of Marcus and Marcus (1956) and Hand and Steinberg (1955) which demonstrate that Alderia uda and the well known Alderia modesta occupy identical habitats (mud flats, on Vaucheria) in widely separated parts of the range of this genus (Europe, Brazil, California, and Washington).

Systematics: Ten species of the genus

Hermaeina have been described to date; these are:

1. Hermaeina maculata Trinchese, 1874; from the west Mediterranean coast of Europe.
2. H. (Phyllobranchopsis) enteromorphae (Cockerell and Eliot, 1905); from San Pedro, California.
3. H. orientalis Baba, 1949; from Sagami and Suruga Bays, Japan.
4. H. nigra Baba, 1949; from Sagami and Toyama Bays, Japan.
5. H. formosae Pruvot-Fol, 1953; from the Atlantic coast of Morocco, North Africa.
6. H. sinusmensalis MacNae, 1954; from Table Bay, near Capetown, South Africa.
7. H. minor Baba, 1959; from Toyama Bay, Japan.
8. H. toyamana Baba, 1959; from Toyama Bay, Japan.
9. H. brattstroemii Marcus, 1959; from Northern Chile.
10. H. smithi Marcus, 1961; described from Tomales Bay, California.

With the possible exception of the first, none of these species has been described in sufficient detail to be distinguished completely and with certainty from all of the others, yet the resemblances are such that at least some are probably synonymous. All lots of material examined in this study agreed in the details of internal anatomy, especially the genital system, so these species will be discussed in the light of the variation shown to exist in the external appearance of Hermaeina smithi. It is probable that the material described by Eliot (in Cockerell and Eliot, 1905) was of the species treated here; this, however, cannot be established definitely, and it seems best to regard this name as a nomen dubium. Eliot carefully stressed in three places that his four specimens were badly macerated both externally and internally and that important distinguishing characters could not be made out with certainty. The only character that might allow identification is the description that the cerata were flattened. Their shape was not further described, and the very poor figure is useless. The abundant material examined here occasionally showed flattened cerata tips, and in badly preserved specimens other distortions as well, and it seems likely that material in the condition described by Eliot would be likewise distorted. Moreover, in starved animals the cerata become more flattened and ovoid as the digestive diverticula regress. The figure given by Eliot of the radula is obviously of a Hermaeina, but it is of the worn portion only and cannot be used to distinguish the species.

The other species from this Pacific coast, Hermaeina brattstroemi, was also described from a single small preserved specimen, and unfortunately, much of its anatomy is unknown, since it was sexually immature. It cannot be completely distinguished from the present material on external appearance. Contracted, preserved specimens of H. smithi often resemble the figures Marcus (1959, figs. 21-23, p. 113) has given, in that the cerata and the labial lobes may be much contracted and the rhinophores very shortened so that their natural shape is lost; they come to be short and widened distally, with the rhinophoral lobe quite obscure. The foot is identical, and the range of variation in pigment intensity and pattern include the condition of Marcus' specimen. The careful drawing of two apparently unused radular teeth (Marcus, 1959, fig. 27, p. 114) does not show any features which would distinguish these teeth from some of the material examined in this study, and indeed resembles the figure later provided for H. smithi. However, Marcus states that the earlier teeth were not in order in the ascus, a feature not shown by any of the other known species. Two other features might distinguish this southern form. Figure 24, p. 113, of Marcus (1959) indicates that the digestive diverticula only bulge out at regular intervals. In the present material these structures varied from showing slight, irregular lobulation in young and starved animals to extensive, rather regular branching of the type indicated by fig. 34, Pl. 2 of Marcus, 1961. The penis described for the specimen of H. brattstroemi consisted of a simple straight tubular structure. If this organ was completely differentiated in this immature specimen, then it alone will serve to differentiate the two species.

Hermaeina sinusmensalis MacNae was not sufficiently described to permit it to be distinguished from other dark species with any certainty. The description of the radula permits assignment to the genus only; it is presumed that the structure of the teeth was misinterpreted because of the close overlapping and that they are similar in detail to those of other species, with two denticulate lamellae on the cutting face. Unfortunately, the size and shape of the terminal disc cannot be used alone as a specific character because it is subject to wear; indeed, it differs slightly within the unused teeth of the same radula in H. smithi.

The material examined is identified as Hermaeina smithi chiefly on the basis of the morphology of the penis as given by Marcus (1961) since this proved to be completely constant while other characters given proved to be quite variable or of generic level only. The form of this structure is usually species-specific in Opisthobranchs and is used here in selecting a name for the material studied even though the structure is not described for most of the species.

It is difficult to evaluate the four species described from Japan by Baba, since he provided no information about internal anatomy. Fortunately, however, Baba was able to examine and accurately figure living material. All four species show certain close resemblances to the present material, at least indicating that this genus is a well defined group of closely related species and further emphasizing the marine faunal connections between Japan and the American Pacific Coast (Baba, 1957; Marcus, 1961). These common characters have been utilized in an attempt to re-define the generic concept.

The two light-colored species of Baba seem distinct from Hermaeina smithi. Hermaeina orientalis has strongly rolled rhinophores with flaring tips and no rhinophoral lobes, thus differing from H. smithi. The black-tipped cerata seem more pointed as well. Baba only tentatively separated the other light form, H. toyamana, from H. orientalis because of difference in pigment intensity, and it is likely that these specific names are synonyms.

Because of the highly variable nature of the black color and the variation in tooth and cerata number with age and size, it is more difficult to separate Hermaeina smithi from the two black Japanese species, H. nigra and H. minor. According to the very brief description, H. minor differs from the preceding two in that it is said to have no ceratal veins and, judging from the figure (Baba, 1959, figs. 7, 7a), apparently no rhinophoral lobes on the anterior rhinophore margins. The description of H. nigra greatly resembles the specimens of H. smithi in external appearance, except that the three specimens upon which H. nigra was based were larger (12-30 mm. long) and had more ceratal rows (25). The figure (Baba, 1949, p. 34, textfig. 23-B) of an apparently unused radular tooth of H. nigra differs from the appearance of the unused teeth of H. smithi in outline of the tooth tip and in relative height and may prove significant if constant.

The original description of Hermaeina formosa is not available to me at present, but apparently this species is similar to H. maculata in the distinctive color stripes on the cerata and also in the structure of the radula (Pruvot-Fol, 1954, p. 190). These purple stripes differentiate these two species from H. smithi and the other known Pacific forms.

The two earlier attempts of MacNae (1954) and Pruvot-Fol (1954) at defining the generic concept uniting the species described under Hermaeina may be extended now that more information is available.

Hermaeina Trinchese 1874

Type: Hermaeina maculata Trinchese, 1874
(? = Aplysiopsys elegans Deshayes, 1834-1858)

Rhinophores auriculate, with the anterior (median) border often prolonged into a rhinophoral lobe which overlaps the posterior border below. Distinct, short oral lobes present. Anterior free margin of the foot set off by a groove behind the oral lobes. Cerata fusiform, ovoid in cross section, usually with venation on the mesial surface, and branched hepatic diverticulum (but no branches of the albumen or prostate glands) within. Anus anterior near the first cerata and placed medianly, or slightly to the right. The radula coiled in the ascus, with old teeth in order; tooth form (described earlier) quite characteristic of the genus, but not at the specific level. Genital system diaulic, penis unarmed. Often with black or brown pigmentation showing a general pattern, such as clear areas around the eyes and two streaks down the foot, which, however, is held in common with other Styligerids.

Hermaeina may be separated from the genera of the "family" Polybranchiidae (sensus Pruvot-Fol, 1954) possessing cerata on many points of internal and external anatomy. The most important of these are the dorso-median anus, cerata with hepatic branches, unbranched rhinophores, lack of a muscular crop or a large esophageal diverticulum and various details of the genital tract (compare Caliphylla mediterranea, Marcus, 1958) such as lack of peneal style and the single spermatheca.

The arrangement of the supraspecific categories in the Styligerid group is highly artificial and remains in a confused state uninfluenced by evolutionary concepts or newer taxonomic ideas reflected in the systematics of better known groups. This can readily be attributed to the lack of good studies of anatomy. The resulting disorder is well described by Pruvot-Fol (1954, pp. 180 ff.). This situation makes systematic comparison of the genera impossible since they are poorly defined. A few comparisons have been made in the descriptions of internal anatomy whenever these have been pertinent. Some remarks, supporting the separate status of Hermaeina, about the critical genital system may be made since through the careful work of Marcus and Rao there are available recent accounts of five species of Stiliger (s. s.) and one of Hermaea coirala.

The genital systems of Hermaeina smithi and Hermaea coirala are similar since both are diaulic, with an unarmed penis. But Hermaea coirala has both a spermatocyst and a spermatheca and the latter structure does not have separate efferent and afferent ducts as does Hermaeina smithi. Hermaea dendritica differs even more in that it is triaulic, possesses a peneal stylet and has branches of the albumen gland in the cerata. The reproductive system of Hermaeina smithi differs from this system in Stiliger talis, S. fuscatus, and S. vanellus mainly in that these species are triaulic, have peneal stylets, and the albumen gland joins the mucus gland directly. But in addition, it differs from S. talis and S. gopalai in the location of connections of the female organs.

Literature Cited

Baba, Kikutarô

1949. Opisthobranchia of Sagami Bay collected by His Majesty, the Emperor of Japan. 4+2+194+7 pp., pls. 1-50. Iwanami Shoten, Tokyo.

——, ——

1957. A revised list of the species of Opisthobranchia from the northern part of Japan, with some additional descriptions. Jour. Fac. Sci. Hokkaido Univ. Ser. IV, Zool., 13 (1-4): 8-14.

——, ——

1959. The family Stiligeridae from Japan (Opisthobranchia-Saccoglossa). Pub. Seto Mar. Biol. Lab. 7 (3): 327-334, pls. 27-28.

Baba, Kikutarô, & Iwao Hamatani

1952. Observations on the spawning habits of the Japanese Opisthobranchs. Publ. Seto Mar. Biol. Lab. 2 (2): 87-90, pl. 7.

Burn, Robert

1960a. A bivalved gastropod. Nature 186 (4719): 179.

——, ——

1960b. Australian bivalved gastropods. Nature 186 (4731): 44-46.

Cockerell, T. D. A., & Charles Eliot

1905. Notes on a collection of Californian nudibranchs. Jour. Malacol. 12 (3): 31-53, pls. 7, 8.

Fretter, Vera

1941. On the structure of the gut of the ascoglossan nudibranchs. Proc. Zool. Soc. London, Ser. B, 110 (3-4): 185-198.

Gascoigne, T.

1956. Feeding and reproduction in the Limapontidae. Trans. Roy. Soc. Edinb. 63, pt. 1 (7): 129-151, pls. 1, 2.

Gonor, Jefferson J.

1961. Observations on the biology of Lobiger serradifalci, a shelled saccoglossan opisthobranch from the Mediterranean. Vie et Milieu 12: (in press).

Hamatani, Iwao

1960. Notes on the veligers of Japanese Opisthobranchs (1). Publ. Seto Mar. Biol. Lab. 8 (1): 59 to 70.

Hand, Cadet, & Joan E. Steinberg

1955. On the occurrence of the nudibranch Alderia modesta (Lovén, 1844) on the central California coast. Nautilus 69 (1): 22-28 (addendum ibid. 69 (2): 72).

Hoffmann, Hans

1932-1940. Opisthobranchia. in: Bronn, Klassen und Ordnungen des Tierreichs, Bd. 3, Abt. 2, Buch 3, Teil 1, xi + 1247 pp.; Teil 2: 90 pp. Akad. Verlag, Leipzig.

MacNae, William

1954. On four saccoglossan molluscs new to South Africa. Ann. Natal Mus. 13 (1): 51-64, pl. 3.

Marcus, Ernst

1959. Rept. Lund Univ. Chile Exped. No. 36, Lamellariacea and Opisthobranchia. Lunds Univ. Arsskrift, N. F. Avd. 2, 55 (9): 1-135.

——, ——

1961. Opisthobranch mollusks from California. Veliger 3 (Suppl., pt. I): 1-84, pls. 1-10.

Marcus, Eveline, & Ernst Marcus

1956. On two sacoglossan slugs from Brazil. Amer. Mus. Novitates No. 1796: 1-21.

Portmann, Adolf

1958a. Über zwei wenig bekannte Ascoglossa des Mittelmeers (Gast. Opisthobranchia). Rev Suisse Zool. (65 (25): 405-411.

——, ——

1958b. Bosellia mimetica Trinchese, Opisthobranche retrouvé en Méditerranée. Vie et Milieu 9: 74-80.

Pruvot-Fol, Alice

1953. Etudes de quelques opisthobranches de la côte Atlantique de Maroc et du Sénégal. Trav. Inst. Cherifien 5 (1952): 1-105, pls. 1-3.

——, ——

1954. Mollusques opisthobranches. Faune de France, 58: 460 pp., 173 textfigs., 1 pl. Paul Lechevalier, Paris.

Rao, K. Virabhadra

1937. Structure, habits and early development of a new species of Stiliger Ehrenberg. Rec. Indian Mus. 39: 435-464, pls. 7-9.

Rasmussen, Erik

1951. Faunistic and biological notes on marine invertebrates II. The eggs and larvae of some Danish marine gastropods. Vidensk. Medd. Dansk Naturh. Foren. 113: 201-249.

Russell, Lilian

1929. The comparative morphology of the elysioid and aeolidioid nervous system. Proc. Zool. Soc. London 1929 (2): 197-233, pls. 1-10.

Smith, Allyn G.

1961. Notes on the habitat of Berthelinia sp. nov. from the vicinity of La Paz, Baja California. Veliger 3 (3): 81-82.

On Certain Littoral Species of *Octolasmis* (Cirripedia, Thoracica) Symbiotic with Decapod Crustacea from Australia, Hawaii, and Japan

by

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(Plates 21, 22, and 23)

This paper concerns the reinstatement of Octolasmis neptuni (MacDonald), long held in synonymy with O. lowei (Darwin). Australian and Japanese subspecies are designated. The paper is also concerned with a remarkable new species of Octolasmis from Hawaii. An analysis of the ontogeny and adult morphology suggests a new interpretation of the origin and phylogeny of this and related forms is required.

POECILASMATIDAE NILSSON-CANTELL, 1921
[TRILASMATIDAE NILSSON-CANTELL, 1934]
Octolasmis GRAY, 1825
Octolasmis PILSBRY, 1907

When Darwin (1851) described the small pedunculate barnacle Octolasmis lowei from the gills of a spinous crab from Madeira, he was quite unaware that numerous comparable forms were to be found on large crustacea in all warm seas, and in the depths of the ocean as well. Had he foreseen this, he probably would have recognized that the reduction in external armament of this type of barnacle in response to the protection afforded by the host might not only express more than ordinary variability within a species, but that the trend would achieve comparable degrees and form of disarmament in different species. Had he suspected such trends, he probably would have stressed arthropodal rather than conchological characteristics in the description of O. lowei for the future was to see a number of otherwise distinct species confused with it.

Subsequent taxonomists have also tended to rely on conchological characteristics in their diagnoses of species in this group, and many doubtful as well as good species were described during the five or so decades following Darwin. During this period of expansion, workers began to suspect the sorts of variability found in the group, and many of the previously described species were placed in synonymy. Octolasmis lowei acquired ten junior synonyms primarily due to the efforts of Annandale (1909), Barnard (1924), and Nilsson-Cantell (1927). In some cases the synonymies were rather indiscriminately placed, being based on external appearance alone and were thus not well founded (Newman, 1960a).

Resistance to this trend was inaugurated in the brilliant analysis of the "Octolasmis lowei complex" by Hiro (1937) in which he clearly demonstrated that the deep water form, O. aymonini (Lessona & Tapparone-Canefri), was distinct from the littoral form, O. lowei sensu Darwin, and that O. geryonophila Pilsbry, also from deep water, was probably closely related to it. He further set order to the complex by dividing the remaining species into two series: forma lowei and forma neptuni. However, this system has not been followed in later systematic considerations of the group.

I have been able to confirm the opinion of Hiro (1937) regarding the close affinities of Octolasmis geryonophila and O. aymonini; in fact, it is my opinion that they must be considered the same species (Newman, 1961). It now affords me pleasure to announce that not only is O. lowei forma neptuni distinct from his forma lowei as he proposed, but that O. neptuni (MacDonald, 1869), in accordance with the present state of our knowledge, must be considered a distinct species, as originally described. This conclusion has been reached through a study of MacDonald's form from the type locality and type host.

A supplementary description of Octolasmis *neptuni* is given here, and Australian and Japanese subspecies are designated.

Octolasmis (Octolasmis) neptuni (MacDonald, 1869)

Distribution: Indo-West-Pacific; Durban, South Africa (Barnard, 1924) and Suez (Gruvel, 1905), to Moreton Bay and Sydney, Australia, and the ? Islands of the South West Pacific (MacDonald, 1869), to the Seto Inland Sea, Japan (Hiro, 1937). ? Caribbean (Pearse, 1932). Occurring on gills, occasionally on mouth parts, of Brachyura, generally portunids.

Diagnosis: Basal segment of scutum narrow, needle-like, usually not reaching carinal fork; tergum broad, semilunar or quadrangular with small occludent projection (Hiro, 1937). Supplementary diagnosis: Basal arm of tergum often chitinous and/or vestigial, situated approximately one fourth the length of the capitulum above the basal fork of the carina. Surface of capitulum and peduncle studded with minute transparent closely spaced sharp or blunt spines (not hair-like bristles or amber beads). Aperture without inner margin of minute denticles. Labrum with 15 to 21 sharp closely spaced teeth; mandible with fifth tooth conspicuous (not rudimentary); penis with apex obliquely truncate, without pronounced apical languet, supporting terminal comb of relatively short bristles; clothed sparsely throughout with soft setae arranged more or less at random or in ill-defined rows.

Octolasmis (Octolasmis) neptuni neptuni (MacDonald, 1869)

(Plate 21)

1869 *Parodolepas neptuni* MacDonald: 442
1894 *Dichelaspis neptuni* (MacDonald), Aurivillius: 19
1900a *Dichelaspis vaillanti* Gruvel: 2
1900b *Dichelaspis vaillanti* Gruvel: 109
1900b *Dichelaspis neptuni* (MacDonald), Gruvel: 110
1905 *Dichelaspis neptuni* (MacDonald), Gruvel: 127
1905 *Dichelaspis vaillanti* Gruvel: 128
1906 *Dichelaspis vaillanti* Gruvel, Annandale: 45
1908 *Dichelaspis vaillanti* Gruvel, Annandale: pl. 4, fig. 6
1909 *Dichelaspis sinuata* in part. Annandale: 121 (non *D. sinuata* Aurivillius, 1894)
1924 *Octolasmis neptuni* (MacDonald) in part. Barnard: 60
1927 *Octolasmis lowei* (Darwin) in part. Nilsson-Cantell: 766
1931 *Octolasmis lowei* (Darwin) in part. Broch: 129
1932 ? *Dichelaspis sinuata* Aurivillius, Pearse: 110 (identified by P. J. Vissher)
1937 *Octolasmis lowei* forma *neptuni* Hiro: 426
1938 *Octolasmis lowei* (Darwin) in part. Nilsson-Cantell: 11
1960a *Octolasmis lowei* forma *neptuni* Hiro, Newman: 108
1960b *Octolasmis lowei* forma *neptuni* Hiro, Newman: 10
1961 *Octolasmis lowei* (Darwin) in part. Causey: 51

Locality: Moreton Bay and Sydney, Australia, on the gills of *Neptunus pelagicus* (Linnaeus); the islands of the South-West Pacific (according to MacDonald). Eighteen specimens were collected from the gills of *N. pelagicus* from Moreton Bay, Queensland, Australia, by Dr. Cadet Hand, March 26, 1960. Five of these specimens have been sent to Dr. Huzio Utinomi, Seto Marine Biological Laboratory, Japan.

Neotype: U. S. N. M. Cat. No. 107'011.

Type locality: Moreton Bay; approximately 27° 10' S. Lat., 153° E. Long.

Diagnosis: Capitulum and peduncle translucent, surface studded with minute sharp spines (Plate 21, figure 1). Color (in alcohol), pink. Valves 5 in number; arms not overlapping; basal arm of scutum traversing capitulum approximately one fourth the length of the capitulum above the capitulo-peduncular junction; distal portions of basal arms of scuta and carina chitinous rather than calcareous. Labrum with 15 to 21 closely set minute conical teeth. Rami of Cirrus I equal, each ultimate article supporting 5 or 6 strong plumose spines and a few simple shorter setae (Plate 21, figure 7). Penis with soft setae scattered, or arranged in linear groups of 2, 3, or 4 over the surface; apex without distinct languet, supporting a few short blunt spines and a transverse row of about 7 longer soft setae of about equal length (Plate 21, figure 9).

Supplementary Description: Capitulum ovoid or somewhat pear-shaped, laterally compressed, translucent, tinted pink in most specimens; occludent margin, from basi-scutal angle to apex, nearly straight; orifice somewhat flaring, without inner border of small denticles; carinal margin broadly convex (Plate 21, figures 1, 2). Outline of growth increments as chitinous areas, approximating the original extent of the valves, clearly visible in young spe-

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Explanation of Plate 21

Octolasmis neptuni neptuni (MacDonald, 1869)

Figure 1: neotype; Figure 2: young specimen; Figures 3 through 9: armament and appendages of neotype; Figure 3: spines on peduncle; Figure 4: spines on lateral surface of capitulum; Figure 5: mandible; Figure 6: inner maxilla; Figure 7: last three articles of rami of Cirrus I; Figure 8: caudal appendage; Figure 9: terminal portion of penis.

Figure 1

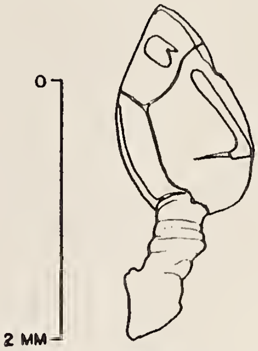

Figure 2

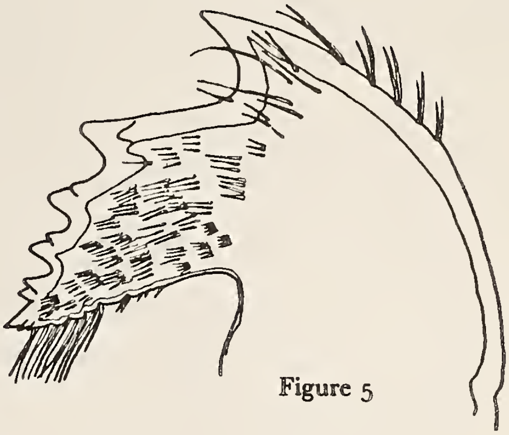

Figure 5

Figure 3

Figure 4

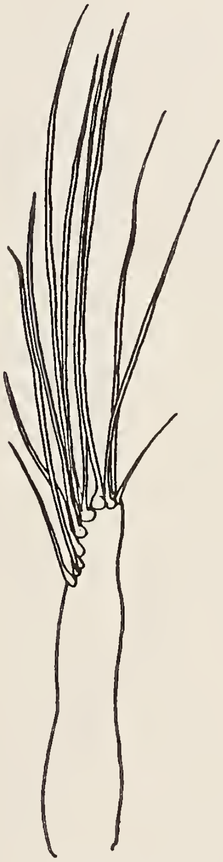

Figure 8

Figure 6

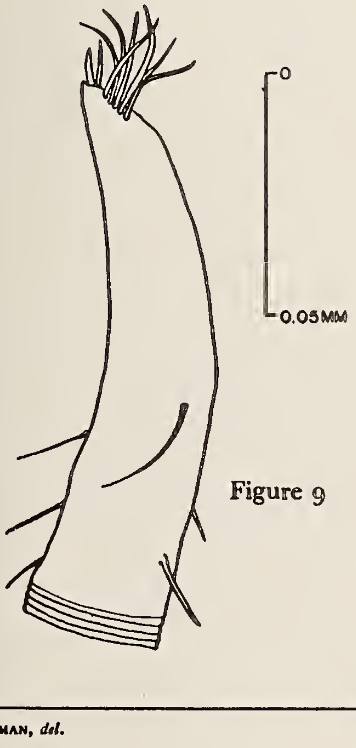

Figure 9

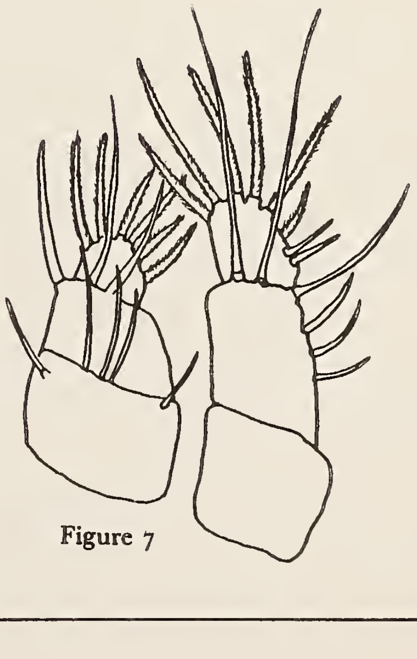

Figure 7

Newman, *del.*

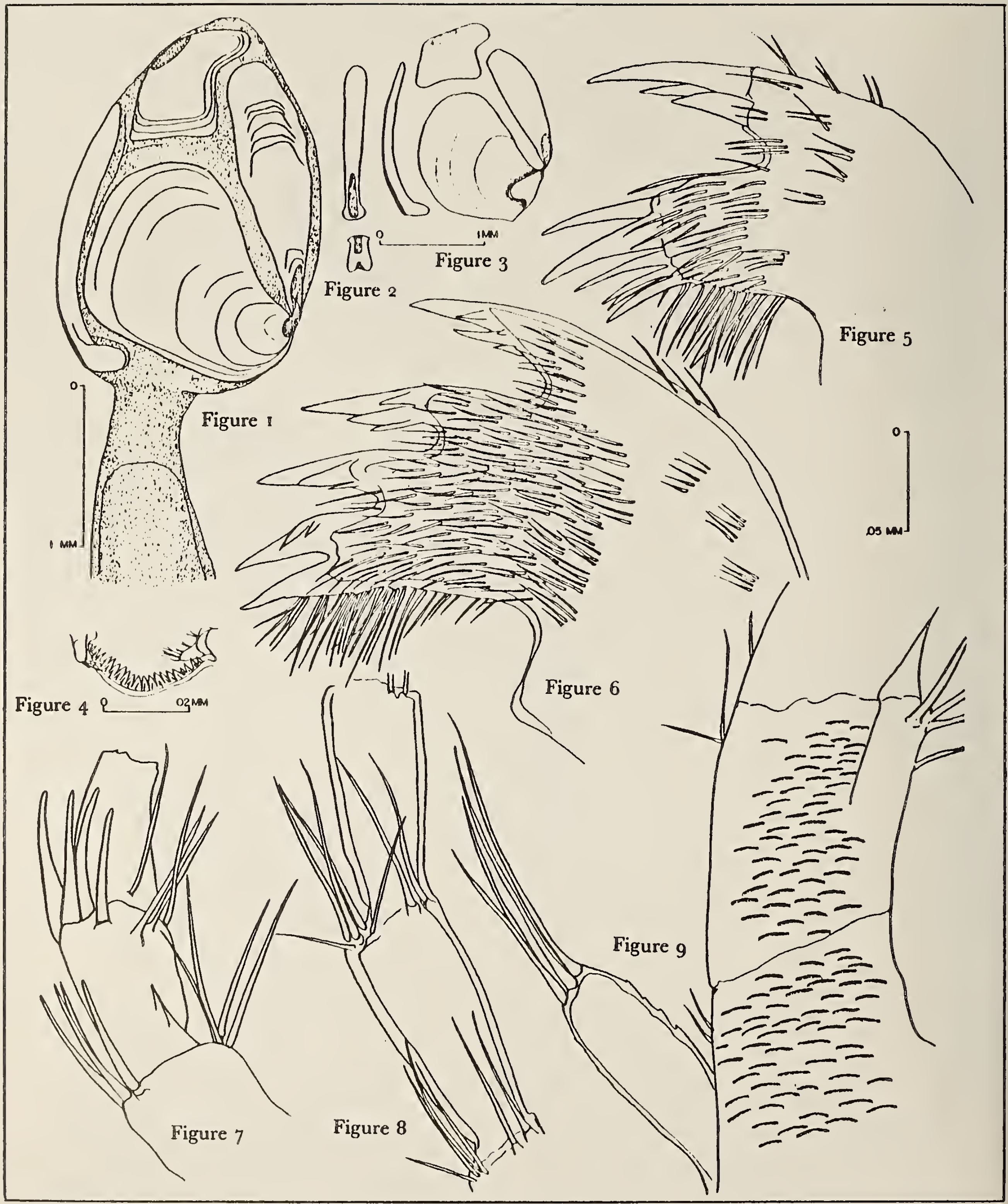
Figure 1
0
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Figure 6
Figure 7
Figure 8
Figure 9

Newman, *del.*

cimens, becoming less conspicuous with growth, essentially lost in mature forms except in tergal region. Surface studded with minute sharp spines which are transparent, never amber ("minute points or pseudo-cellular structures" in MacDonald's account), spines best seen along capitular margins or along folded edge of torn mantle (Plate 21, figures 3, 4).

Measurements taken from four specimens (in millimeters):

	Range	Mean
Capitulum		
Length:	1.72 - 2.25	2.08
Depth:	1.27 - 1.84	1.57
Width:	0.69 - 1.15	0.97
Peduncle		
Length:	0.92 - 1.95	1.32
Av. Diam.:	0.53 - 0.78	0.66
Total Length:	2.87 - 4.13	3.40*

*Three millimeters in MacDonald's account.

Valves 5, much reduced. Scutum of 2 arms; occludent arm calcified, straight or a little convex, not overlapping tergum; basal arm reduced, chitinous rather than calcareous for most of its length ("rudimentary" according to MacDonald), traversing capitulum approximately one fourth the length of the capitulum above the capitulo-peduncular junction, pointing at or somewhat below the middle of the carina. Basi-scutal angle acute, ranging between 50° and 76° (mean 64°, from paired measurements of 18 specimens; approximately 58° in MacDonald's figure). Tergum variable in form; moon or saddle-shaped; occludent arm reduced, nearly lacking in some specimens. Carina not extending up between terga; forked basally; a small point extending below basi-carinal angle; basal arms of carinal fork for most part chitinous rather than calcareous, not overlapping basal arms of scuta.

Peduncle variable in length, depending on position on host and state of contraction; color pink, becoming maroon basally (color or tinting comparable to color of gills and membranes of host); studded with minute closely spaced stout sharp spines.

Labrum bullate; bullate portion marked by fine widely spaced scales over general surface and a few short soft setae in front of crest area; crest supporting 15 to 21 rather closely-spaced small conical teeth (13 visible in MacDonald's figure, rest obscured?). Palps spatulate, supporting numerous long setae along upper margin and inner angle; lower margin and surface covered with small ctenoid scales. Mandible with 5 teeth, third, fourth, and fifth tooth bifid, second tooth occasionally bifid; fifth tooth, although smaller than fourth, not rudimentary, occasionally trifid; inferior angle cleft, forming 2, sometimes 3, hyaline spines; superior margin supporting several pairs of soft spines; inferior margin supporting numerous strong spines (Plate 21, figure 5). Inner maxilla with cutting edge nearly straight, divided into 2 portions by a small notch; portion above notch supporting 3 strong spines; notch with 2 spinules; portion below notch with 6 or 7 spines and a few spinules; superior margin with numerous pairs of soft spines equally spaced over at least half the entire length; inferior margin supporting 3 to 5 pairs of stiff spinules (Plate 21, figure 6). Outer maxilla rhomboid, corners rounded; superior margin supporting about 7 slender long curved spines and a few spinules; inner margin with numerous spinules.

Cirrus I with equal rami; rami one half length of rami of Cirrus II; outer ramus about three fourths the width of inner ramus; both rami clothed with dense soft setae; ultimate articles supporting 5 or 6 strong plumose spines and a few soft setae (Plate 21, figure 7). Cirri II through VI ctenopod, essentially equal in length and with equal or nearly equal rami; posterior margins of pedicles and some proximal articles supporting small distally directed scales. Inner curvature of intermediate articles of Cirrus VI supporting 7 pairs of setae, the number gradually becoming less in more distal articles; greater curvature supporting about 5 long setae in a clump at each articulation. Counts for the neotype are given below,

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Explanation of Plate 22

Octolasmis indubia Newman, spec. nov.

Figure 1: holotype; Figures 2 and 3: valves of a paratype; Figure 2: anterior and dorsal view of carina; Figure 3: disarticulated valves - lateral view of carina, interior view of tergum and scutum; Figures 4 through 9: trophi and appendages of holotype; Figure 4: labrum and palps; Figure 5: outer maxilla; Figure 6: mandible; Figure 7: intermediate articles of outer ramus of Cirrus IV; Figure 8: intermediate articles of outer ramus of Cirrus VI; Figure 9: caudal appendage and pedicle of Cirrus VI.

variations noted in other specimens being placed parenthetically:

Cirrus	I	II	III	IV	V	VI
Outer Ramus	6	10	9(10)	9	9	9
Inner Ramus	6(7)	10(9)	9	9	9	9

Caudal appendage uniarticulate, nearly as long as pedicle of Cirrus VI, supporting apical tuft of about 10 long strong setae, the longest of which equals the length of the entire appendage (Plate 21, figure 8).

Penis moderately long, surface supporting a few scattered soft bristles occurring singly or in linear groups of 2, 3, or 4; tapering gradually for the first three quarters and then abruptly to a smaller diameter in distal quarter of length; basal surface clothed with closely spaced distally directed scales, central portion with smooth but irregular surface, distal third (except apical region) finely folded; apex without distinct terminal languet, supporting a few short spines followed by a transverse row of about 7 longer soft obliquely placed bristles of nearly equal length (Plate 21, figure 9).

Discussion

The species Octolasmis neptuni (MacDonald, 1868), reinstated here, was originally described from the gills of Neptunus pelagicus (Linnaeus) from Moreton Bay, Queensland, Australia. It was placed in synonymy with O. lowei (Darwin, 1851) by Nilsson-Cantell (1927) while working on specimens from the gills of a xanthid crab, Pseudocarcinus gigas (Lamarck), from Tasmania. It is my opinion that although Nilsson-Cantell's form is O. lowei s. l., it is not O. neptuni as he supposed. It does not compare favorably with the material described here, which originated from the type locality and the type host and is clearly O. neptuni as originally described.

In addition to the Australian localities, MacDonald reports and describes a comparable barnacle from a swimming crab from Fiji. From the description and accompanying text, it appears that he is not at all convinced that the Fijian form is identical with those seen at Moreton Bay. Although one can only guess, it is my opinion that MacDonald's Fijian form is not Octolasmis neptuni. This opinion rests on MacDonald's own reluctance to confirm the identity and on the fact that the fifth tooth of the mandible is rudimentary and the rami of the first cirri are grossly unequal. For these reasons the locality records for this species in the islands of the south west Pacific have been questioned.

Octolasmis (Octolasmis) neptuni hiroi NEWMAN, subspec. nov.

1937 Octolasmis lowei forma neptuni in part. Hiro: 426; fig. 13 E-H, fig. 15 A-C.

Locality: Seto Inland Sea, Japan, on gills and occasionally mouth parts of Neptunus trituberculatus Miers and on gills of Charybdis japonica (Milne-Edwards).

Holotype: U. S. N. M. Cat. No. 107'308; Hukuyama, Seto Inland Sea (34° 30' N. Lat.; 133° 22' E. Long.), on gills of C. japonica, kindly sent me by Dr. Huzio Utinomi.

Diagnosis: The present subspecies is described by Hiro (1937) from Japan, and it differs little from the typical form from Australia. The differences are considered diagnostic for the Japanese subspecies and are briefly described here: Color (in alcohol), opaque white; mature specimens with minute transparent closely spaced extremely low blunt spines clothing capitulum and peduncle. In the specimens on hand the basal arm of the scutum is for the most part calcareous rather than almost entirely chitinous as it is in the typical form. In any event, it ranges from needle-like to nearly absent, and this is normal for the species.

The following description is of an interesting species of Octolasmis from the mouth parts of a macrurous decapod crustacean from Hawaii. The valves, and armature of the mouth parts and cirri, are quite different from the aforementioned species. An understanding of these differences is crucial to an appreciation of the unique position occupied by this and related forms. For this reason, a consideration of their significance follows rather than preceeds the general description.

Octolasmis (Octolasmis) indubia NEWMAN, spec. nov.

(Plate 22)

Locality: Kaneohe Bay, Oahu, Hawaii (Coconut Island; approximately 21° 27' N. Lat.; 157° 47' W. Long.). Numerous specimens from the mouth parts of a single specimen of Scyllarides squamosus (Milne-Edwards), the gills of which were infected with Octolasmis lowei (Darwin); collected by Stephen A. Wainwright.

Holotype: U. S. N. M. Cat. No. 107'310; paratypes: U. S. N. M. Cat. No. 107'311, 107'312.

Diagnosis: Capitulum ovoid, laterally flattened, of 5 valves separated from one another by a narrow border of mantle wall (Plate 22, figure 1). Carina narrow, extending up between terga, terminating basally in a bifurcate knob. Scutum of 2 arms connected by an uncalcified portion; occludent arm spatulate, extending into notch of tergum; basal arm broadly expanded, with internal broad flat platform. Border of scutum in line with occludent margin of capitulum below primordial valve, forming a broad curve with the basal margin. Labrum with numerous closely spaced large sharp teeth, palps relatively small (Plate 22, figure 4). Chaetotaxis of Cirrus IV acanthopod (Plate 22, figure 7). Mandible with 4 sharp teeth, each tooth with strong basal spines; inferior angle developed as a sharp tooth, often as large as the fourth tooth (Plate 22, figure 6). Inner maxilla with 3 strong spines above and approximately 6 spines below the deep notch, second spine in lower group strongest (Plate 22, figure 5).

Description: Five valves, appearing as 7 due to incomplete calcification of scuta above rostral angle (Plate 22, figures 1-3). Carina narrow, extending up between terga, terminating proximally in a bifurcate knob, calcification not extending below primordial valve. Tergum broad, rounded, tending to form 3 angles; carinal angle projecting between carina and basal arm of scutum; median angle extending over occludent arm of scutum; median and occludent angles forming notch receiving distal portion of occludent arm of scutum. In young specimens, terga somewhat rectangular, although indentation receiving occludent arm of scutum already developed. With growth, portion between carinal and median angles of tergum broadens and the scutal indentation becomes reduced. Occludent arm of scutum spatulate, connected to basal arm by a yellowish ligament overlying primordial valve. About three fourths of the primordial valve extends onto the occludent arm of the scutum in large individuals. Basal arm of scutum broadly expanded, rounded; interior portion, near rostral angle, thickened and elevated as a broad flat platform. Platforms of scuta are fused, rendering basal segments rigid, preventing lateral compression of the animal. (Valves can be readily separated by corrosion of cementing substance with five percent sodium hypochlorite.) Ligament allows movement of the occludent arm and permits closure of the aperture. The nearly complete armored condition seen in mature specimens is attained by slow ontogenetic increments, during which the area occupied by the valves becomes greater and greater. This process is quite unusual and its postulated significance is taken up in the discussion below.

Peduncle: Smooth, without chitinous spines, knobs, beads, or calcareous inclusions; length apparently dependent upon postion of barnacle on host.

Measurements for four individuals (in millimeters):

Capitulum

Height	Width	Depth
1.2	0.4	0.9
1.4	0.6	1.0
1.8	0.8	1.3
2.0	0.8	1.4

Peduncle

Length	Average Diameter
3.5	0.35
2.5	0.3
3.5	0.5
3.5	0.5

Labrum bullate, crest supporting approximately 21 strong sharp teeth. Palps oblong, sparsely setose along the superior margin and inner angles; situated well toward lateral margins of labrum (Plate 22, figure 4). Mandible with 5 sharp teeth not including inferior angle; first, second, third, and fourth teeth supporting 2 to 4 strong spines at their bases (not pectinate in the ordinary sense); inferior angle forming a sharp tooth which may be equal to or slightly less well developed than the fourth tooth (Plate 22, figure 6). Inner maxilla with 3 strong spines above and 7 strong spines below deep notch, second spine in the lower group the strongest; 3 pairs of setae along upper margin appear to be a constant characteristic (Plate 22, figure 5). Outer maxilla broadly rounded, clothed sparsely with short bristles and long slender spines or setae along the superior and inner margins.

Cirri relatively short and stout. Cirrus I with unequal, Cirrus II with subequal, and Cirri III through VI with equal rami. Pedicles of Cirrus I originate at some distance forward of Cirrus II. Outer ramus of Cirrus I about two-thirds as long and two-thirds as wide as inner ramus; clothed with numerous long relatively soft setae; terminal article supporting tuft of about 3 stout spines; inner ramus clothed with numerous stout setae. Several proximal articles of rami of Cirrus I with indistinct or fused sutures. Cirrus IV with articulations of fourth and fifth articles of rami supporting about 4 stout claw-like spines on the greater curvature and 3 to 4 slender long spines on the lesser curvature. Fourth and fifth articles of Cirrus VI supporting approximately 4 slender spines on greater and 2 or 3 slender spines on lesser curvature at the articulations (cf. Plate 22, figure 8 — acanthopod; figure 9 — lasiopod). Pedicles of all cirri, except the first, clothed with minute ctenoid elevations or scales (Plate 22, figure 9).

Counts of articles of the rami are given below for two spei

with minute ctenoid elevations or scales (Plate 22, figure 9).

Counts of articles of the rami are given below for two specimens. Although Cirrus I is 6-6, three segments in each are fused. The first set is for the holotype.

	Cirrus	I	II	III	IV	V	VI
1.	Outer Ramus	6	8	7	8	7	7
	Inner Ramus	6	7	8	8	7	6
2.	Outer Ramus	6	8	8	8	8	8
	Inner Ramus	6	6	9	8	8	8

Caudal appendage as long or slightly longer than the first article of pedicle of the Cirrus VI; margins roughened by scales; apex supporting a tuft of 4 to 6 long slender spines (Plate 22, figure 9). Penis smooth, tapering gradually through its length; clothed sparsely with minute setae not symmetrically arranged; terminating abruptly with a tuft of terminal sensory hairs, apical or just below a rounded terminal languet.

Discussion

The species described here has been assigned to the subgenus Octolasmis because the valves and their primordia are most comparable to those of other members of this group; that is, the terga are notched to receive the distal ends of the occludent arms of the scuta, and the primordial valves of the scuta lie in a line along the occludent margin of the capitulum. The latter character is the most undisputed diagnostic feature for the subgenus, and its form clearly separates this species from species of Temnaspis, which is currently somewhat enigmatic (Broch, 1932; and 1947; Nilsson-Cantell, 1934; Stubbings, 1936).

The following species of the Poecilasmatidae are known to me from Hawaii:

1. Trilasmis (Temnaspis) fissum hawaiense (Pilsbry, 1928)
   1899 Trilasmis fissum Weltner
2. Trilasmis (Trilasmis) eburneum Hinds, 1844
3. Trilasmis (Poecilasma) kaempferi (Darwin, 1851)
4. Octolasmis (Octolasmis) lowei (Darwin, 1851)
5. Octolasmis (Dichelaspis) hawaiense (Pilsbry, 1907)
6. Megalasma (Megalasma) minus Annandale, 1906
   1907 Poecilasma bellum Pilsbry

Of the Hawaiian forms, the present species is most similar to Trilasmis (Temnaspis) fissum hawaiense. These two barnacles are comparable in size and habitat but are basically different in the development of the primordial valve of the scutum and the degree of armament of the capitulum. Trilasmis (T.) fissum hawaiense is more fully covered by its valves, the scutal umbo is "rotated" basally, the distal portions of the scutal arms are acute rather than rounded, the tergum is considerably more reduced and is not notched to receive the occludent arm of the scutum, and the carina terminates in an "obtuse tooth and a distinct heel" rather than a bifurcate knob. Internally, the scutal platform is basal, corresponding to the rotation of the umbo, rather than being situated along the occludent margin. The mouth trophi are similar in both species, however, the fourth rather than the second spine below the notch of the inner maxilla is strongest in Pilsbry's form, the mandible has but 4 teeth, including the inferior angle, and the teeth are simple, lacking spines or pectinations. The chaetotaxis and mouth trophi of the new species appear quite similar to those described for Octolasmis clavula Hiro (1936) from Japanese waters, especially in regard to the details of the mandible. However, there are so many differences in the form of the valves that further comparison seems unnecessary. A comparison with O. tridens (Aurivillius, 1894) and its Caribbean allies (forms all having ctenopod cirri) seems superfluous. At this time I see no close affinities of the new species with any form known to me. The barnacle clearly shares characters with members of the genera Trilasmis, Temnaspis (if considered valid), and Octolasmis. As Broch (1931) has pointed out, the group is in need of revision.

The nearly fully armored condition seen in mature specimens of this species is achieved through slow ontogenetic increments in the valves, particularly in the basal arm of the scutum, at a rate greater than the rate of increase in the size of the capitulum. By this sort of differential development, partially armored juveniles become fully armored somewhat later in life than do related free-living species in which juveniles are essentially as fully armored as adults. The same process is seen to occur in Octolasmis tridens (Aurivillius), (Nilsson-Cantell, 1934), and in O. cor (Aurivillius), (Newman, 1960b). This process suggests that species in this family with the scutum split into two parts have descended from forms in which the valves were much reduced, the split-valve being a product of rearmament. This suggestion is believed to be quite plausible for it not only explains their somewhat aberrant form, but it also explains the vestige of a scutal suture seen in such species as Trilasmis eburneum Hinds and occasionally in T. crassum sensu Darwin (1851). These two species have apparently completed the rearmament process, the vestigial, fully-fused, non-functional suture testifying to a split-valve ancestry, being acquired through relatively unarmored forms living in protected environments.

This argument is contrary to the concept of the prototype of split-valve forms in which Pilsbry (1911) envisions a fully armored ancestral type with a split-valve already developed, becoming reduced in protected environments. The same argument is the reverse of that of Broch (1947), which is essentially Pilsbry's concept in more detail, without additional evidence. What Pilsbry and Broch fail to take into consideration is the functional aspect of the split-valve; that is, what purpose does it serve the barnacle, especially when the occludent arm is immovably fused to the basal arm? They also fail to consider what possible path selection might take to achieve such an unusual structural arrangement.

In fully armored species, without a split-valve, the scuta are hinged to one another as they are in nearly naked species of Octolasmis. In this way the valves can be opened and closed, and when closed, being fully approximate at their edges, they prevent crushing of the soft animal within. Forms with greatly reduced valves are relatively easy to crush, but they generally survive in environments where crushing is not likely to occur. If rearmament were gradually selected for, in response to more exposed conditions, the barnacle would still be subject to crushing until the valves became fully approximate. In such partially armored forms, this problem is overcome by a fusion of the hinge area of the basal scutal arms, which, being the strongest and overlying the body of the animal when withdrawn, offer fair protection. However, this necessitates having the occludent arms, each connected to a basal arm by an uncalcified ligament, free to be drawn together by the scutoral adductor muscle, closing the aperture. In this way, partially armored species are protected against crushing, yet retain the facility of closing. In exploiting more exposed environments, fuller armament being selected for, the valves would become fully approximate. Fusion of the basal scutal arms is no longer a requirement but actually a disadvantage, for the occludent arms must remain free of the basal arms in order to continue to close the aperture. This arrangement sacrifices a considerable degree of rigidity. In overcoming this final complication in rearmament, the fusion platforms could become transformed into a hinge, with the simultaneous fusion of the occludent arm to the basal arm of the scutum, leaving the vestigial suture mentioned above. Indeed, the peculiar hinge-like platforms of Trilasmis fissum (Darwin) and the peculiar hinge of T. eburneum Hinds are more readily understood as being derived in this way than from the ordinary hinge of more remote fully armored ancestral forms.

Following this explanation for the origin of the split scutal valve, it appears most likely that split-valve forms have descended from relatively naked ancestors inhabiting the gill chambers of decapod Crustacea (Plate 23). This is not as unlikely as it may at first appear, for it is a fact that relatively unarmored species which inhabit gills are often found occurring around the exhalant area of gill chambers and along the basal portions of the last maxillipeds of the host (Annandale, 1909). In this position they are at a disadvantage as regards mechanical injury, but they conceivably may be rewarded by fragments of food drifting away from the food being fed upon by the host. To this end a ctenopod feeding mechanism would be satisfactory, for barnacles could carry on normal setose feeding when not receiving food escaping the host. If the protection afforded by fuller armor were attained in forms tending to settle near the mouth field, there would be a better chance of survival. Thus, they could occupy positions further out on the mouth parts, closer to the new source of food. If the rather delicate feeding mechanism were gradually replaced with stouter clawed appendages, the barnacle might be able to capture larger particles of food or even rasp directly at the food being manipulated by the host. It is a fact that most split-valve forms occur on the mouth parts, primarily the maxillipeds of macrurous forms, and it is a fact that where the ontogeny of these forms is known, the split-valve is seen to be acquired through slow ontogenetic increments and differential growth. It may be simply a coincidence that most species in this position also have very peculiar, strong, stout clawed cirri and unusually spiny mouth parts which appear poorly adapted to setose feeding, but I prefer to suggest that these structures are correlated with the unique habitat in which the barnacle, having descended from forms inhabiting gill chambers, has moved forward into the mouth field, enabling it to share the food of the host.

That such species are the descendants of more naked ancestors and have come to occupy such an unusual niche by an indirect route through the gill chambers of the host is suggested not only because it would explain the split-valve as a result of rearmament, but also because a more gradual transitional process could hardly be imagined in achieving such a remarkable and precarious position on the host and in attaining the highly modified feeding mechanism correlated with it.

Acknowledgment

Specimens of *Octolasmis* (*Octolasmis*), *Trilasmis* (*Trilasmis*), *T.* (*Poecilasma*), and *Megalasma* (*Megalasma*) studied in conjunction with this paper were obtained from a number of individuals to whom I am deeply indebted. The specimens originated from widely separated localities, and together they allow one to gain a fuller concept of the family than could otherwise be obtained. I am grateful to Dr. Thomas E. Bowman for the loan of specimens from the Caribbean, to Dr. Fenner A. Chace, Jr., for the loan of specimens from the Society Islands, to Dr. Cadet Hand for specimens from New Zealand and Australia, to Dr. Arthur G. Humes for specimens from the Caribbean, East Africa, and New Guinea, to Arnold Ross for specimens from the Caribbean, to Dr. H. G. Stubbings for specimens from West Africa, to Stephen A. Wainwright for specimens from Hawaii, to Dr. Huzio Utinomi for specimens from the Seto Inland Sea, and to Victor A. Zullo for specimens from Shoal Guyot, South East Pacific. I would also like to thank Dr. Hand for his reading and criticism of the manuscript.

It is currently my wish to revise the family Poecilasmatidae and I solicit specimens from any quarter of the world for this purpose.

Literature Cited

Annandale, N.
1906a. Natural history notes from the R. I. M. S. "Investigator". Ser. III, No. 12. Preliminary report on the Indian stalked barnacles. Ann. Mag. Nat. Hist. 7th ser. 17 (100, Art. 53): 389-400.

—, —
1906b. Natural history notes from the R. I. M. S. "Investigator". Ser. III, No. 13. Two new barnacles dredged in 1905-06. Ibid. 18 (103, Art. 10): 44-47, 2 textfigs.

—, —
1908. Illustrations of the zoology of the R. I. M. S. Ship "Investigator". Crustacea entomostraca, Pt. ii, pls. 3-5; Calcutta.

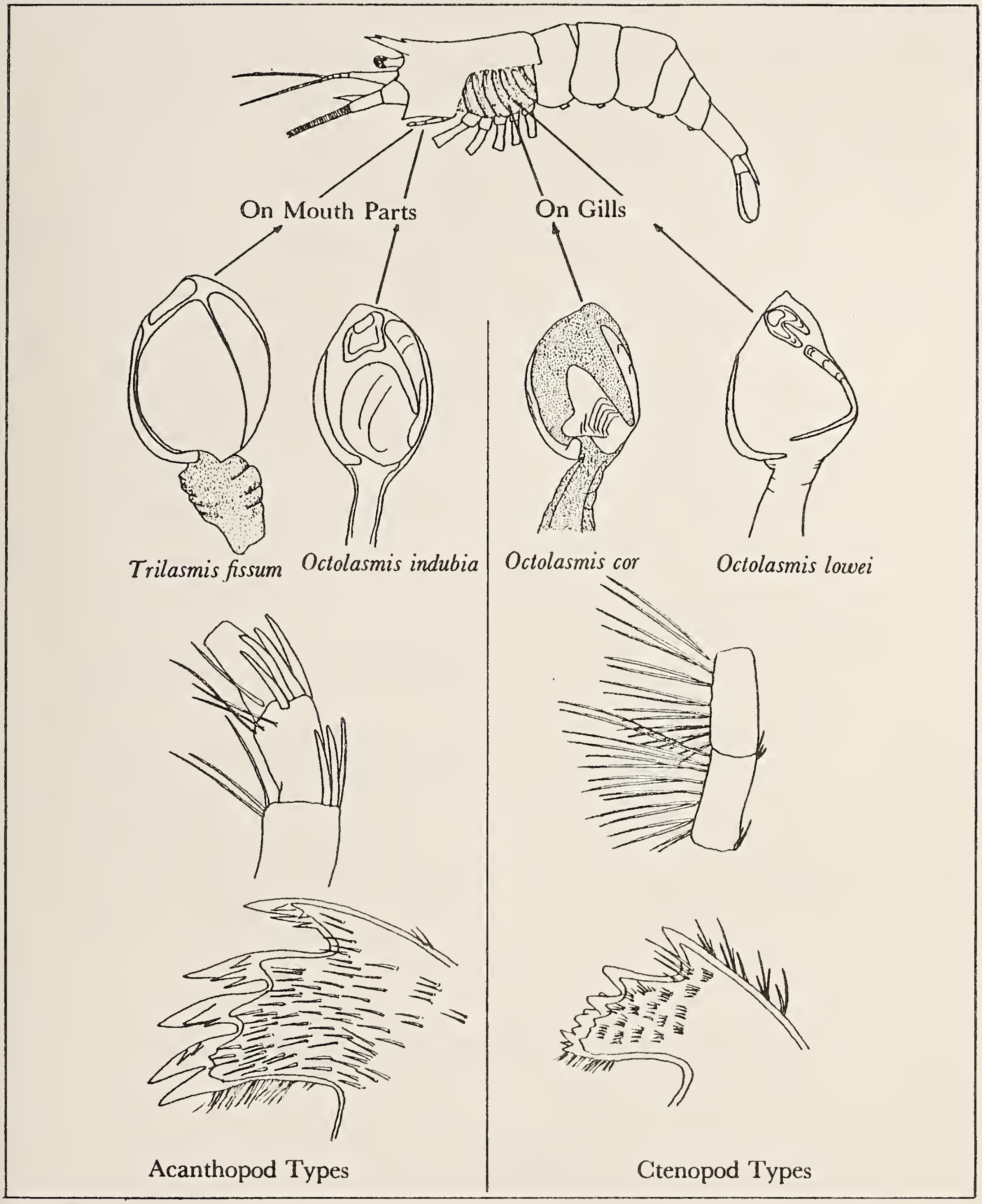
—, —
1909. An account of the Indian cirripedia pedunculata. Mem. Ind. Mus. 2 (2): 61-137, 11 textfigs., pls. 6 and 7.

Aurivillius, C.
1894. Studien über Cirripedien. Svensk. Vet. Ak. Handl. 26 (7): 4-107, 9 pls.

Barnard, K.
1924. Contribution to the crustacean fauna of South Africa. 7. Cirripedia. Ann. S. Afr. Mus. 20 (1): 103 pp., 1 pl.

Explanation of Plate 23

Schematic drawing indicating certain types of barnacles associated with gills and mouth parts of decapod crustacea. From right to left: *Octolasmis lowei* (Darwin), usually on "soft" gills of macrurans, and *Octolasmis cor* (Aurivillius), usually on the "hard" gilled brachyuran, *Scylla serrata* (Forskål); *Octolasmis indubia* Newman, spec. nov. and *Trilasmis fissum* (Darwin), both usually on last maxillipeds of macrura. While acanthopod types are quite location-specific, lasiopod and ctenopod types are not, their degree of armament apparently determining where they will survive. The lasiopod type (Pilsbry, 1911) is an intermediate condition between ctenopod and acanthopod types. Split-valve forms can be acanthopod, lasiopod or ctenopod, while unarmored forms are always ctenopod as are armored forms that do not have a split-valve ancestry.


On Mouth Parts
On Gills
Trilasmis fissum
Octolasmis indubia
Octolasmis cor
Octolasmis lowei
Acanthopod Types
Ctenopod Types

Newman, *del.*

Broch, H.
1931. Indomalayan Cirripedia. Papers from Dr. Th. Mortensen's Pacific expedition 1914-16. 56. Vidensk. Meddel. Dansk. naturh. Foren. 91; 142 pp., 41 textfigs.

——, ——
1947. Cirripedes from Indochinese shallow-waters. Arch. utg. Norske Vidensk. - Akad. Oslo. 1. Mat.-Naturv. Kl. No. 7: 32 pp., 8 textfigs.

Causey, D.
1961. The barnacle genus *Octolasmis* in the Gulf of Mexico. Turtox News 39 (2): 50-55, 17 textfigs.

Darwin, Charles
1851. A monograph on the sub-class Cirripedia. I. Lepadidae. Ray Soc. London, pp. 1-400, figs. 1 to 3, pls. 1-10.

Gruvel, A.
1900a. Note sur deux espèces nouvelles du genre "Dichelaspis". Proc. Verb. Soc. Sci. phys. nat. Bordeaux, 1899-1900: 2.

——, ——
1900b. Sur quelques nouvelles espèces appartenant au genre *Dichelaspis* Darwin. Bull. Mus. Hist. nat. Paris, No. 3: 109-111.

——, ——
1905. Monographie des cirripèdes ou thécostracés. pp. 1-472, 472 textfigs. Mason, Paris.

Hiro, F.
1936. Descriptions of three new species of Cirripedia from Japan. Bull. Biogeogr. Soc. Japan 6 (23): 221-230, 3 textfigs.

——, ——
1937. Studies on cirripedian fauna of Japan II. Cirripeds found in the vicinity of the Seto Marine Biological Laboratory. Mem. Col. Sci. Kyoto Imp. Univ. Ser. B, 12 (3, art. 17): 385-478, 43 textfigs.

MacDonald, J.
1869. On an apparently new genus of minute parasitic Cirriped, between *Lepas* and *Dichelaspis*. Proc. Zool. Soc. London, 440-444, pls. 33, 34; 1 textfig.

Newman, William A.
1960a. *Octolasmis californiana*, spec. nov., a pedunculate barnacle from the gills of the California spiny lobster. Veliger 3 (1): 9-11, pl. 2.

——, ——
1960b. Five pedunculate cirripeds from the western Pacific, including two new forms. Crustaceana 1 (2): 100-116, 6 textfigs.

——, ——
1961. Notes on certain species of *Octolasmis* (*Octolasmis*) from deep sea crustacea. Crustaceana 2 (4): in press.

Nilsson-Cantell, C. A.
1921. Cirripedien Studien. Zur Kenntniss der Biologie, Anatomie und Systematik dieser Gruppe. Zool. Bidrag fr. Uppsala 7: 75-395, textfigs. 1 to 89, pls. 1 - 3.

——, ——
1927. Some barnacles in the British Museum (Nat. Hist.). Proc. Zool. Soc. London Pt. 3: 743-790, 19 textfigs.

——, ——
1934. Indomalayan cirripeds in the Raffles Museum, Singapore. Bull. Raffles Mus. (9): 42-73, 7 textf. pl. 5.

——, ——
1938. Cirripedes from the Indian Ocean. Mem. Ind. Mus. 13 (1): 81 pp., 28 textfigs., pls. 1-3.

Pearse, A.
1932. Observations on parasites and commensals found associated with crustacea and fishes at Dry Tortugas, Florida. Pap. Tortugas Lab. Carnegie Inst. Wash. 28 (6): 103-115.

Pilsbry, Henry A.
1907a. Hawaiian cirripedia. U. S. Bull. Bur. Fish. 26: 181-190, pls. 4, 5, 4 textfigs.

——, ——
1907b. The barnacles (cirripedia) contained in the collections of the U. S. National Museum. Bull. U. S. Nat. Mus. 60: 1-122, pls. 1-76, textfigs. 1-99.

——, ——
1911. Remarks on new cirripeds. Proc. Acad. Nat. Sci. Phila. 63: 170-173, 3 textfigs.

——, ——
1928. Littoral barnacles of the Hawaiian islands and Japan. Proc. Acad. Nat. Sci. Phila. 79: 305-317, pls. 24-26, 4 textfigs.

Stubbings, H.
1936. Cirripedia. Brit. Mus. (Nat. Hist.), John Murray Expedition 1933-34, Sci. Report 4 (1): 1-70, 30 textfigs.

Weltner, W.
1899. Ergebniße einer Reise nach dem Pacific (Schauinsland 1896-97). Cirripedien. Zool. Jahrb. Abt. System. 2: 441-447.

Another Statistical Study in Size of Cowries

by

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The length of the shells of each cowry species varies considerably, even in specimens coming from a limited area. The frequencies of the classes, distributed according to a binomial curve, show a positive skewing so that the summit of the curve approaches nearer to the class of the smallest shell than to that of the largest specimen.

These usual features may be illustrated by 1'555 Luria isabella (Linnaeus) coming from the beach of Tjilaut Eureun, South Java, the length of which varies from 15 to 40 mm. in adult shells. In the following table the size has been reduced to classes of 3 mm. (e. g., 15 = 13.5 to 16.5 mm.); the number of specimens belonging to every class has been expressed in percent of 1'555 (the sign 0 indicates less than 0.5 percent; the sign o expresses less than 0.1 percent):

16	19	22	25	28	31	34	37	40	mm.
1	17	30	26	17	7	1	0	o	%

The sum of shells coming from the whole area of distribution of a species supplies a similar curve, if the numbers of specimens preserved at each locality are rather similar. Thus, e. g., the distribution of 8'169 Monetaria annulus coming from 425 localities between Natal and Polynesia is as follows:

10	13	16	19	22	25	28	31	34	mm.
0	10	33	32	17	6	1	0	o	%

The minimum length is 10.3 mm., the maximum 33.7 mm.; ninety percent of these shells vary from 14 to 24 mm. only.

The differences in size observed in various populations can be environmental or racial. The local modifications may be caused by the depth of the sea in which the population lives, by differences in the motion of the sea or in the quantity and quality of food: so we learned from the collections carefully made by R. S. Benton that most specimens living on the coral reefs of Mombasa Island are distinctly smaller than the specimens of the same species collected among the sea weed on a sandy and muddy bottom at Shimoni a few miles off. In the same way, Barry Wilson stated (personal communication) that in Geographe Bay the adult specimens of Zoila friendii (Gray) collected between Quindalup and Dunsborough (about a mile apart) are stunted: they live "in an enclosed area in only three to six feet of water cut off from the deeper water offshore by a wide and very shallow sand bar." He has "never seen a small adult specimen outside the bank, nor a large specimen inside the bank". He suspects "the difference may be a physiological one" (quoted from Wilson's letter, dated 6th February, 1959). Therefore, the curve of variation in 79 Z. friendii (the Eastern vercoi Schilder included) shows two summits:

40	50	60	70	80	90	100	mm.
2.5	14	9	29	24	19	2.5	%

There are, however, also racial differences in size, if the average length of most populations living in a continuous large region significantly differs from the usual size observed in other parts of the world. Thus, in my previous statistical study, published in The Veliger (Schilder, 1961), I have shown that in Mauritia arabica (Linnaeus), the South Western* race immanis Schilder-Schilder distinctly differs by its larger size from M. arabica living between Ceylon and the Pacific, though the limits of variation overlap; this fact may be illustrated by the following table, in which the size of 2'140 M. arabica and 86 M. immanis has been expressed in percent:

	20	30	40	50	60	70	80	90	mm.
arabica:	o	13	46	29	10	2	o	-	%
immanis:	-	-	-	3	27	41	24	5	%

Similar differences may be observed in Erosaria lamarckii (Gray): the subspecies redimita (Melvill) with purely white spots lives in the Indian Ocean from Mauritius and Karachi to Penang, while the Western E. lamarckii with the larger spots distinctly ocellated occupies the area between Natal, Kenya, and Madagascar. The following table illustrates the variability in size of 127 E. l. redimita (including the specimens published by Griffiths, 1956) and 112 E. l. lamarckii, expressed in percent:

	20	25	30	35	40	45	50	mm.
E. l. redimita:	1	21	46	27	5	-	-	%
E. l. lamarckii:	-	1	9	30	34	24	2	%
Port Reitz:	2	9	48	34	6	1	-	%

The last line indicates the percentage of 124 specimens collected in a restricted area at

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*In The Veliger, vol. 4, p. 17, left line 12, erroneously has been said "South Eastern".

Port Reitz near Mombasa: the size agrees with E. l. redimita, though by zoogeographical reasons one would expect large E. l. lamarckii. As Mr. R. S. Benton at Nairobi, who collected most of these specimens alive at Port Reitz, kindly has given 36 shells to the writer and has carefully measured and described the remaining 88 specimens, the ocellation of each shell is known: in 37 percent there are no traces of purplish ocelli in the white dots (as it is in E. l. redimita), in 31 percent the ocelli are pale and indistinct, and in 42 percent as distinct as it is in typical E. l. lamarckii; the average size of the shells in these three groups is slightly increasing: 30, 31, and 33 mm. Therefore, the population from Port Reitz seems to be rather intermediate, possibly on account of its living on the northern border of its distribution in East Africa.

In Lyncina carneola (Linnaeus) giant specimens will be observed sometimes; in the Hawaiian Islands there is a distinct contrast between the smaller L. carneola and the large L. leviathan Schilder-Schilder (45 to 90 mm.), which has been recently confirmed ecologically and anatomically by Miss Kay (1961). The common length of both seems to range from 45 to 55 mm. Farther West giant shells (which anatomically belong to L. carneola) are very rare, but they usually cause a slight second summit of the curve of variation, as it is in the large series from Tjilaut Eureun, South Java, and from New Britain (percent of 1'732 and 195 shells, respectively):

	20	25	30	35	40	45	50	55	60	65 mm.
Tjilaut Eureun:										
10	50	27	8	3	1	0	1	-	-	%
New Britain:										
1	31	33	18	11	4	1	-	1	-	%
Shimoni:										
-	4	27	15	4	8	8	15	15	4	%

The last line refers to 26 Lyncina carneola collected by R. S. Benton at Shimoni (see above) in March 1961: there are evidently two varieties in size, which live together in the same place, but there is no difference in the characters of the animal nor in its radula, and both sexes are distributed about equally among the small and large specimens.

The rare Derstolida coxeni (Cox) which is a native of the Solomon Islands, seems to have developed in New Britain a dwarf race varying from 14 to 18 mm. (Ulamona; Rabaul?; "New Britain" in the museum of Hamburg, destroyed) instead of from 19 to 26 mm. (Solomon Islands; Astrolabe Bay? [Schilder, 1928a]). These smaller shells are also more slender (the breadth is 46 to 51 instead of 49 to 57 percent of the length), have finer teeth (l-p/o-t instead of k-n/n-p according to Schilder, 1958), and the dorsal blotches are dark, coarse, and more confluent. The material available (8 and 12 shells, respectively), however, is too scanty to establish a named Northwestern race of coxeni.

In examples mentioned above the small and the large shells are linked by a continuous series of intermediates. There are some rare exceptions, in which a rare dwarf or giant variety is separated from the more common shells by a broad gap.

The 118 adult Siphocypraea mus (Linnaeus) preserved in European collections vary in size as follows:

30	35	40	45	50	55	60	65	mm.
11	21	45	11	5	-	3.5	3.5	%

The gap ranges from 51 to 58 mm. No habitat of the giant variety is known, of which two specimens are preserved in the museum of Copenhagen and in the Dautzenberg collection, while the remaining six shells were preserved in the museum of Hamburg so that one should suppose that they came from the same locality. (These six shells were destroyed during World War II, except for one shell presented to the writer's collection.)

In contrast, in Erronea chinensis (Gmelin) the dwarf shells are widely separated from the typical ones:

5	10	15	20	25	30	35	40	45	50	mm.
0	3	-	1	15	32	34	12	2	0	%

In these 257 examined shells, the gap between the nine dwarfs and the usual E. chinensis ranges from 13 to 20 mm.! The former, which have been named E. tortirostris (Sowerby), are restricted to Kowie (Port Alfred), as the indication "Natal" in coll. Tomlin seems not to be reliable. Though Turton (1932, p. 114) declared that he collected also typical "cruenta" (a synonym of E. chinensis) of 25 mm. at Port Alfred, I think all E. tortirostris belong to a degenerate population living in very unfavorable conditions on the Southern border of the species; the minute shells (7 to 12 mm.) show the aperture wide, the labial teeth obsolete, the fossula reduced, and the extremities (especially the left anterior top) pathologically produced. These characters vary in different degrees so that almost normal shells occur which differ from typical E. chinensis only by their minute size (coll. Schilder).

Many collectors are proud to possess the smallest or the largest known adult specimen of a cowry species. When beginning my studies on cowries, I compiled a list of the minimum and maximum length of each species known at that time (Schilder, 1928b); the supplement published the following year (Schilder, 1929), however, proved the extremes to be farther apart when more specimens are examined. Now having measured personally far more than 100'000 cowries, these figures mostly should be replaced by still smaller minima and larger maxima. But instead of publishing a new list of such purely accidental extremes, I prefer to indicate the limits of ninety percent of shells approaching the average length: they may be called "normal" shells, while the five percent minute and the five percent giant shells are "unusual extremes in size". The limits of these "percentiles" hardly change even when the number of examined specimens becomes much increased.

In the following list the species have been arranged, with some slight emendations, according to the writer's last catalogue (Schilder, 1941); the specific names are preceded by the logarithm of the number of measured specimens, and they are followed by two figures indicating the limits of ninety percent in millimeters. The figures have been calculated by my wife, Dr. Maria Schilder.

1.6	teulerei	43-55
0.8	fultoni	55-61
1.0	venusta (1)	55-80
1.7	decipiens	48-58
1.9	friendii	46-90
1.7	thersites	67-80
0.3	marginata	(47-59)
0.0	rosselli	(49)
2.0	mus (2)	31-47
2.2	testudinaria	80-134
3.5	isabella	17-34
2.1	mexicana	29-44
1.8	pulchra	27-59
2.6	cinerea	18-34
2.6	lurida	19-51
1.9	tessellata	20-35
2.2	stercoraria	36-80
2.6	zebra	44-105
1.8	cervus	63-134
2.1	cervinetta	43-86
3.3	arabica	35-71
2.3	grayana	32-68
2.5	histrio	45-71
2.1	maculifera	42-72
2.4	depressa	28-43
2.4	eglantina	42-70
2.9	scurra	28-47
2.4	mappa	46-85
0.8	valentia	(79-103)
2.7	mauritiana	53-94
1.2	nivosa	38-66
0.6	broderipii	(67-76)
0.3	leucodon	(78-83)
1.8	aurantium	86-108
2.4	argus	53-92
2.5	talpa	45-85
1.5	exusta	58-84
3.2	tigris	59-120
2.8	pantherina	49-85
3.1	lynx	24-47
2.8	vitellus	28-71
1.8	camelopardalis	39-71
1.9	ventriculus	35-61
3.5	carneola	20-44
1.8	leviathan	54-86
2.0	sulcidentata	30-54
2.0	schilderorum	24-38
1.7	reevei	28-40
2.0	mariae	10-17
2.5	globulus	11-21
2.6	bistrinotata	12-20
2.4	cicercula	12-20
2.5	margarita	10-16
2.1	childreni	13-23
1.4	surinamensis	25-36
3.9	annulus	14-24
2.9	obvelata	13-22
3.6	moneta (3)	14-28
2.1	irrorata	9-14
1.7	dillwyni	11-14
1.2	beckii	8-12
0.8	macandrewi	13-17
2.9	labrolineata	11-20
1.8	tomlini	12-28
1.6	cernica	17-27
1.6	citrina	17-26
3.1	gangranosa	14-23
3.1	boivinii	17-28
1.1	ostergaardi	16-28
3.3	helvola	15-25
3.4	caputserpentis	23-35
1.9	caputdraconis	23-36
2.0	albuginosa	16-28
2.4	acicularis	15-26
2.5	spurca	17-32
2.8	poraria	13-20
3.4	erosa	22-38
2.2	nebrites	19-34
2.5	ocellata	17-32
1.7	marginalis	21-31
2.5	miliaris	24-41
1.9	eburnea	29-50
2.4	lamarckii	26-45

2.9	turdus	21-42
1.0	guttata	52-68
2.9	staphylaea	9-21
2.4	limacina	18-30
2.3	semiplota	10-24
3.0	nucleus	15-25
2.1	granulata	22-34
2.1	achatidea	25-38
0.5	langfordi	(50-54)
0.9	hirasei	(40-55)
0.3	teramachii	(58-78)
2.1	zonaria	23-37
1.2	gambiensis	22-28
2.1	picta	21-34
1.0	aequinoctialis	36-44
1.8	annettae	26-49
1.2	spadicea	33-56
1.5	sanguinolenta	18-25
1.4	petitiana	18-29
2.5	pyrum	27-42
2.0	robertsi	17-30
2.0	arabicula	18-32
2.3	nigropunctata	19-34
1.3	fuscorubra	30-44
2.5	fuscodentata	26-35
1.6	algoensis	17-27
2.6	edentula	20-28
0.7	amphithales	(26-30)
2.5	capensis	28-34
1.9	pulicaria	15-20
2.1	reticulifera (4)	17-23
1.6	bicolor (5)	19-26
2.1	piperita (6)	18-25
2.1	comptonii (7)	20-27
1.3	declivis	21-28
1.9	angustata	21-30
2.1	armeniaca (8)	71-104
1.9	walkeri	18-33
2.0	pyriformis	19-32
1.8	pulchella	26-44
1.2	hungerfordi	31-37
0.0	barclayi	(26)
1.7	xanthodon	20-34
3.2	vredenburgi	16-25
2.8	pallida	20-29
2.1	subviridis	24-40
2.9	onyx	30-51
2.6	ovum	21-32
3.2	errones	17-31
2.3	cylindrica (9)	23-36
3.0	caurica	26-47
1.9	coloba	21-33
2.4	chinensis (10)	25-40
2.6	listeri	11-20
2.5	felina	14-23
1.0	martini	13-17
2.6	punctata	8-19
3.2	asellus	11-19
2.6	clandestina	11-21
2.1	artuffeli	13-20
1.3	saulae	19-27
1.5	contaminata	9-13
2.0	lutea	11-22
2.3	ziczac	12-21
2.3	diluculum	15-31
1.6	lentiginosa	21-32
3.0	gracilis	11-21
1.7	raysummersi (11)	11-17
2.3	fimbriata	9-16
2.9	minoridens	7-10
1.7	serrulifera	6-10
2.2	microdon	7-14
2.3	quadrimaculata	16-25
1.3	coxeni	15-26
2.9	pallidula	13-21
2.6	interrupta	17-23
1.5	rashleighana	14-27
1.7	latior	25-40
3.1	teres	20-31
1.4	subteres	17-27
1.8	goodallii	8-15
2.6	kieneri	10-21
1.3	owenii	9-20
2.7	hirundo	11-19
2.6	ursellus	8-15
2.4	stolida	19-33
1.4	erythraeensis	15-25
2.7	cribraria	16-29
1.7	cribellum	12-18
1.9	esontropia	14-30
2.0	catholicorum	11-17
1.7	gaskoini	11-26
1.8	cumingii	9-22

NOTES:

1) Includes episema
2) The giant variety has been omitted (see above).
3) Includes icterina.
4) A synonym prior to occidentalis
5) A revision of the genus Notocypraea will be published in another paper; bicolor should replace piperita sensu Griffiths.
6) The slender comptonii sensu Griffiths.
7) Includes mayi.
8) I think armeniaca to be a subspecies of hesitata; by law of priority, the species must be called armeniaca.
9) Includes sowerbyana.
10) The pathological tortirostris have been excluded.
11) Includes some dubious North West Australian shells; the holotype of hammondae possibly belongs to the same species.

Literature Cited

Cate, Crawford N.

1961. Description of a new Hawaiian subspecies of Cypraea tigris (Linnaeus, 1758). Veliger 3 (4): 107 to 109, pl. 19.

Griffiths, R. J.

1956. Cypraea in north-west Malaya. Jour. Conch., London, 24 (3): 85-90, pl. 3, 2 textfigs.

Kay, Alison

1961. Anatomical characters which distinguish two species of Cypraea. Proc. Malac. Soc., 34 (4): 199-202, 2 textfigs.

Schilder, Franz Alfred

1928a. Eine wenig bekannte Cypraeiden-Art. Arch. Molluskenkunde 60 (3, 4): 193-195, 1 textfig.

——, ——

1928b. Die Variabilität der Schalenlänge der Cypraeidae (Moll. Gastr.). Zool. Anzeiger 79 (1, 2): 5-21.

——, ——

1929. Beiträge zur Kenntnis der Cypraeacea (Moll., Gastr.): 2. Ein Nachtrag zu Zool. Anzeiger 79, S. 18-21. Zool. Anzeiger 85 (5-8): 132-133.

——, ——

1941. Verwandtschaft und Verbreitung der Cypraeacea. Arch. Molluskenkunde 73 (2, 3): 57-120, 2 pls.

——, ——

1958. Die Bezeichnung der Zahndichte der Cypraeacea. Arch. Molluskenkunde 87 (1-3): 77-80.

——, ——

1961. A statistical study in Cowries: The size of Mauritia arabica (Linnaeus. Veliger 4 (1): 15-17, 2 textfigs.

Turton, W. H.

1932. The marine shells of Port Alfred, S. Africa. xvi + 331, 72 pls. Oxford & London.

Remarks on a Variation in *Cypraea annettae* Dall, 1909

by

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(Plate 24)

From the Gulf of California I have what I consider an unnoticed and hitherto unrecognized dwarf form of Cypraea annettae Dall, 1909. Despite several morphological differences, it seems to be more closely associated with C. annettae than with any of the other known Gulf species of Cypraea. However, C. annettae is typically much larger, more slender and elongate than this form.

Since the locality data on the three specimens in my collection were vague and indefinite — that is, "Gulf of California" — no attempt was made to work on them further, although the question of their identity had intrigued me for several years. Such an uncertain locality reference, without further substantiation such as the collector's name, for instance, had no value whatsoever as far as a study of the species is concerned. Now, however, after having discovered the exact localities for three similar specimens, it seems the existence of this variant is important enough to be mentioned. Last April I came across two nearly identical specimens in the collection of the California Academy of Sciences which were accompanied by reliable collecting data. These shells had been collected by Fred Baker at El Coyote Bay and by Dr. Emmett Rixford at San Marcos Island. Both collecting stations are within 15 miles of Mulege, El Coyote to the south and San Marcos Island about the same distance to the north. These two specimens were very kindly loaned to me by Dr. Hertlein for comparison with the three specimens in my collection. An additional specimen has since been discovered in the collection of Mrs. Faye B. Howard of Santa Barbara, California. Mrs. Howard's specimen was collected at Santa Rosalia, in the same general area as the Academy's specimens.

Explanation of Plate 24

Dorsal and ventral aspects of *Cypraea annettae* and variant.

Figure 1a: variant, ventral aspect. Figure 1b: same, dorsal aspect. Figure 2a: *Cypraea annettae*, ventral aspect. Figure 2b: *Cypraea annettae*, dorsal aspect.

(all figures natural size)

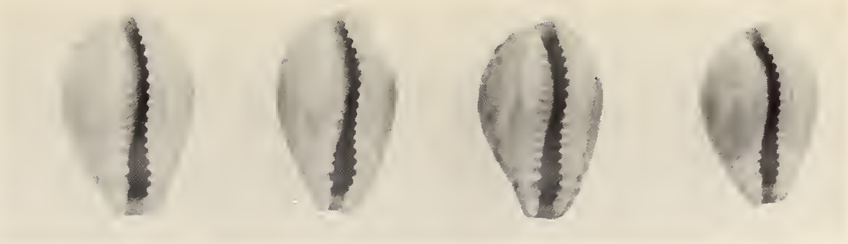


Figure 1 a

Figure 1 b

Figure 2 a

Figure 2 b

Pierson, Oswald, & Pierson, *photo.*

Due to the small number of specimens known, it is impossible to determine the degree of its abundance or the extent of its distribution. Apparently it is restricted to a rather narrow region, the present known range encompassing only 60 miles along the east coast of Baja California, from Santa Rosalia south to El Coyote. It is hoped that the extensive shore collecting and deep-water dredging now being done in the Gulf of California will bring to light additional information about this form.

It is important to note the fact that the typical *Cypraea annettae* is uniform in its appearance; of a great number of specimens examined, not one was seen to deviate more than minutely from the typical form, even in smaller and younger specimens, so that the different appearance of the variant is more than ever noticeable. When mingled with a large group of typical *C. annettae*, the six specimens of the different form stood out from the rest in a striking way.

DIFFERENCES BETWEEN TYPICAL SPECIMENS OF BOTH FORMS

variant	*Cypraea annettae*
small, pyriform	large, elongate, cylindrical
margins sharply angled	generally cylindrical
margins thickened, extending high onto shell	margins more narrowly thickened or not at all
extremities compressed	extremities produced
aperture narrow, acute	aperture nearly straight, more declivous anteriorly
teeth small, fine, less numerous (C = 13, L = 15)	teeth larger, stronger, more numerous (C = 20, L = 21)
color pattern thinly distributed, paler	color pattern more fused, darker
base color fleshy beige	base color darker peach color
interior cream color	interior deep lavender

The extent to which this shell differs from typical *Cypraea annettae* may be evaluated when I mention that I showed it to several competent conchologists, none of whom associated it with *C. annettae*. As a matter of fact, it bears a remarkable resemblance to the West African species *C. gambiensis* Shaw, 1909; even the late Lloyd E. Berry, with his large collection of worldwide *Cypraea*, confused the Gulf of California specimens with this rare species.

The dorsal area of the shell has a mottled appearance, with fulvous and chestnut-brown markings rather unevenly applied. The color and pattern somewhat resemble those of *Cypraea annettae*, and the lateral marginal spots are seen in both forms. However, the color is darker in *C. annettae* in all parts of the shell; also the interior of *C. annettae* is purple, whereas in this form it is cream color.

Morphologically the variant seems quite different from *Cypraea annettae* (Plate 24, figures 2a, 2b); even small specimens of *C. annettae*, of similar size, are narrower and more elongate. Therefore, the relationship between the two forms seems distant enough to make it worthy of further study.

I decided to carry my investigation beyond the obvious visual aspects and computed the average measurements of all the specimens in both groups as well as the obesity index (= width x 100: length) and other ratios (height x 100: length and height x 100: width); the results were:

Table 1: Mean Measurements and Ratios of *Cypraea annettae* and Variant

	Length	Width	Height	Ratios:	Width : Length	Height : Length	Height : Width
Variant:	25.96	16.56	12.80 mm.		63.84	49.48	77.51
Cypraea annettae:	35.26	20.10	16.00 mm.		57.43	45.51	79.29

It was then decided to try a more critical analysis, and a standard deviation study was made. However, with only six specimens to work with as against a series of 32 Cypraea annettae, it was almost a foregone conclusion that the results would give only a very general idea of the deviation.

There are many approaches one may take in quantitative analysis. I chose the so-called 90 percent method, whereby if population "B" can be proved to be composed of 90 percent of the new form based on the measurements and ratio figures, and assuming that the population "A" or Cypraea annettae maintains 100 percent of normal species characteristics, the variant could then be considered a subspecies or even possibly a separate species.

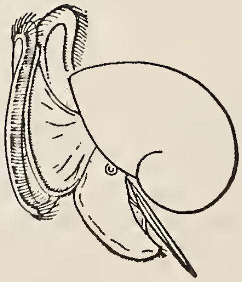
To be brief, despite the imbalance in numbers of specimens of both species used in this study, the over-all picture developed reasonably well. However, even if the desired 90 percent had been the result, many other factors would still have to be considered before the results could be called conclusive. The final answer will have to come from future collections to be made in the vicinity of Concepçion Bay.

I have no plan to propose or even suggest taxonomic recognition for this variant at the present time. This is merely an effort to study it, to analyze its distinguishing characters, to pinpoint its locality, and to encourage collectors to be on the lookout for it in the Gulf of California. To carry the study any further taxonomically at this time would be hasty, merely adding another name to the already crowded nomenclature in Cypraeidae.

There is an urgent need for a far greater number of specimens for consideration so that a reasonably accurate coefficient of deviation can be determined and compared with that of a like number of typical Cypraea annettae. Until this can be accomplished, it should be considered merely a local ecological variant.

I should like to express my appreciation to Dr. Myra Keen, Dr. Leo G. Hertlein, Dr. Caesar R. Boettger, Mrs. John Q. Burch, Mrs. Faye Howard, and Mr. Gale G. Sphon, Jr., for their consideration of the problem, and to Dr. Rudolf Stohler and Dr. Gary Lane for invaluable assistance with the quantitative analyses. And above all, to one other, whose help and encouragement made this paper possible.

The photographs are by Pierson, Oswald and Pierson.



Notes & News

Range Extension of *Anatina cyprinus* (Wood, 1828)

by

Bruce Campbell
Conchological Club of Southern California
Los Angeles 7, California

(3 Textfigures)

Since the Ariel Expedition in the summer of 1960, attention has been called to "one of the rarest of the Panamic province Mactras", Anatina cyprinus (Wood, 1828). It was during the Ariel cruise that Dr. Keen discovered two unmatched opposite valves and the upper halves of two matched valves of this species among the trawled material from Guaymas and from the Loreto channel between Carmen Island and Baja California. Consequently, everyone aboard began searching for "Anatina anatina", as we knew it then, when each load of new material came aboard (see Keen, 1961). At the end of the trip I took four sacks of material home and carefully searched through it. Among the material from the Loreto channel were the upper halves of two unmatched opposite valves.

During the New Year's weekend of 1960-1961, Dr. Donald Shasky, Gale Sphon, and I spent several days dredging at San Luis Gonzaga Bay and at Punta Final, ten miles to the south (Baja California). It was in a small cove at the south end of Willard Island (Lat. 29° 48' N.; Long. 114° 23' W.), which forms part of the entrance to San Luis Gonzaga Bay, that a live specimen of Anatina cyprinus was taken. It was dredged from a mud-hole in 18 fathoms about 150 feet off-shore. This not only extends the range of this species northward 250 miles into the upper portion of the Gulf of California, but establishes bathymetrically one area of its habitat. The southern range extends at least as far as Ecuador (Olsson, 1961, p. 332), and possibly to Peru since in Wood's original description the shell was thought to have come from Peru. Additional data are needed to bear this out.

Literature Cited

Keen, A. Myra
1961. What is Anatina anatina? Veliger 4 (1): 9-12, 5 textfigs.

Olsson, Axel A.
1961. Mollusks of the tropical eastern Pacific, particularly from the southern half of the Panamic Pacific faunal province (Panama to Peru). Part I. Panamic-Pacific pelecypoda. Paleont. Res. Inst., Ithaca, N. Y. pp. 1-574, pls. 1-86.

Figure 1: San Luis Gonzaga Bay, Baja California. The • at the south end of Willard Island indicates the cove where *Anatina cyprinus* (Wood, 1828) was dredged.

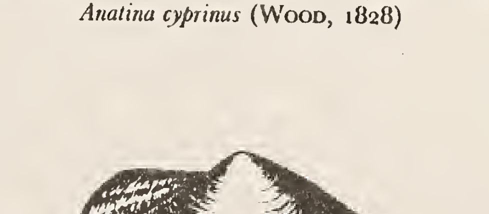


Figure 2: Drawing of the hinge (right valve) of *Anatina cyprinus* (Wood, 1828)

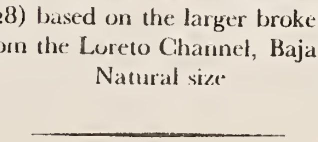


Figure 3: Reconstruction of *Anatina cyprinus* (Wood, 1828) based on the larger broken right valve trawled from the Loreto Channel, Baja California. Natural size

ABOUT COPYRIGHT -

In our review of Dr. Keen's paper "A proposed reclassification of the gastropod family Vermetidae", published in the Bulletin of the British Museum (Natural History), Zoology, volume 7 in February this year, we called attention of our readers to the fact that the journal was copyrighted and that we therefore did not list the new genus name. We also raised some questions in regard to the availability of names published in copyrighted papers, for taxonomic purposes. On August the 7th, we received the following letter, which we here reproduce in toto with the kind permission of Mr. Ferguson.

" My attention has been drawn to your review of Dr. Keen's Vermetidae paper in The Veliger, 1961, 4: 53, and in particular to the point you raise in connection with the Copyright Act, 1956.

"I can assure you that there is no difficulty at all. Section 6 of the Act reads:-

(1) No fair dealing with a ... work for purposes of research or private study shall constitute infringement of the copyright in the work.

(2) No fair dealing with a .... work shall constitute an infringement of the copyright in the work if it is for purposes of criticism or review, whether of that work or of another work, and is accompanied by a sufficient acknowledgement.

"So there would have been no bar whatever to the inclusion of the new generic name, or any other quotes from Dr. Keen's paper in your review (which of course acknowledges the source), likewise there is complete freedom for research workers to use the material contained in the paper in the normal course of research or criticism. There is nothing in the Copyright Act to inhibit taxonomy in any way.

"The position with regard to our publications is therefore no different from that of other scientific publications or journals, in this country at any rate, namely that if someone wants to reprint the entire work, or to reproduce text-figures or plates from it, he should ask permission in the normal way. I think this a fairly universal custom. One of the reasons for indicating the ownership of the copyright is to make clear that permission to reprint the work (or the figures or plates) should be sought from the Trustees of the British Museum rather than from the author, though we do of course always consult the author.

"Yours sincerely
sig. W. A. Ferguson
W.A. Ferguson,
Secretary. "

After receiving the above letter and while awaiting Mr. Ferguson's permission to publish his letter, we made further inquiries about the copyright laws. Among other things we learned that the American Copyright act does not contain the "fair dealing" clauses. Further, publishers insist on the authors securing written permission in every case if their books or papers quote from copyrighted publications.

We are happy, however, as our own policy to accept papers which quote from copyrighted articles published in certain European countries - we will, at some future date, list the specific countries, mentioning now only Great Britain and Switzerland, where the fair-dealing clauses apply - provided that the usual references to the quoted articles are included and provided, of course, that the submitted papers meet our usual standards. We deviate, in this respect, knowingly and intentionally, from the customs adopted by the other American publishers. But because of the strict interpretation by the latter, we will have to insist that authors secure written permission in those cases, where American works are cited, if they are protected by copyright.

The Editor.

Books, Periodicals, Pamphlets

REVISION OF TORNATELLINIDAE AND ACHATINELLIDAE (GASTROPODA, PULMONATA)

by C. Montague Cooke, Jr.,
and Yoshio Kondo

Bull. 221, Bernice P. Bishop Museum,
December 30, 1960. 303 pp., 123 figs.
in text. Price, $6.50.

This splendid contribution to the distribution, morphology, evolution, and systematics of the land snail fauna of the Pacific Ocean Basin is the culmination of earlier work resulting in the publication of Volume 22 of the Manual of Conchology on the Achatinellidae by Pilsbry and Cooke (1912-1914), and of an appendix to the Amastridae and Tornatellinidae in Volume 23 of the Manual by the same authors (1915-1916). The present work represents a complete revision of two large and widespread families, which Pilsbry stated (in 1914) could not be accomplished without a complete knowledge of the anatomy of the soft parts. As a result, a total of 94 new taxons are described, including three subfamilies, 11 tribes, 10 genera, seven subgenera, three sections, 40 species, 18 subspecies, and two forms.

The conchological work for this report was done by Cooke. It is to be regretted that neither of the earlier collaborators on these land snail families could have lived to delight in the masterful manner in which the junior author, Dr. Yoshio Kondo, completed the detailed anatomical part in line with what must have been their basic specifications.

The revision is technical and will be difficult reading for the beginning conchologist, although the excellent pen and ink drawings of the shells will help greatly in identifying species that may be collected on the various islands of the Pacific. On the other hand, the experienced malacologist will find the treatment of each species complete and authoritative both as to the shells and to the animals.

Good keys are included to the higher groupings and to the species in each genus. There are a number of carefully drawn distributional maps of principal species groups. A bibliography and a good index complete the work, these being essential in a reference volume of this scope.

Quite appropriately this Bishop Museum Bulletin is dedicated to the memory of Henry Augustus Pilsbry "who laid the foundation for this work". It is a great credit to the institution that sponsored its publication.

AGS

COLORED ILLUSTRATIONS OF THE SHELLS OF JAPAN
Volume II

by Tadashige Habe

Osaka, Japan: Pp. xii + 148 + 183 (Appendix), 66 col. pls., 1961. Published by Hoikusha Publishing Co., 1-Chome Uehonmachi Higashi-Ku, Osaka, Japan. Price, 1'500 yen (about $5.-).

This is a companion volume to the one by Tetsuaki Kira, done in the same style but with even better quality color plates. About 1'460 species of Japanese and Formosan shells are here figured, which, added to those previously figured by Kira, brings the total to around 2'700. Between the two volumes, therefore, most of the large and many of the small forms of Japanese mollusks are illustrated. A number of new genera, subgenera, and species are proposed, with descriptions (in Japanese) in the Appendix. An English edition is scheduled for publication in September 1961, which will give the book yet wider usefulness. The Japanese edition is handsomely bound, the colorful dust-jacket covered with plastic. Scientific names and captions are in Roman type and thus make the book usable even to the reader who has not mastered Japanese. Dr. Habe is to be congratulated on a fine and worthwhile new shell book.

MK

THE MOLLUSCAN SHELLS
Parts I-IV

Parts I-III published by Science and Photography Club, Tokyo, Japan. 1957-1959; Part IV published by Resources Exploitation Institute, 1960. Available from the editor, Dr. Katura Oyama, Geological Survey of Japan, Kowada-cho 8, Shinjuku-ku, Tokyo, Japan. Approximate price, $5.- per part. [Katura Oyama (Editor) and Yoshio Takemura (Photographer)].

Dr. Oyama, aware of the difficulty of identifying shells from the often poor and inadequate illustrations available — especially the small forms — has set about remedying this for the Japanese molluscan fauna by publishing sets of plates expertly photographed and carefully reproduced as high quality half-tones. Magnifications of minute shells are sufficient to enable one to make rigorous comparisons. Explanations with each 7 x 10 inch plate give name, locality, and magnification. If the work can be carried through to completion, it will constitute an unparalleled iconography of the fauna. A text is promised as a summary. As yet, the plates are issued in random order, a covering list on the jacket of each part giving dates of issue. Approximately 30 plates comprise each part. To show the scope of the work, here is a sample list of genera, taken from the beginning of Part II: Siliquaria, Cerithidea, Cerithium (2 plates), Mammilla, Sinum, Lambis (2 plates), Apollon (2 plates), Fusitriton, Charonia, etc. As the plates are otherwise unnumbered, the user is left to decide whether to arrange them alphabetically for ease of finding (thus losing the order of issuance, which is probably not important), or to number them arbitrarily and make up a reference set of filing cards. The promised textual material probably will solve this quandary. One may hope that the authors are given sufficient encouragement so that they can continue this valuable series, the parts of which now are appearing one per year.

MK

PROCEEDINGS OF THE MALACOLOGICAL SOCIETY OF LONDON

Vol. 34, Part 4, April 1961.

"A zoogeographical analysis of species of Cypraea in the Hawaiian Islands", A. Kay.

"Anatomical characters which distinguish two species of Cypraea", A. Kay.

"Sexual dimorphism in Cypraeidae", R. J. Griffiths.

"Sexual differences in cowries", F. A. and M. Schilder.

"A late Tertiary bivalve gastropod from South Australia", N. H. Ludbrook.

MK

VENUS: The Japanese Journal of Malacology

Vol. 21, No. 2, January 1961.

"Diagnoses of new Japanese Naticidae", T. Kuroda.

"On the Japanese species of the genera Microglyphis and Ringiculospongia", T. Kuroda.

"On a new species of Scintilla (Galeommatidae) from Japan", T. Kuroda and I. Taki.

"A note on the animal of Scintilla violescens collected in Genkae Sea", Y. Arakawa.

"Notes on two buccinid species described by Dr. W. H. Dall", T. Habe.

"Four new bivalves from Japan", T. Habe.

"On some new facts of the taxonomy of Terebridae", K. Oyama.

"Descriptions of five species of Japanese marine Gastropoda", M. Azuma.

"Studies on the radulae of Japanese Naticidae (1)", M. Azuma.

"Boring behaviour and mechanism of a moon shell, Tectonatica janthostomoides", S. Hamada.

MK

SIMILARITY IN THE TURRITELLID PHYLOGENY IN THE LATE CENOZOIC

by Tamio Kotaka

Science Reports, Tohoku University,
ser. 2 (Geol.), spec. Vol. 4, pp. 301-308, text fig. 1-4, 1960.

The appearance and strengthening of secondary spiral sculpture at progressively earlier growth stages has been shown by the author to characterize a chronologic sequence of Turritella species leading to the living Japanese T. (Neohaustator) andenensis Otuka (The Cenozoic Turritellidae of Japan: Science Reports, Tohoku University, ser. 2, vol. 31, no. 2, pp. 1-135, pl. 1-15, text fig. 1-10, A-B). In this new work, Kotaka outlines analogous trends in late Cenozoic species from areas outside of Japan. Zeacolpus (Stiracolpus) delli Marwick, Turritella cooperi Carpenter, and Turritella (Haustator) communis Risso are living representatives of sequences from New Zealand, western North America, and western Europe, respectively.

ECA

SEARCHERS OF THE SEA: PIONEERS IN OCEANOGRAPHY

by Charles Michael Daugherty

Viking Press, New York. 1961. 160 pp.
Illustrated by Don Miller. $3.00.

This concise, well written account of the development of oceanography should interest many young readers of about junior high age and perhaps older. Many of the great events and names in the history of learning about the sea are here, including Cook, B. Franklin, Maury, Forbes, Nansen, Albert Grimaldi, Alexander Agassiz, and such moderns as Iselin and Piccard. More might have been said, perhaps, of the sort of education it takes to be a modern oceanographer, for such books as this stimulate interest and may influence careers. Such facts as are presented are reasonably accurate, although some names are misspelled and a portrait labelled Alexander Agassiz is actually his father Louis. There is a brief reading list and an index.

JWH

JOURNAL DE CONCHYLIOLOGIE

Vol. 100, No. 4, for October 1960 (issued March 1961).

"Les mollusques décrits par de Folin à part les Caecidae et Chemnitzidae, avec catalogue", B. S. Kisch.

MK

THE VELIGER is open to original papers pertaining to any problem concerned with mollusks from the Pacific Region.

This is meant to make facilities available for publication of articles from a wide field of endeavor. Papers dealing with ecological, morphological, anatomical, physiological, distributional, taxonomic, etc. aspects of marine, fresh water or terrestial mollusks from any region bordering on or situated within the Pacific Ocean, will be considered. Even topics only indirectly concerned with mollusks may be acceptable.

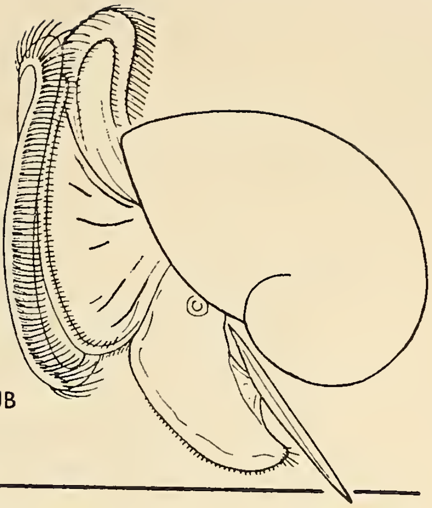
It is the editorial policy to preserve the individualistic writing style of the author; therefore any editorial changes in a manuscript will be submitted to the author for his approval, before going to press.

Short articles containing descriptions of new species or lesser taxa will be given preferential treatment in the speed of publication provided that arrangements have been made by the author for depositing the holotype with a recognized public Museum. Museum numbers of the type specimens must be included in the manuscript. Type localities must be defined as accurately as possible, with geographical longitudes and latitudes added.

Short original papers, not exceeding 500 words, will be published in the column "NOTES & NEWS"; in this column will also appear notices of meetings of the American Malacological Union, as well as news items which are deemed of interest to our subscribers in general. Articles on "METHODS & TECHNIQUES" will be considered for publication in another column, provided that the information is complete and techniques and methods are capable of duplication by anyone carefully following the description given. Such articles should be mainly original and deal with collecting, preparing, maintaining, studying, photographing, etc., of mollusks or other invertebrates. A third column, entitled "INFORMATION DESK," will contain articles dealing with any problem pertaining to collecting, identifying, etc., in short, problems encountered by our readers. In contrast to other contributions, articles in this column do not necessarily contain new and original materials. Questions to the editor, which can be answered in this column, are invited. The column "BOOKS, PERIODICALS, PAMPHLETS" will attempt to bring reviews of new publications to the attention of our readers. Also, new timely articles may be listed by title only, if this is deemed expedient.

Manuscripts should be typed in final form on a high grade white paper , 8½″ by 11″, double spaced and accompanied by a carbon copy.

THE VELIGER



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[Continued on Inside Front Cover]

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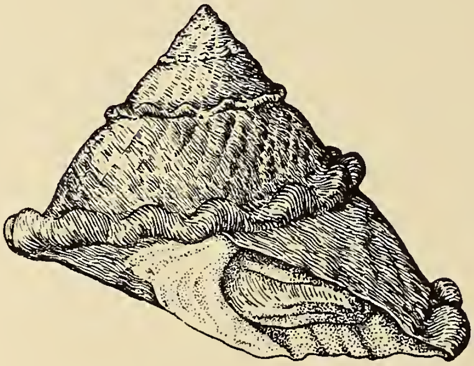

Note: The various taxa above species are indicated by the use of different type styles as shown by the following examples:

ORDER, Suborder, **DIVISION, Subdivision,** SECTION,
Superfamily, Family, Subfamily, *Genus*, (*Subgenus*).

Ciliary Currents in the Mantle Cavity of Species of *Acmaea*

by

C. M. Yonge

University of Glasgow

(From the Hopkins Marine Station, Pacific Grove, California)

(2 Textfigures)

Introduction

In all aquatic Mollusca with a mantle cavity housing ciliated respiratory organs, either primitive ctenidia or secondary pallial outgrowths, there is a paramount problem of cleansing. Sediment is inevitably drawn into the mantle cavity in the respiratory current created by the cilia. Only in the dibranchiate Mollusca where this current is created by muscular means does this problem not exist. Accumulation and eventual rejection of such sediment is essential if the all-important respiratory chamber is not to be fouled.

As described in some detail elsewhere (Yonge, 1938, 1947), the prosobranch Gastropoda possess a series of mechanisms for dealing with this problem, namely osphradia for the detection of sediment, hypobranchial glands producing copious mucus for its aggregation and suitable ciliary currents on both gills and mantle surface for its collection and ultimate rejection. These currents are divisible into three groups: A, those concerned with removal of the heavier particles which almost immediately fall on to the floor of the mantle cavity, i. e., short of the ctenidia, and are carried by these currents for rejection by way of the inhalant opening; B, those concerned with medium sized particles which settle further within the cavity and which carry them to the exhalant opening on the right; C, the frontal and abfrontal cilia on the ctenidial filaments together with cilia on the surface of the hypobranchial glands which collect the finest particles on the roof of the mantle cavity. Consolidated in mucus from the gland, this material also is then rejected by way of the exhalent opening (Yonge, 1938). In various Mesogastropoda, e. g., some Vermetiidae, the Trichotrophiidae, the Calyptraeidae, and the Capulidae, some or even all of these currents are used for the collection of food particles (with suitable enlargement of the pectinibranch ctenidium), and this has become the major function of the primitively cleansing frontal cilia on the hypertrophied ctenidia of the Bivalvia.

In the major group of limpets, the archaeogastropod Patellacea, the problem is complicated by the change in form of the shell and body with its effects on that of the mantle cavity. This now consists of a restricted nuchal cavity above and behind the head together with pallial grooves which encircle the rounded foot. The difficulties represented by housing the solitary (left) ctenidium in the restricted nuchal cavity and by cleansing the pallial grooves are met in different ways in the three families of the Patellacea. In the Acmaeidae the ctenidium is retained. It extends across the nuchal cavity and beyond, being also twisted to the right so that the efferent surface faces to the left, i. e., towards the incoming current. In the genus Lottia (Fisher, 1904) there is an additional development of pallial gills consisting of ciliated flaps fringing the inner margin of the external pallial blood vessel which runs around the pallial grooves.

The ctenidium is lost in the Patellidae, respiration taking place by way of pallial gills. These are interrupted anteriorly in Patina (as there are in Lottia) but are continuous in Patella and related genera. Finally in the Lepetidae, which are sublittoral in contrast to the characteristically intertidal Acmaeidae and Patellidae, there are neither ctenidia nor pallial gills.

The course of the respiratory and cleansing currents has been described in Acmaea (Patelloida) tessulata and A. (P.) virginea (Yonge, 1947), Lottia gigantea (Abbott, 1956), Patina pellucida and Patella vulgaris (Yonge, 1947), and Lepeta concentrica (Yonge, 1960). In the two species of Acmaea (textfig. 1A) the inhalant current enters on the left, passes between the filaments of the ctenidium and, together with sediment collected by the cleansing currents and the faeces and renal products, leaves in the mid-line posteriorly. In Lottia (textfig. 1F) the exhalant current with sediment, faeces and excrement from the nuchal cavity leaves on the right of the head. Apart from slight inflowing currents between the pallial gills, there are no currents in the pallial grooves and cleansing appears to be carried out by water movements, rendered the more effective by the habitat (mid-tidal rocks) and the posture (usually head downward on steeply sloping or vertical surfaces) of this limpet (Abbott, 1956).

In Patina there are similar inflowing currents between the gills but both exhalant and ciliary currents in both pallial grooves and nuchal cavity lead to a common exit on the right side of the nuchal cavity; this despite the fact that there is no ctenidium. In Patella there are generalized inhalant and exhalant currents all around the mantle margin but within the pallial grooves and nuchal cavity all sediment and other waste is conveyed round to the middle of the right side where it accumulates for periodic

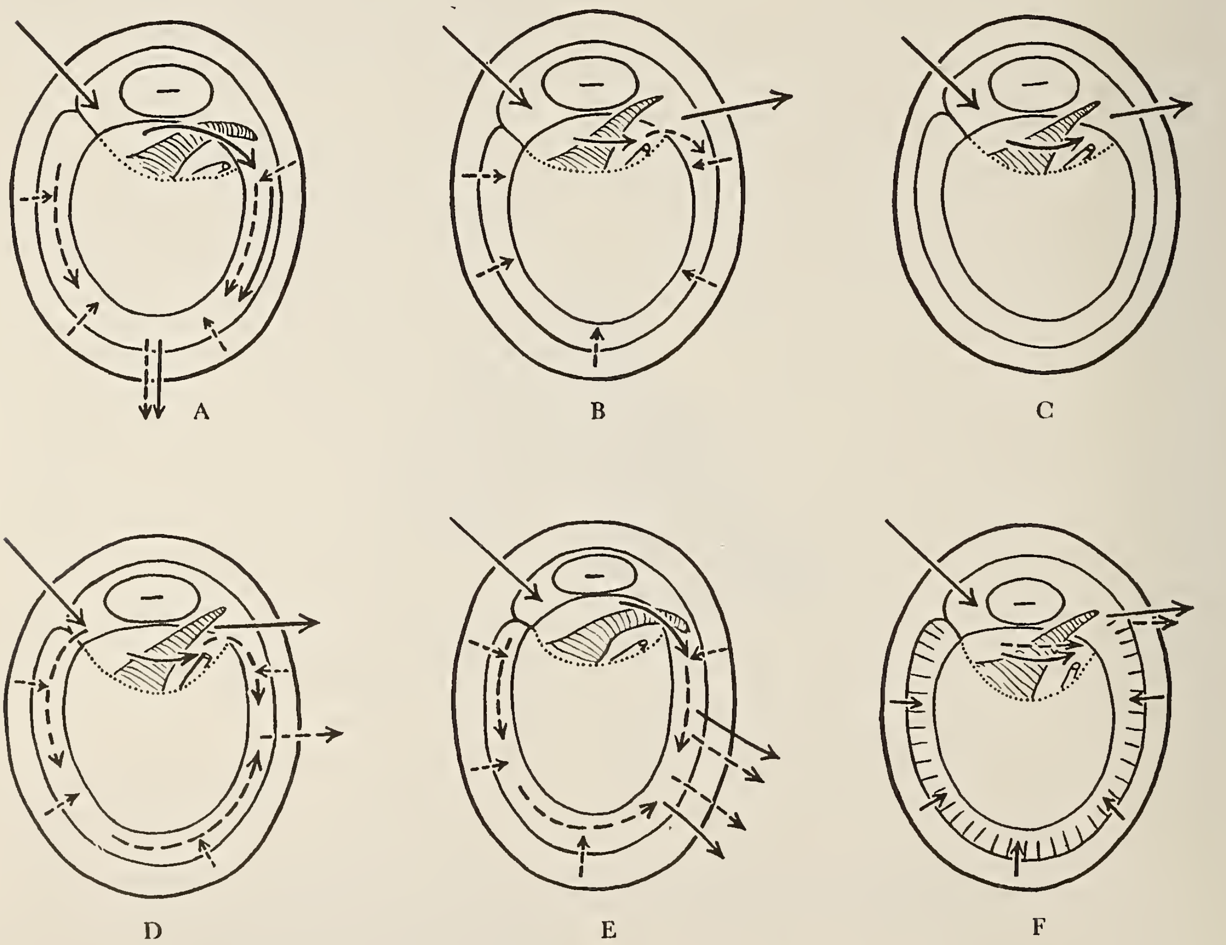

Figure 1: Diagrammatic dorsal views of species of the Acmaeidae showing nuchal cavity (containing ctenidium directed to the right and anus) and pallial grooves (containing pallial gills in F) with direction of respiratory and cleansing currents indicated by solid and broken arrows respectively.

A: *Acmaea tessulata* and *A. virginea*; B: *A. digitalis*, *A. mitra*, *A. scabra*, *A. scutum* and *A. instabilis*; C: *A. pelta*; D: *A. asmi*, *A. insessa*, *A. triangularis* and *A. paradigitalis*; E: *A. ochracea*; F: *Lottia gigantea* (After Abbott) expulsion following sudden muscular contractions (Yonge, 1947). Finally in Lepeta conditions, apart from the absence of a ctenidium, resemble those in Acmaea tessulata and A. virginea with ciliary currents moving water with sediment and excrement to the mid-point posteriorly. Respiration must here be through the mantle wall into the pallial blood vessel, the advantages of organs of respiration being presumably more than offset by the greater amount of sediment carried in by the greater ciliary current. These sublittoral limpets live on stones embedded in mud (Yonge, 1960).

CURRENTS IN NORTH PACIFIC SPECIES OF ACMAEA

The remarkable wealth and unusual degree of specialization of species of Acmaea on north American Pacific coasts prompted examination, during January to March, 1960, of conditions in 13 available species. Information about their ecology is given by Test (1945). In no case were the cleansing currents found to be the same as in the European A. tessulata and A. virginea (textfig. 1A), both of which live in relatively quiet water where there is some settlement of mud particles. The range of conditions found is shown in textfigs. 1B through 1E and 2. In all, as must be so where there is a ctenidium, the respiratory current enters on the left of the nuchal cavity and in the majority of cases it leaves on the right carrying with it sediment, faeces and excrement.

In the commonest condition, found in Acmaea digitalis, A. mitra, A. scabra, A. scutum and A. instabilis (textfig. 1B) there are currents up the pallial walls but not along the groove or on the sides of the foot. There is a slight current into the pallial groove on the right side of the nuchal cavity. In A. limatula the only, very minor, difference is the presence of a similar current on the left side. Currents in young individuals of this species are rather different as noted below. In A. pelta (textfig. 1C) there is an apparent complete absence of cilia in the pallial grooves.

All but one of these species, although each occupies a characteristic zone, live intertidally under conditions where, like Lottia, they are fully exposed to wave action. The exception is Acmaea instabilis, with a rocker-like shell fitting it for life only on such a substratum, which lives invariably on the stipes of the massive brown weed, Laminaria Andersoni, which grows in very agitated water. In all, therefore, cleansing can be effectively carried out by water movements.

In Acmaea asmi, A. insessa, A. triangularis and A. paradigitalis the respiratory current is the same but all have well developed cleansing currents in the pallial grooves (textfig. 1D). Sediment and other waste is carried to the middle of the right side and there moves down the pedal wall. The mucus-laden mass is then presumably expelled by occasional, probably quite gentle, muscular contractions. The same arrangements for cleansing were observed in young (up to 8 mm. long) A. limatula. Conditions, to be described later, in A. palaeacea represent a modification of this arrangement (textfig. 2).

The habitat of these four species is significant. Acmaea asmi lives always on the shells of Tegula funebralis and so normally in the shelter of pools or crevices inhabited by these topshells. Acmaea triangularis is a very small limpet which feeds exclusively on the coralline alga Amphiroa tuberculosa which sometimes grows on the bottom of pools and occasionally on the shells of Tegula brunnea. Acmaea paradigitalis occurs on rocks at high mid-tidal levels and usually on horizontal surfaces. It occurs with A. digitalis with which it was formerly confused but is distinguished from that species by the characters listed by Fritchman (1960) but also by the nature of the ciliation in the pallial grooves and in the size of the ctenidium. That of A. digitalis is the larger and the more active and may probably, as in other species, assist by its movements the process of cleansing. Acmaea insessa lives always on the large "boa weed" Egregia Menziesii which grows about low tide level and in considerably more sheltered conditions than does Laminaria Andersoni. All of these species therefore live under conditions where water movements can be of little help in cleansing; this applies to A. paradigitalis because of the horizontal posture and the small size of the ctenidium in comparison with A. digitalis.

Conditions in Acmaea ochracea (textfig. 1E) alone come close to those in A. tessulata and A. virginea. This small limpet lives below tidal levels and apparently on sheltered rock surfaces. Ciliary currents in the pallial grooves accumulate sediment on the right side but near to the posterior end. The very active ctenidium extends for some distance into the right pallial groove so that the exhalant current is directed along this and emerges along the right side where it actively assists cleansing. The generalized region of sediment extrusion is for this reason carried posteriorly although not to quite the full and concentrated extent displayed in the two European species (textfig. 1A) which inhabit quieter and more sediment-laden water.

ACMAEA PALEACEA

Particular attention was paid to this small species which is certainly the most highly modified acmaeid limpet. It is highly specialized for life on the thin strap-like leaves of the eel grass Phyllospadix Torreyi to the shape of which the narrow shell conforms. As shown in textfigure 2, this is relatively high with parallel sides and is transversely slightly saddle-shaped, so making perfect contact with the surface of the leaf which, in cross section, is a flattened oval. A full-grown limpet, some 7.5 mm. long, 2.1 mm. high and 1.8 mm. broad (textfig. 2), is usually almost precisely the same width as the leaf it lives upon. Occasionally the shell bulges out a little above the margins as though the limpet had moved from a broader to a narrower leaf. But no animal was observed to move. They eat their way into the substance of the relatively stout leaf, and probably only move very slightly forward after the radula has reached the limit of its penetration.

Acmaea paleacea is more strikingly adapted to its host plant than are either A. instabilis (on Laminaria Andersoni) or A. insessa (on Egregia Menziesii). A study of the life histories of all of these limpets, involving an understanding of the manner in which the pelagic larva finds its way on to the adult environment, would be of great interest. Moreover, the life history of these limpets (presumably annuals) must be largely conditioned by that of the plant.

A unique feature of the shell of Acmaea paleacea is the presence on the right side of the nuchal cavity of a knotch giving passage to the exhalant and waste current (textfig. 2A). Both nuchal cavity and pallial grooves are relatively deep and ciliary currents in them are unusually rapid. The course of the cleansing currents in the pallial grooves is somewhat different from that in any other species observed. As shown in textfigure 2C, the cilia in the anterior two-thirds of each pallial groove beat towards the nuchal cavity from which sediment is then removed. But ciliary currents around the posterior end carry particles to the right side for at least temporary accumulation.

The presence of the knotch in the shell will enable this species to circulate water for respiration and to remove faeces and excrement from the nuchal cavity without appreciably raising the shell from the substrate to which it must always tightly adhere. Loss of contact would be fatal. Sediment from the greater part of the pallial grooves will also leave by this route while the accumulation on the right side may also be moved there for expulsion after it reaches a certain size. This cannot be observed in situ; all that is clear when the animals are examined ventral side upwards is the accumulation and, under those conditions, disposal of sediment on the right side. This division of the cleansing currents into two series appears to be a consequence of the lengthening of the shell due to adaptation of this limpet to its unique habitat.

Summary

The respiratory and cleansing currents in the nuchal cavity and pallial grooves have been examined in 13 species of Acmaea. Acmaea digitalis, A. mitra, A. scabra, A. scutum, A. instabilis, A. limatula and A. pelta, all of which live in considerable exposure, rely on water movements for cleansing, just as does

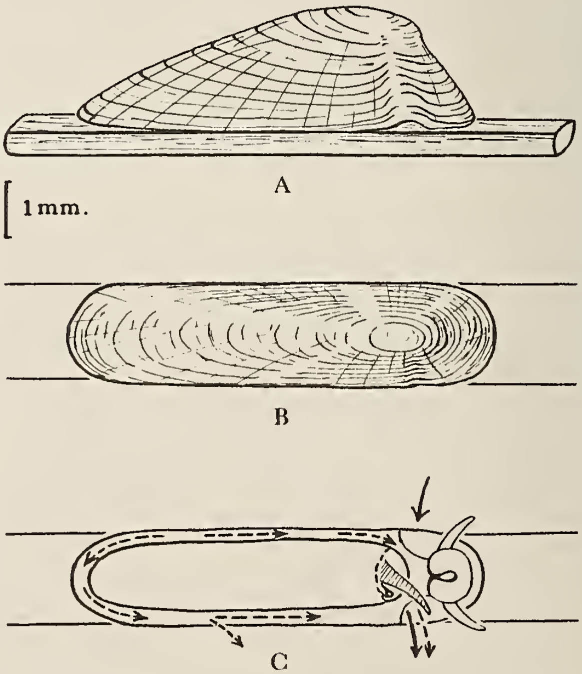

Figure 2: *Acmaea paleacea.* A: attached to leaf of *Phyllospadix Torreyi*, lateral view showing knotch on right side of shell; B: viewed from above; C: viewed as transparent object from above showing direction of respiratory and cleansing currents indicated by solid and broken arrows respectively.

Lottia gigantea (Abbott, 1956). In A. asmi, A. insessa, A. triangularis and A. paradigitalis where there is less exposure owing to habitat or posture, ciliary currents in the pallial grooves assist in cleansing. In A. ochracea which lives below tidal levels in relatively still water, cleansing is further assisted by the exhalant current which is directed by the ctenidium along the right pallial groove. This condition comes nearest to that in the European A. tessulata and A. virginea which live in water with considerable mud content and where both exhalant and cleansing currents leave in the mid-line posteriorly. In A. paleacea, which is highly modified in connexion with life on the leaves of Phyllospadix, the exhalant current with the greater part of the cleansing currents leaves by way of a knotch in the shell on the right of the nuchal cavity.

Acknowledgment

These observations were carried out at the Hopkins Marine Station, Pacific Grove, California and the author is happy to acknowledge the kindness and help of the Director, Dr. L. R. Blinks and of Dr. D. P. Abbott; he is also endebted to Mr. James A. McLean for the specimens of Acmaea triangularis and A. ochracea which he obtained by diving. The visit was assisted financially by the Carnegie Trust for the Universities of Scotland, and the author also held a Fulbright Travel Grant. The illustrations have been prepared by Miss J. I. Campbell whose services as research assistant have been made possible by a grant from the Department of Scientific and Industrial Research.

Literature Cited

Abbott, Donald P.
1956. Water circulation in tne mantle cavity of the owl limpet Lottia gigantea Gray. Nautilus 69: 79 to 87.
Fisher, W. K.
1904. The anatomy of Lottia gigantea Gray. Zool. Jahrb. Anat., 20: 1-66.
Fritchman, Harry K.
1960. Acmaea paradigitalis sp. nov. (Acmaeidae, Gastropoda). Veliger 2 (3): 53-57.
Test, Avery R. (Grant)
1945. Ecology of California Acmaea. Ecology 26: 395 to 405.
Yonge, C. M.
1938. Evolution of ciliary feeding in the Prosobranchia, with an account of feeding in Capulus ungaricus. J. Mar. Biol. Ass. U. K. 22: 453-468.
——, ——
1947. The pallial organs in the aspidobranch Gastropoda and tneir evolution throughout the Mollusca. Phil. Trans. Roy. Soc., B, 232: 443-518.
——, ——
1960. Mantle cavity, habits, and habitat in the blind limpet, Lepeta concentrica Middendorff. Proc. Calif. Acad. Sci., 31: 103-110.

Limestone Boring by the Mytilid *Lithophaga*

by

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(Plates 25, 26, 27; 3 Textfigures)

Lithophaga (synonym: Lithodomus), one of the rock-boring members of the family Mytilidae, occurs throughout the world in tropic and temperate seas. The genus was erected by Röding in 1789 and is characterized by its boring habits. It is found in stone, chalk, coral, and Spondylus shells, according to Reeve (1858). I have noted it in lime-cemented sandstone, calcareous shale, and Chama shells. Sayre (1931), Hanley (1844), Ihering (1900), and other authors have specifically mentioned calcareous material as a substrate for Lithophaga, while Berry (1907), Amemiya (1933), and Haas (1942) have reported finding Lithophaga plumula in non-calcareous material.

Carazzi (1903), List (1902), Kühnelt (1930), Otter (1937), and Yonge (1955) have all recognized the possibility that Lithophaga may bore into limestone substrates with the aid of an acid secretion from the mantle tissue or at least by some chemical means. Of the investigators that have reported Lithophaga in noncalcareous material, Haas (1942) is the only author specifically to contradict the acid-boring theories. He does not offer an explanation for boring, but does state categorically that it cannot be chemical and it therefore must be mechanical. A summary of the findings of the above-mentioned authors appears in the next section.

It has been the purpose of this study to determine whether Lithophaga plumula bores into rock by a chemical or a mechanical process. The conclusion of this work is that L. plumula kelseyi does bore by a chemical action on the rock substrate, but it is beyond the scope of this paper to analyze the chemical mechanisms involved.

HISTORICAL THEORIES OF BORING BY LITHOPHAGA

Carazzi (1903) was the first worker to publish a theory of boring by Lithophaga. He described three glands in the mussel which he claimed were acid-secreting: a gland in the visceral mass of the animal which he called "protacid gland", and two "deutacid glands". One of these "deutacid" glands is anterior to the hinge, just dorsal to the anterior adductor muscle, and is called the "anterior acid gland". The other gland is called the "posterior acid gland" and is immediately posterior to the hinge in the extreme dorsal position adjacent to the internal surface of the shell valves.

List (1902) has also suggested that these mussels bore by acid secretions from the area of the fused inner mantle lobes. He described two types of gland cells: basophils with hyaline content and granulated acidophils.

Pelseneer (1911) redescribed the same glands that Carazzi and List had seen and emphasized that these glands occur in the Mytilidae. Pelseneer also described a second pallial gland in Lithophaga gracilis which, he said, is absent in other species of Lithophaga. Pelseneer claimed that this unpaired gland may have something to do with boring and, in fact, called it an "acid" gland. Yonge (1955) dismissed its connection with boring by saying that this gland secreted into the mantle cavity and so the acid, if there were such, would never come in contact with the rock substrate. Yonge (1955) did not find this gland in the Californian L. plumula.

In a long and general discussion Kühnelt (1930) reviewed the history of the theories of boring by the pelecypods and brought it up to date with his own observations. Kühnelt recognized two mechanisms by which pelecypods bore into their substrates: mechanical and chemical. Most of the paper dealt with chemical borings as exemplified by Lithophaga. Kühnelt's experimental work showed that Lithophaga does bore chemically. He put a piece of Sepia shell in a tube and allowed one of his specimens to press its anterior mantle up against the shell. There were marks of erosion in a few days, although Kühnelt had not seen any movement by the mussel. He was also able to detect actual boring of from two to three millimeters in pre-bored Sepia shells in a period of 14 days. Kühnelt put some Lithophaga in paraffin-lined glass test tubes but was unable to detect any free acid in these tubes over a period of eight days. He also attempted to repeat Carazzi's experiments in which the latter had shown that the so-called "acid gland" tissue turned blue litmus paper red. Kühnelt found that this reaction was not limited to the so-called "glandular" tissue. The mantle, gill, and foot also turned blue litmus paper red. Kühnelt further stated that all experiments to prove the existence of acid in the glands were negative, although he did not describe his experiments. He was convinced that the boring is effected chemically and that the agent which causes the solution does not come from any specific source in the animal.

Otter (1937) studied several species of Lithophaga at Low Isles on the Great Barrier Reef. He included Lithophaga and probably Modiolus as chemical borers among the Mollusca in a general article on rock-destroying organisms. He felt that the rock is dissolved away by an acid but stated that no acid had been identified. He suggested hydrochloric acid as the most likely but also considered an organic acid or mixture of acids. Otter cited Duerden (1902) as saying that most boring algae utilize carbonic acid from respiration and Carazzi (1892) as saying that carbonic acid is also used by Lithophaga for boring. Otter objected to the idea that free acid is secreted into the burrow because if it were, the calcareous deposits on the shell and burrow would be dissolved. He wrote (l. c., p. 336), "It appears that the acid secretion is only applied directly to those surfaces of the burrow in contact with the free edges of the siphons and mantle when these are protruded, the acid secretion being immediately neutralized by the rock before it can come into contact with the shell or any other region of the burrow."

Yonge (1955) made observations on Lithophaga plumula (Hanley, 1844) at Pacific Grove, California. He actually saw a specimen of Lithophaga extrude its anterior mantle tissue and place it in intimate contact with the rock at the head of a broken burrow. Yonge was unable to detect any free acid on the surface of the fused inner lobes of the mantle. He did confirm the glandular areas, both anterior and posterior, that were described by Carazzi, List, and Pelseneer. Yonge postulated an acid mucous secretion from these glands. The anterior gland would do the original softening and the posterior gland would widen the burrow as the animal grows in size. Yonge saw cilia on the protruded anterior mantle tissue and suggested that these cilia carry the dissolved rock and mucus ventrally and then posteriorly into the mantle cavity. This dissolved material then passes posteriorly and out the dorsal surface of the inhalant siphon, which is the usual tract for the removal of pseudofeces.

Three authors, Berry (1907), Amemiya (1933), and Haas (1942), have reported finding Lithophaga plumula in non-calcareous substrates. Berry claims to have found L. plumula in hard blue clay dredged from 12 fathoms in Monterey Bay. The Lithophaga were found with other pelecypods which are known to bore mechanically, such as Botula, Parapholas californica (Conrad, 1837), and three species of Pholadidae. Amemiya (1933) reported finding Lithophaga in tuffaceous mudstone. He did not test the mudstone for calcium carbonate content. Haas (1942) collected L. plumula in lime-cemented sandstone and in non-calcareous argillaceous shale, both at La Jolla and at Pacific Grove, California. The first two authors mentioned did not comment on the methods of boring. Haas (1942) offered no theories on chemical or mechanical boring except to state that the boring could not be chemical. The reason he gave for this statement was that he had found Lithophaga in non-calcareous shale along with Irus lamellifer (Conrad, 1837), Botula californiensis Philippi, 1847, and some pholads. If this be true, it would suggest that Lithophaga can bore mechanically.

MATERIALS AND METHODS

Field and laboratory studies were made at the Kerckhoff Marine Laboratory, Corona Del Mar, California. Further laboratory experiments were conducted at the University of California, Berkeley, California. The specimens used for these studies were collected at Carpenteria, California, and at Corona Del Mar. The specimens were identified by Dr. L. G. Hertlein of the California Academy of Sciences as Lithophaga plumula kelseyi Hertlein and Strong, 1946. This subspecies is found from San Diego, California, to Duxbury Reef, immediately north of San Francisco Bay and is shown in Plate 25, figures 1, 2, 3, and 4.

Two separate experiments were set up for the observation of Lithophaga in the laboratory in both artificial and natural burrows. In the first experiment, which will be identified as Experiment No. 1, ten of the mussels were left on the bottom of a five-gallon tank of aerated sea water. No burrows were provided. Three others were put into Pyrex test tubes of approximately the same diameter as the original burrows, and five were put into holes bored in limestone rock with a tungsten-carbide drill bit. The shape of the bottom of the holes in the limestone is shown by the dotted line across the bottom of the hole in textfigure 1. The purpose of this experiment was to observe the animals and to determine if they could live for a protracted period in the laboratory.

The second experiment (No. 2) was a controlled experiment in which freshly collected specimens of Lithophaga plumula kelseyi were placed in holes bored in the same limestone as that used in Experiment No. 1, and in a non-calcareous mudstone. The limestone had a

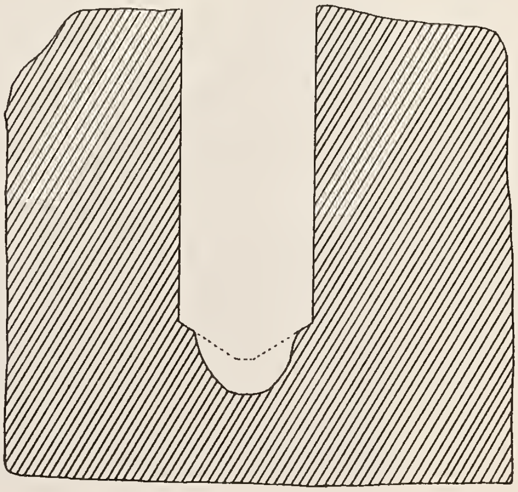

Figure 1: Cross section of a typical artificial burrow in limestone and mudstone showing extent of boring activity by *Lithophaga*

hardness equal to fluorite (number 4 on the hardness scale). The mudstone had a hardness of 3, equivalent to calcite. The mudstone was obtained from Duxbury Reef, Bolinas, California, and is a rock in which numerous mechanically boring mollusks such as Botula, Platyodon, and Pholadidea are found. Lithophaga were placed in the holes in the two pieces of rock, and the rocks were put into a five-gallon aquarium filled with sea water which was kept aerated at all times. Experiment No. 1 lasted one year, followed by Experiment No. 2 which was continued for six months.

The purpose of Experiment No. 2 was to compare the boring abilities of Lithophaga in a rock which can be attacked and dissolved by chemical action, namely, calcium carbonate or limestone; and in a rock that cannot be affected by an acid or by chemical activity, viz., non-calcareous mudstone. Additional observations were made on the rotation of the animals in the mudstone and limestone burrows.

Miscellaneous observations were made on animals from both of the above-mentioned experiments in regard to deposits on the burrow walls. The anterior end of one of the natural burrows was broken off, and the activities of the anterior mantle tissue of the enclosed specimen was observed.

OBSERVATIONS AND RESULTS

Lithophaga Burrows in Nature

In nature Lithophaga burrows are found in carbonate-cemented sandstone and calcareous shale. The inside of the burrow is a little longer than the animal, which allows it to move back and forth by the action of the byssal retractor muscles. When the animal is in its extreme posterior position, the ends of the "plume" are level with the plane of the entrance of the burrow (textfig. 2). The aperture is small and is usually found with a mass of white limy material surrounding it and extending it above the rock surface for a distance of about two millimeters. This white material fizzed and produced CO_2 gas when it was treated with dilute hydrochloric acid. The cation was not determined but was presumed to be calcium.

The sandstone burrows were variably lined with a white substance which also proved to be a carbonate and was thus assumed to be calcium carbonate. In all cases the posterior third was lined and in some cases observed the entire burrow was lined, as in Plate 25, figure 5.

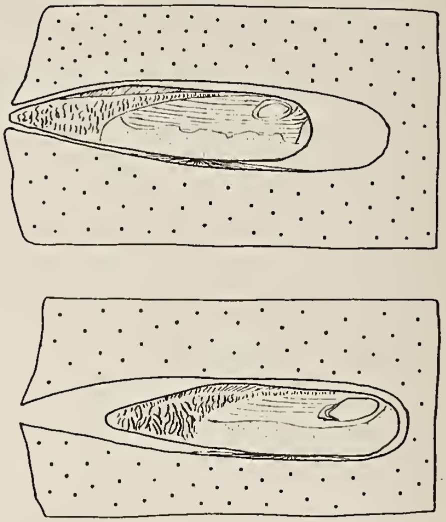

Figure 2: *Lithophaga* in its most posterior position (top) and most anterior position (bottom) in its natural rock burrow.

Experimental Results

The main purpose of Experiment No. 1 was to determine the length of time Lithophaga could live under laboratory conditions in a five-gallon tank of sea water both inside and outside the confining burrows. The specimens in the artificially bored limestone burrows, in the test tubes, and on the bottom of the tank all lived through a period of one year. No attempt was made to feed the animals, and the water was not changed. It was noted, however, that there was a fairly uniform algal growth on the rocks and on the walls of the tank, indicating that free-

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Explanation of Plate 25

Figures 1 to 4: *Lithophaga plumula kelseyi.*

Figure 1: Ventral view. Figure 2: Dorsal view. Figure 3: Lateral view. Figure 4: Lateral view.

Figure 5: A longitudinal section of a *Lithophaga* burrow in lime-cemented sandstone showing complete calcareous lining.

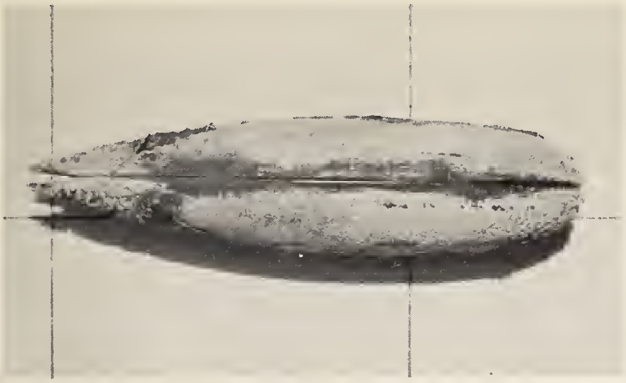

Figure 1

Figure 2

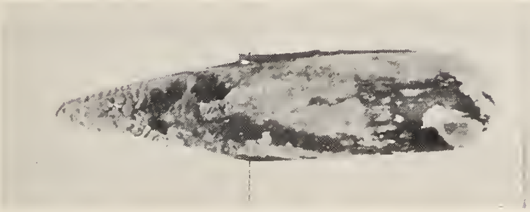

Figure 3

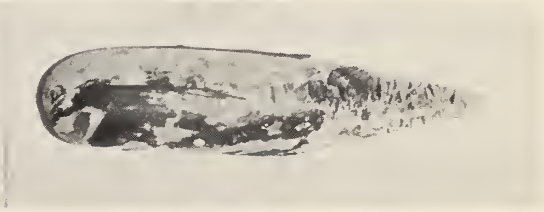

Figure 4

Figure 5

Hodgkin, *photo.*

Bottom of the burrow of Textfigure 3. The dark area in the center is the erosion caused by the specimen of *Lithophaga* that was unable to rotate. Notice the symmetry across the dorso-ventral axis.

Hodgkin, *photo.*

swimming algal gametes were probably available for food.

The three groups of Lithophaga all deposited a material assumed to be calcium carbonate. The specimens on the bottom of the tank placed their deposits flat on the glass bottom adjacent to their ventral surface where they had attached themselves by their byssal threads.

The observation that led directly to Experiment No. 2 was that the specimens of Lithophaga left in the limestone holes all continued to bore into the rock. After the animals were removed, symmetrical, concave depressions were seen at the bottom of the holes as shown in textfigure 1. The volume of material removed by the two largest Lithophaga (about 6 cm. in length) was measured and found to be 0.12 cm^3 in one case and 0.17 cm^3 in the other case.

The next point to determine was whether Lithophaga could elongate artificially-bored holes in a non-calcareous mudstone under laboratory conditions similar to those in Experiment No. 1. Experiment No. 2 was set up with a block of mudstone from Duxbury Reef, and a new piece of the same limestone that was used in Experiment No. 1 was used as a control.

The result of Experiment No. 2 was that all four specimens of Lithophaga continued to bore into the limestone but none of the three individuals in the mudstone had any effect whatsoever on that rock. No erosion could be detected, even microscopically, on the bottom of the mudstone holes. The bottoms of the holes in the mudstone remained as they had been bored by the drill, as shown by the dotted line in textfigure 1. The volume of material removed from the limestone by three of the Lithophaga was measured and found to be 0.18, 0.23, and 0.12 cubic centimeters, respectively. The fourth Lithophaga burrow was not measured because of accidental fracture of the rock. This particular specimen was slightly larger than the others and as a result was not able to rotate in its burrow as did the others. The shape of the excavation caused by this particular animal is significant as proof against a mechanical theory of boring and is discussed at the end of this section and in the conclusion.

Rotation of the Lithophaga specimens in their burrows was observed during Experiment No. 2 and checked by the actual byssal attachments at the conclusion of the experiment. Both groups rotated very little, but it was noted at the end of the experiment that the animals in the mudstone as a group rotated less than those in the limestone. In natural burrows the points of attachment around the inside are quite regular, indicating that the animal in nature does not seem to favor any one position.

One of the Lithophaga in the limestone of Experiment No. 2 was too large to rotate freely. It was able to gape a very slight amount, however, and this gape was sufficient to allow anterior mantle tissue to flow out and up against the head end of the artificial burrow. The excavation was symmetrical about the projection of the dorso-ventral axis on the head end of the burrow, but it was not radially symmetrical. The holes eroded by the Lithophaga which were free to rotate in both Experiments 1 and 2 were very nearly radially symmetrical. Textfigure 3 and Plate 26 show the shape of the hole eroded by the individual which was stuck in its hole. Records of the rotation of all the animals were kept throughout the experiment. At no time was the specimen which made the boring shown in textfigure 3 and Plate 26 seen to rotate. As further evidence against rotation by this animal the points of byssal attachment were checked after the animal was removed. Only one small area was covered heavily by the byssus implantations, proving that the animal kept its dorso-ventral orientation constant during the experiment.

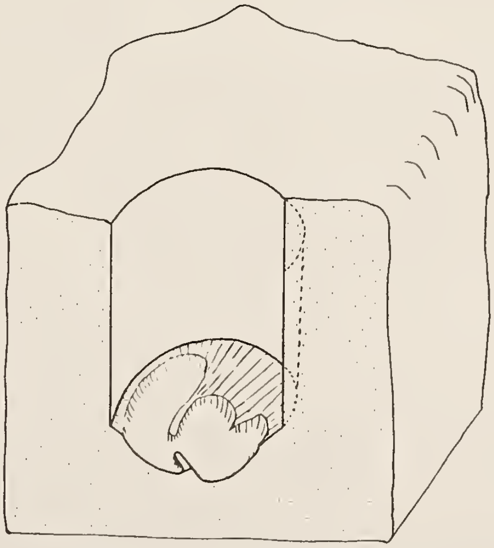

Figure 3: View of artificial burrow in limestone in which the animal was unable to rotate. The plane of the break in the rock is almost in the plane of symmetry of excavation.

Miscellaneous Observations

A specimen of Lithophaga plumula kelseyi in its natural burrow was placed in the tank with Experiment No. 1 and kept alive for a year. The anterior tip of the burrow was broken off. From time to time mantle tissue would extend out of the broken end and expand. The appearance of the mantle tissue as shown in Plate 27, figures 1 and 2, would seem to indicate that if the burrow end had been intact the tissue would have made intimate contact with the rock surface. In the case of the animal that could not rotate, it is apparent that some sort of chemical action is responsible for the peculiar shape of the erosion caused by that animal. Considering the shape of the eroded area in question and the fact that sea water is a highly buffered medium, intimate contact of the mantle tissue with the rock may be a necessary part of the boring process.

The deposits of calcareous material on the walls of the burrows may furnish a clue to the mechanisms involved in boring by Lithophaga plumula kelseyi. The deposits on the walls of the glass test tubes in Experiment No. 1 and the mudstone in Experiment No. 2 were chalky in appearance and very fragile. There was a small amount of deposition compared to the deposits on the walls of the artificially-bored limestone burrows. The deposits on the limestone burrows were shiny, very hard, and mechanically strong. The deposit on the wall of the natural burrow deserves some comment. In the case of the small burrows, only the posterior half or third was covered with the calcareous substance. The largest burrows were completely lined with the material. A possible explanation for this is that the small and presumably young animals are still growing and, consequently, must continue to elongate their homes. It may also be assumed, therefore, that the largest specimens are the adults and as such no longer need to bore. The adults then lay down a continuous covering over the entire inner surface of the burrow.

Conclusions

The direct evidence from the boring activity of Lithophaga plumula kelseyi as compared in limestone and mudstone would seem to indicate that this species bores by some sort of chemical rather than mechanical means. This evidence is supported by the observation that the specimen that was stuck in its burrow and could not rotate did actually dissolve limestone and in so doing made an oddly shaped excavation that could not have been made by any sort of rotation.

The argument against a mechanical method of boring is as follows: The animals in the mudstone were able to rotate and did rotate but had no abrasive effect on the burrow bottoms. The specimen which was stuck in the limestone burrow and was not able to rotate did make an excavation. It is not known whether this dissolving of the limestone was caused by an acid mucus secretion by the mantle or by a more complex activity such as ion exchange between the mantle tissue and the calcareous rock.

Acknowledgment

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Literature Cited

Amemiya, I. Y., & O. Amemiya
1923. Note on the habitat of rock-boring molluscs on the coast of central Japan. Proc. Imp. Acad. (Tokyo) 9: 120-123.

Berry, S. Stillman
1907. Molluscan fauna of Monterey Bay, California. Nautilus 21 (2): 17-21.

Carazzi, D.
1892. La perforazione delle rocce calcaree per opera dei Datteri (Lithodomus dactylus). Atti. Soc. Ligust. sci. nat. Anno 3: 279-297.

——, ——
1903. Contribute all'istologia e alla fisiologia dei Lamellibranchi. Int. Monat. Anat. Physiol., 20: 57 to 86.

Duerden, J. E.
1902. Boring algae as agents in the disintegration of corals. Bull. Amer. Mus. Nat. Hist. New York, 16: 323-332.

Explanation of Plate 27

Figure 1: Anterior mantle tissue of *Lithophaga plumula kelseyi* when extended, looking posteriorly.
Figure 2: Lateral view of extended anterior mantle tissue of the same animal.

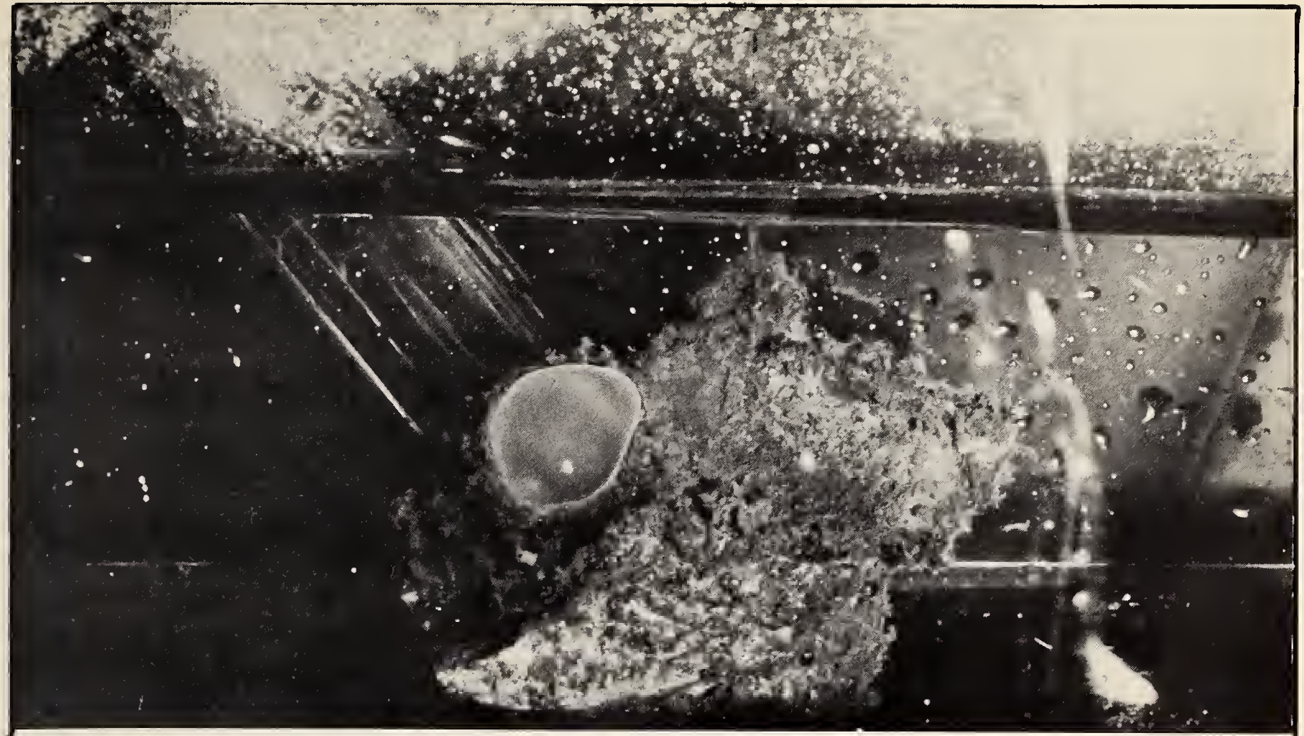

Figure 1

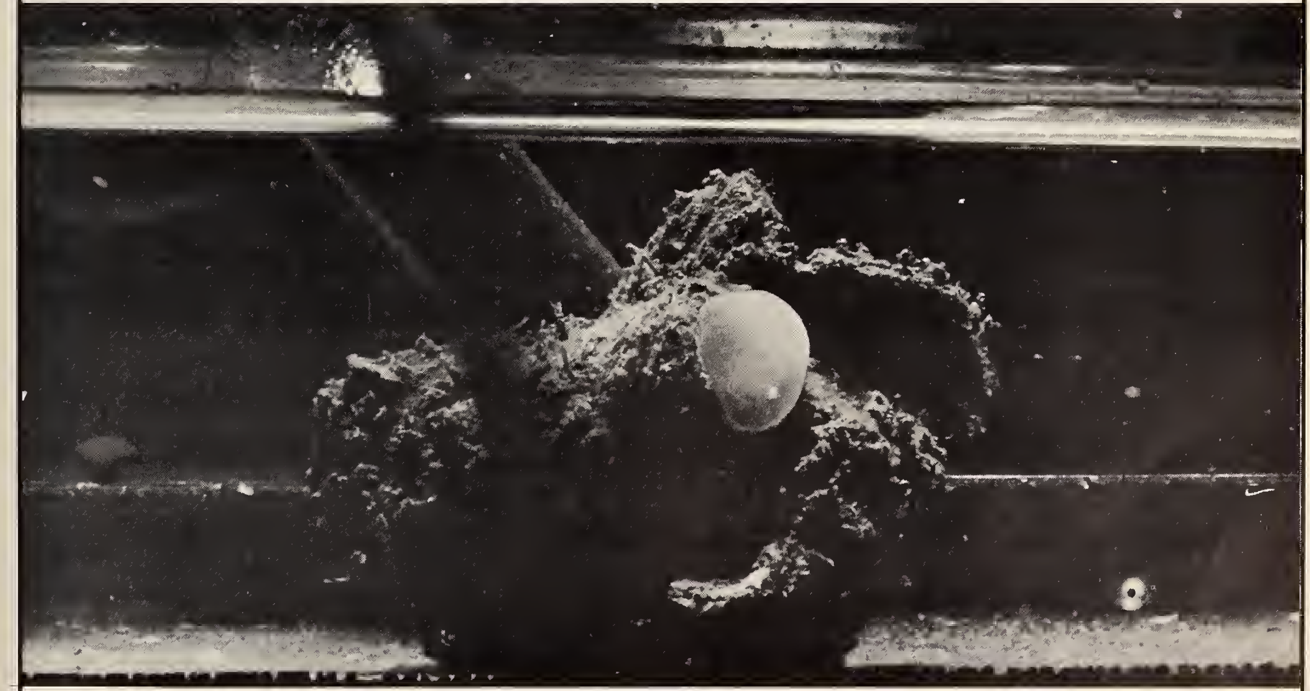

Figure 2

Hodgkin, *photo.*

Haas, Fritz
1942. The habits of life of some west coast bivalves. Nautilus 55: 109-113.

Hanley, S.
1844. Description of new species of Mytilacea, & C. Proc. Zool. Soc. London, p. 17.

Hertlein, Leo G., & A. M. Strong
1946. Mollusks from the west coast of Mexico and Central America. Zoologica, 31: 53-79.

Ihering, H. von
1900. On the South American species of Mytilidae. P. Malacol. Soc. London, 4: 84-98.

Kühnelt, W.
1930. Bohrmuschelstudien, 1. Paleobiologica 3: 53 to 91.

List, Th.
1902. Die Mytiliden des Golfes von Neapel und der angrenzenden Meeresabschnitte. Fauna & Flora Golfes von Neapel, Monogr. 27.

Otter, G. W.
1937. Rock destroying organisms in relation to coral reefs. Sci. Repts. Gr. Barrier Reef Exp. 1: 323 to 352.

Pelseneer, P.
1911. Les lamellibranches de l'expédition du Siboga. Siboga-Expeditie, Leiden, Monogr. 53a: 1-125.

Reeve, Lovell Augustus
1858. Conchologia Iconica. Monograph of the genus Lithodomus.

Sayre, A. N.
1931. The fauna of the Drum limestone of Kansas and western Missouri. Kansas Univ. Sci. Bull. 19(2): 102-202; pls. 1-21.

Yonge, C. M.
1955. Adaptations to rock boring in Botula and Lithophaga (Lamellibranchia, Mytilidae) with a discussion on the evolution of this habit. Quart. J. Micr.Sci. 96: 383-410.

The Fresh Water Clam *Pisidium tremperi* (HANNIBAL)

by

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(Plate 28)

(Publication authorized by the Director, U. S. Geological Survey)

Only one species of freshwater clam has been considered restricted to southern California. Pisidium tremperi (Hannibal) has so far been known only from Bluff Lake, San Bernardino Mountains. We have examined the type lot and refer P. tremperi to the synonymy of the widespread P. obtusale Pfeiffer. The species is known nowhere else in the State, however, and its disjunct occurrence in southern California is parallel to that of other locally restricted species.

SYNONYMY

Corneocyclas sp. nov.: Hannibal, 1912a, p. 42.

Corneocyclas Tremperi, n. sp.: Hannibal, 1912b, p. 137, 210, pl. 7, fig. 22.

Pisidium tremperi Hannibal: Sterki, 1916, p. 471.

Pisidium tremperi (Hannibal): Gregg, 1947, no. 70, p. 18.

ORIGINAL DESCRIPTION

"Shell minute, globular-trigonal, beaks anterior, broad and somewhat elevated, hinge much reduced; habitat marshy lakes. Length 1.4, altitude 1.3 mm., depth of valves 1 mm.

"Mojave System.

"Bluff Lake Cienaga, San Bernardino Mountains, California (H. Hannibal).

"Named after Dr. R. H. Tremper, the first conchologist to visit this portion of the San Bernardino Mountains" (Hannibal, 1912b, p. 137).

This inadequate description is not usefully supplemented by the poor illustration.

IDENTITY

Considering the inadequate description by Hannibal, one cannot blame later writers for misinterpreting Pisidium tremperi. Sterki (1916, p. 471) thought it was close to P. ashmuni, a synonym of P. casertanum (Poli). Gregg (1947, no. 70, p. 18) thought P. tremperi was probably the young of P. ashmuni.

We have examined the following material:

4827 S. S. Berry collection. Lower end of Bear Lake, alt. 6700 ft., San Bernardino Mountains. S. S. Berry, August 1908. Identified as Pisidium rotundatum Prime by Victor Sterki, January 26, 1920.

4824 S. S. Berry collection. Swamp at Bluff Lake, alt. 7550 ft., San Bernardino Mountains. S. S. Berry, August 1908. Identified as Pisidium rotundatum Prime by Victor Sterki, January 26, 1920.

5805 Stanford University Paleontological Type Collection. Bluff Lake Cienaga, San Bernardino Mountains. Harold Hannibal. Type and three others.

All these specimens are closely similar and easily referable to the form rotundatum of Pisidium obtusale Pfeiffer. They have the characteristic oval shape, fine striae, small size, short hinge, and low rounded, smooth beaks. The cusps on the lateral teeth are sharp on top as in P. obtusale, not blunt. The pseudocallus at the proximal end of the posterior sulcus is weak, and the shells are not as large as usual P. obtusale, but these are trivial differences.

The type (Plate 28, figures 1 and 2) measures as follows: Length 1.8 mm., breadth 1.3 mm., height 1.5 mm. The paired valves were not separated for fear of breakage, but the specimen is so close to the others in external features that one cannot reasonably doubt they are all one species.

Our measurements of the type do not agree well with those published by Hannibal. It is possible but not certain that we have erred in simply accepting the identification as type on the labels. If this specimen is not the type, then the identity of Pisidium tremperi remains uncertain. It is a synonym of either P. casertanum or P. obtusale, in our opinion.

ZOOGEOGRAPHY

Although we have deprived southern California of an endemic species, the isolated occurrence there of Pisidium obtusale retains considerable zoogeographic interest. The disjunct distribution is shown to be of historical significance by the occurrence in the San Bernardino Mountains of seven other species of mollusks also isolated there.

FRESHWATER CLAMS, SPHAERIIDAE

Pisidium obtusale Pfeiffer. In California known only from Bear Lake and Bluff Lake, San Bernardino Mountains.

Sphaerium lacustre (Müller). In southern California known only from Bluff Lake, San Bernardino Mountains (Hannibal, 1912a, p. 42; Gregg, 1947, no. 69, p. 12, as Musculium raymondi).

Sphaerium hanhami Sterki. In southern California known only from Bear Lake, San Bernardino Mountains (Gregg, 1947, no. 69, p. 13).

FRESHWATER SNAILS, VALVATIDAE

Valvata humeralis californica Pilsbry. In southern California known living only from Bear Lake and Bluff Lake, San Bernardino Mountains (Hannibal, 1912a, p. 35). It is recorded by Woodring and others (1946, p. 65) from the upper Pleistocene of the Palos Verdes Hills.

LYMNAEIDAE

Stagnicola sp. Whatever may be the species recorded by Hannibal (1912a, p. 42) and Berry (1909, pp. 76-77) as Lymnaea palustris (Müller), it is known in southern California only from Bluff Lake and Bear Lake, San Bernardino Mountains.

PLANORBIDAE

Menetus centervillensis (Tryon). In southern California known only from Bear Lake, San Bernardino Mountains (Baker, 1945, p. 478; Hannibal, 1912a, p. 42, as Segmentina dilatata).

LAND SNAILS, PUPILLIDAE

Vertigo modesta form microphasma Berry.

Figure 1

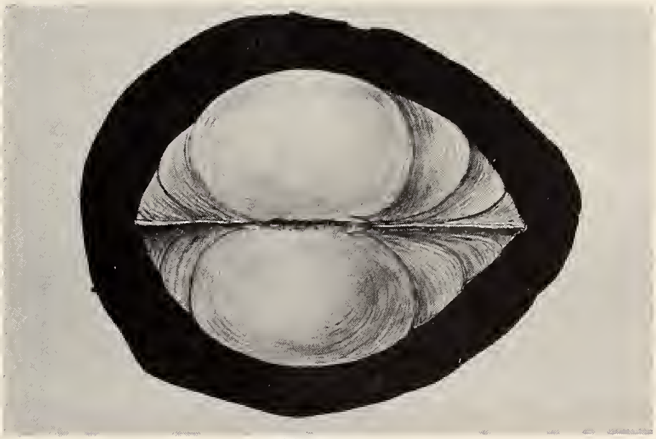


Figure 2

Pisidium obtusale PFEIFFER form *rotundatum* PRIME (type specimen of *P. tremperi* HANNIBAL), x 27. Bluff Lake, San Bernardino Mountains, San Bernardino County, California.

Known only from the San Bernardino Mountains (Berry, 1919; Pilsbry, 1948, p. 987).

Vertigo occidentalis Sterki. Known only from the San Bernardino Mountains (Pilsbry, 1948, p. 993).

Hannibal (1912a, pp. 40-42) accounted for the aquatic species in the Pacific Coast drainage by stream capture of former Mojave headwaters. Pleistocene uplift of the San Bernardino and San Gabriel Mountains, and the recent origin of the present Mojave stream courses are documented geologically (Noble, 1954; Bowen, 1954). From this point of view, Hannibal's interpretation is plausible. Another zoogeographic question remains unanswered, however: Why are these local populations of mollusks (some differentiated, some not) in the San Bernardino Mountains? Their isolation and differentiation may considerably antedate recent drainage changes. The occurrence of these species in the coastal drainage may therefore be a relatively minor geographic phenomenon superimposed on the older biological feature of local isolation.

In the case of Valvata, one can say that the history of the species in southern California is more complicated than appears at first sight. Although the only known living occurrences are in the Bear Lake area of the headwaters of the Santa Ana in the San Bernardino Mountains, this snail is known as an upper Pleistocene fossil from the Palos Verdes Sand in what is now Los Angeles River drainage (Woodring and others, 1946, p. 65). Evidently the restriction of Valvata in southern California to the San Bernardino Mountains is a relatively recent feature of its distribution. Probably its local occurrence is due to the disappearance of other formerly suitable habitats. Whether Pisidium obtusale is analogous to the Valvata in this respect, one cannot say.

Acknowledgment

We are grateful to S. S. Berry, Redlands, California, and to A. Myra Keen, Stanford University, Stanford, California, for loan of the specimens which form the basis of this note.

Literature Cited

Baker, F. C.
1945. The molluscan family Planorbidae. Univ. Illinois Press. xxxvi + 530 pp., frontis.

Berry, S. Stillman
1909. The known mollusca of San Bernardino County, California. Nautilus 23: 73-79.

——, ——
1919. Three new alpine Vertigos from California. Nautilus 33: 48-52; figs. 1-8.

Bowen, O. E., Jr.
1954. Geology and mineral deposits of Barstow quadrangle, San Bernardino County, California. Calif. Div. Mines Bull. 165: 7-185, pls. 1-9.

Gregg, Wendell O.
1947. The fresh water mollusca of California, including a few forms found in adjoining areas. Conch. Club Southern Calif., Minutes 67: 3-21; 69: 3-18 ; 70: 14-20.

Hannibal, Harold
1912a. The aquatic mollusc of Southern California. Southern Calif. Acad. Sci. Bull. 11: 18-46, frontis.

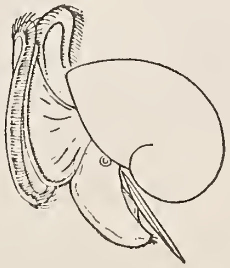
——, ——
1912b. A synopsis of the Recent and Tertiary freshwater mollusca of the Californian Province, based upon an ontogenetic classification. Malacol. Soc. London Proc., 10: 112-211, pls. 5-8.

Noble, L. F.
1954. The San Andreas fault zone from Soledad Pass to Cajon Pass, California. Calif. Div. Mines Bull. 170, chap. 4: 37-48, pl. 5.

Pilsbry, Henry A.
1948. Land mollusca of North America (north of Mexico), v. 2, pt. 2. Acad. Nat. Sci. Philadelphia Monogr. 3, v. 2, pt. 2: i-xlvii, 521-1113.

Sterki, Victor
1916. A preliminary catalogue of the North American Sphaeriidae. Carnegie Mus. Annals 10: 429-477.

Woodring, W. P., M. N. Bramlette, & W. S. W. Kew
1946. Geology and paleontology of Palos Verdes Hills, California. U. S. Geol. Survey Prof. Paper 207, v + 145 pp., 37 pls.



On the Identifications of Five Pacific *Mitra*

by

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(Plate 29)

A great deal of confusion exists concerning the species generally identified as Mitra lugubris Swainson, 1822, M. coronata Lamarck, 1811 (non Helbling, 1779), M. tiarella A. Adams, 1851, and M. lugubris honoluluensis Pilsbry, 1920.

It has been pointed out (Dautzenberg and Bouge, 1923) that the name Mitra coronata Lamarck, 1811 is preoccupied by Voluta coronata Helbling, 1779, which applies to a species Swainson later named Mitra mucronata. If these two species were classified in the same genus, the Lamarck name would be a secondary homonym, but since under modern practice M. coronata Lamarck is retained in the genus Mitra, and M. mucronata Swainson (Voluta coronata Helbling) is placed in Vexillum, and since no valid replacement name has been proposed for the presumed junior homonym, it seems possible under the International Rules for both names to be retained — as Mitra coronata Lamarck, 1811, and Vexillum coronatum (Helbling, 1779) — at least until the long-awaited new Code is published and the matter of secondary homonymy is clarified.

Mitra coronata and M. lugubris were incorrectly illustrated by Sowerby (1874) and by Tryon (1882); only one of Sowerby's three figures of M. lugubris accurately illustrates the species, and his drawings purporting to represent M. coronata are equally confused. Of the eight figures labelled M. coronata by Tryon, only one is referable to the species, although two of his figures of M. lugubris in reality depict M. coronata. None of Tryon's "lugubris" figures is actually that species. Tryon considered M. tiarella a synonym of M. coronata; Sowerby figured it accurately on two occasions, though again referring in another case to an identical species as M. coronata. These erroneous identifications in two widely used monographs may account for some of the incorrect labels so frequently seen in collections. Dautzenberg and Bouge (1923) also considered M. coronata and M. tiarella synonymous, basing this decision mostly on the size differential seen in various specimens. It is true that M. tiarella is extremely variable in size; in my collection there are perfectly typical adult specimens ranging from 12.4 mm. to 31.8 mm., with all intermediate sizes well represented. There are other important morphological differences between these two species, which are enumerated below.

A list of references to some of the valid illustrations will be found at the end of this paper, as well as new photographs of typical specimens of these species and two additional related forms, M. aurora Dohrn, 1861 (Plate 29, fig. 4) and M. floridula Sowerby, 1874 (Plate 29, fig. 5).

The original figure of Mitra coronata referred to by Lamarck (Encyclopédie Méthodique, Pl. 371, figs. 6a, 6b) and subsequent illustrations by Kiener, Küster, Reeve, Wood) and Chenu represent a species similar to M. lugu-

Explanation of Plate 29

Figure 1: *Mitra lugubris* Swainson, 1822. Queensland, Australia (right-hand specimen courtesy of Helen DuShane)
Figure 2: *Mitra coronata* Lamarck, 1811. Hawaii. Figure 3: *Mitra tiarella* A. Adams, 1851. Hawaii. ANSP No. 46797. Figure 4: *Mitra aurora* Dohrn, 1861. Hawaii. Figure 5: *Mitra floridula* Sowerby, 1874. Okinawa.

Photographs (except Figure 3) by Victor Duran, Scientific Photographic Laboratory, University of California.
Figure 3 photograph by Perfecto Mary, courtesy of Stanford University. All photographs twice natural size.
All specimens from Cate collection unless otherwise noted.

Figure 1

Figure 3

Figure 2

Figure 4

Figure 5

bris in some ways: its color is dark brown, or brownish-orange in faded specimens, and it is crowned with a wide white crenulated zone below the sutures. Otherwise, it differs from M. lugubris as follows: it is a slimmer shell, more ovate than pyriform; its aperture is shining and white instead of dull brown; its lip is effuse instead of following the pyriform outline; but most of all, the true M. coronata lacks the white base which is the most striking feature of M. lugubris. This white base is visible from the dorsal side of the anterior tip of the shell; on the ventral side it extends to the adapical fold of the columella. The remainder of the columella is brown, as is the labral side of the aperture except where the white subsutural band may be seen from inside.

Mitra tiarella A. Adams, 1851 (M. lugubris honoluluensis Pilsbry, 1920) differs from M. lugubris and M. coronata in that it exhibits a narrow pale band below the sutures, and its crenulations are white on a brown background, there being no solid white subsutural zone.

Correct Illustrations of the Above Species:

Mitra lugubris Swainson, 1822 (see Plate 29, figure 1):

1822 Swainson, William. Zoological Illustrations, Vol. 2, Pl. 66, upper and lower figures.
1839 Kiener, L. C. Icon. Coq. Viv., Mitra, Pl. 30, fig. 100.
1841 Küster, H. C. Conchylien-Cabinet, Mitra, Pl. 17e, fig. 1.
1844 Reeve, Lovell A. Conch. Icon., Mitra, Pl. 10, fig. 72.
1856 Wood, W. Index Testaceologicus, Supplement Pl. 3, fig. 12a.
1874 Sowerby, G. B. Thes. Conch., Mitra, Pl. 13, fig. 199 (only).

Mitra coronata Lamarck, 1811 (see Plate 29, figure 2):

.... Encyclopédie Méthodique, Pl. 371, figs. 6a, 6b.
1839 Kiener, L. C. Icon. Coq. Viv., Mitra, Pl. 18, fig. 60a (only).
1841 Küster, H. C. Conchylien-Cabinet, Mitra, Pl. 26, figs. 5, 6.
1844 Reeve, Lovell A. Conch. Icon., Mitra, Pl. 14, figs. 104a, 104b.
1856 Wood, W. Index Testaceologicus, Voluta, Pl. 21, fig. 146a.
1860 Chenu, J. C. Man. Conchyl., Vol. 1, p. 193, fig. 904.
1874 Sowerby, G. B. Thes. Conch., Mitra, Pl. 13, figs. 200, 201, 220.
1882 Tryon, George W., Jr. Man. Conch., Vol. 4, Mitridae; Pl. 44, figs. 284, 285.
1946 Edmondson, C. H. Reef and Shore Fauna of Hawaii, p. 127, fig. h (as M. lugubris).

Mitra tiarella A. Adams, 1851 (see Plate 29, figure 3):

1874 Sowerby, G. B. Thes. Conch., Mitra, Pl. 5, fig. 56; Pl. 13, figs. 215, 217.
1920 Pilsbry, Henry A. Proc. Acad. Nat. Sci. Phila., Vol. 72, pl. 12, fig. 16 (as M. lugubris honoluluensis).

Other species in this group include Mitra aurora Dohrn, 1861 (Plate 29, figure 4), and M. floridula Sowerby, 1874 (Plate 29, figure 5). Mitra aurora resembles M. tiarella, but is generally smoother, especially in the middle of the last whorl; it is, additionally, dotted and speckled with white, marked with large irregular white blotches below a white subsutural band, and is a deep rusty-red color in live-taken specimens. It is known from Hawaii, the Cook Islands, Tahiti, the Paumotus and the Philippines.

Mitra aurora has frequently been associated with M. coronata as a subspecies, but since it maintains constant morphological characteristics throughout its range, I prefer to restore it to its original rank as a full species. Even if it were a subspecies, it would have to be assigned to M. tiarella instead of M. coronata.

Mitra floridula Sowerby, 1874 resembles M. aurora but is larger, more ventricose, with broad spiral ribs and deeply punctured spiral grooves. It exhibits a much coarser appearance than any of the other species discussed here. It is recorded from Japan, the Ryukyus, and Mauritius.

Acknowledgment

I wish to thank Dr. Myra Keen for her kind cooperation in furnishing the exact Helbling reference, which was only alluded to in Dautzenberg and Bouge (1922). Dr. Keen's many important contributions to malacology are more than equalled by her gracious helpfulness to students and fellow workers.

Literature Cited

Chenu, J. C.
1859. Manuel de Conchyliologie. I: 1-507. Paris.
Dautzenberg, Ph., & L.-J. Bouge
1922. Mitridésde la Nouvelle Calédonie et de ses dépendances. Jour. Conchyl. 67: Famille Mitridae, 83-259, pl. II.
Edmondson, Charles Howard
1946. Reef and shore fauna of Hawaii. B. P. Bishop Mus. Spec. Publ. 22, iii + 381 pp., figs. 1-223, (family Mitridae pp. 128-130, fig. 58 e-i).
Encyclopédie Méthodique.
1797. Vers, coquilles, mollusques et zoophytes. pls. 189-390.
Helbling auf Hirzenfeld, Sebastian Georg
1779. "Beiträge zur Kenntnis neuer und seltener Conchylien." Abhandlungen einer Privatgesellschaft in Böhmen (Česka společnost nauk, Prague) 4: 102 to 131, 4 pls.
Kiener, L. C.
1839. Iconographie des coquilles vivantes. Vol. 4, Mitra. 1-120, pls. 1-34. Paris.
Küster, H. C.
1841. Die Familie der Walzenschnecken (Volutacea Menke). Nürnberg. Mitra: pp. 33-150, pls. 7-17e.
Pilsbry, Henry A.
1920. Marine mollusks of Hawaii. Proc. Acad. Nat. Sci. Phila., 72: 309-318, pl. 12.
Reeve, Lovell Augustus
1844-1845. Conchologia Iconica. Monograph of the genus Mitra. pls. 1-39.
Sowerby, George Brettingham
1874. Thesaurus conchyliorum. Vol. 4, Monograph of the genus Mitra: 1-46, pls. 1-28.
Swainson, William
1820-1821. Zoological illustrations, Conchology, Series 1, vols. 1 & 2, pts. 1-3, 72 pls.
Tryon, George W., Jr.
1882. Manual of conchology, 4 (Mitridae): 106-200; pls. 32-58. Philadelphia.
Wood, W., & Sylvanus Hanley
1856. Index testaceologicus, an illustrated catalogue of British and foreign shells. i-xx, 1-234; pls. 1 to 38, suppl. pls. 1-8.

A Study of the Reproductive Cycle in the California Acmaeidae (Gastropoda)

Part IV

by

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and the Department of Biology, Boise Junior College, Boise, Idaho)

(Plates 30, 31 and 32)

Discussion

In Parts I-III (Fritchman, 1961a, b, c) of this paper the reproductive periods of eleven species of the limpet Acmaea Eschscholtz 1833 have been reported for the latitude of San Francisco, California. An effort will now be made to correlate these periods with the latitudinal distribution of the species.

The effects of temperature on the breeding and distribution of marine invertebrates have long been noted and discussed. From his studies of the invertebrate fauna at Plymouth, Orton (1920) concluded that the breeding season seemed to be limited by apparently constant maximum or minimum temperatures, or both, which seem to be physiological constants for the species. In addition, he believes that the greatest influence of temperature is at the maximal or minimal temperature for the locality investigated. Runnstrom (1927) working at Bergen showed that the ranges of temperature in which the development of larvae was possible were correlated with the origins of the different faunae producing the larvae. Thus, the northern forms had a much lower range of temperature for development than did the southern faunal components. In addition, he found that the earliest developmental stages were most affected by the temperatures, the larvae and the adults becoming increasingly less sensitive to temperature conditions. Further work by Runnstrom (1929) demonstrated that breeding seasons of the North Sea invertebrates were correlated with their geographic origins, the southern forms being summer breeders in the North Sea; the northern forms, winter breeders. In a later paper, Runnstrom (1936) concludes that stenothermic animals can spread only as far as the reproductive adaptations to temperature permit, the limiting temperature being that at which the early developmental stages succumb. There will, of course, be a fringe of greatest adult extension which is maintained by immigrant larvae, but where successful reproduction cannot occur. The species can be extended beyond these temperature boundaries only by the development of physiological races adapted to different temperature conditions.

Hutchins (1947) briefly reviews the chief contributions to the knowledge of temperature and distribution of marine organisms. He proposes that four types of temperature zonation can be recognized which account for the distribution of marine life. The limits of these distributions are maximal or minimal temperatures at which (1) the adults succumb; (2) reproduction becomes impossible; or (3) and (4) combinations of (1) and (2), one boundary being fixed by adult survival, the other by failure to reproduce. He has applied this system with considerable success to the worldwide distribution of Mytilus edulis and Balanus balanoides and to the distribution of the fauna of the eastern coast of the United States.

Hutchins and Scharff (1947) have plotted calendar month isotheres and isocrymes for intervals of five degrees Fahrenheit. Such isotheres and isocrymes are isotherms which connect points of maximal and minimal monthly temperatures. In these compilations nominal calendar months are the basis of calculations and not the coldest or warmest 30-day periods. These authors, therefore, refer to these isotherms as calendar month isotheres and calendar month isocrymes. Using these data the reproductive seasons of Acmaea were studied with attention to the geographic ranges of the various species.

The species ranges used are largely those of Test (1937), amended where information is available. Two species, Acmaea digitalis Eschscholtz, 1833, and A. asmi (Middendorf, 1847), are listed by her as occurring on the Revillagigedos Islands, Mexico, although no reports of expeditions thereto substantiate this (Strong and Hanna, 1930). The southern limits for these species are, therefore, given as the points of their most southern continental occurrence. The southern limit of A. triangularis (Carpenter, 1864) is vaguely given by Test as the Gulf of California, while Keen (1937) specifically lists it as 33° N. Latitude, which is here adopted. On the basis of specimens in the collection of the California Academy of Sciences, the range of A. insessa (Hinds, 1842) is extended to Cape San Lucas, Lower California. The range of A. mitra Eschscholtz, 1833, has recently been extended by Stohler (1959) to Point Santo Tomas, Lower California, or to the latitude of 31° 35' N. The animals here, however, are subtidal in 40 to 150 feet of water. Acmaea funiculata (Carpenter, 1864), being subtidal, is omitted as is also A. paradigitalis Fritchman, 1960, for which the range limits are presently uncertain. In many cases the northern limits of ranges are listed as the Aleutian Islands or other islands of the Alaskan Peninsula, the latitude of which may be 55° or less. In such cases the northern latitudinal limit will be given as 60° N. Latitude, the most northern point of the southern coast of Alaska. Plate 30 shows the ranges of the California acmaeids in degrees of North Latitude; Plates 31 and 32 show the ranges in relation to isotheres and isocrymes as set up by Hutchins and Scharff (op. cit.). When the ends of the ranges do not coincide with specific isotheres or isocrymes, these limiting temperatures are approximated by interpolation with latitude.

Acmaea persona Eschscholtz, 1833

Geographic range: Shumagin Island and Yakutat, Alaska, to Monterey, California.
Latitudinal range: 60° - 37° N. Lat.
Isothere range: 50° - 60° F. (10°)
Isocryme range: 35° - 55° F. (20°)

Although this high intertidal species has an extensive geographic range, its range in relation to maximal temperatures encountered is quite short (Plate 31). The reproductive cycle of this species correlates well with its geographic range as a northern form. At the latitude of study it is reproductively active from mid-October through March or April and sexually indeterminate from May to mid-October. Although the upswing in gonad activity begins in October, it is not until November that large percentages of ripe animals are found. Similarly, it is not until late April or early May that significant percentages of indeterminate animals are found (Plate 15, Part II). It would appear, then, that the temperatures encountered in April and November are critical ones for this species.

As indicated in Table I, Part I, the mean water temperature for April is 54.7° F. and that for November, 55.9° F. Thus, 55° F. is adopted as a critical temperature for Acmaea persona.

It is important to note that, despite Runnstrom's (1927) demonstration that adults are less sensitive to temperature than larval forms, it is the adult sensitivity which determines the reproductive period of Acmaea persona, since the gonads are completely nonfunctional during the summer months. Thus, although the larvae may be very sensitive to temperatures in excess of 55° F. or thereabouts, it is never a question of their susceptibility to temperature that determines the southern limit of the range since no larvae are produced above 55° F. If this is taken as the maximum at which A. persona spawns and this value is compared with the species range on the isocryme plate, it is seen that the southern range is terminated at the 55° isocryme. Acmaea persona, then, appears to be restricted in its southern distribution by the maximum temperature at which reproduction is possible, this being a function of the adult physiology.

Acmaea fenestrata cribraria Carpenter, 1857

Geographic range: Coal Harbor, Unga Island, Alaska, to Cayucos, San Luis Obispo County, California.
Latitudinal range: 60° - 35.5° N. Lat.
Isothere range: 50° - 60° F. (10°)
Isocryme range: 35° - 56.5° F. (21.5°)

As was the case with Acmaea persona, the period of reproductive activity of this species can be correlated directly with its northern distribution. Plate 16, Part II, shows that reproductively active animals are found only from September through April and during the summer the population is either spawned or sexually indeterminate. The upswing in August and September represents partially ripe animals, fully ripe forms not appearing until October and November. This pattern of activity does not bear close relation to sea temperatures prevailing during the assumed critical months of April and August, 54.7° and 59.8° respectively. However this may be, the redevelopment of the gonads begins during the period of the maximum yearly temperature, at least two months prior to that seen in A. persona. This difference may result from the different intertidal positions of the two species, since A. fenestrata cribraria occurs only in zone two and lower while A. persona is strictly a zone one animal facing slightly increased heating and desiccation. Or the reproductive difference between the two species may reflect the somewhat greater warm water tolerance of A. f. cribraria. Unlike A. persona, a correlation between the maximum temperature at which spawning occurs and the distribution of the subspecies in relation to isocrymes cannot be made. The data indicate that 54° F. must be about the maximum spawning temperature for A. f. cribraria at the latitude of study. Yet, as shown on Plate 32, its range extends almost to the 57° isocryme producing a discrepancy of 3° F. It appears, nevertheless, that this subspecies is restricted in its southern distribution by the maximal temperature at which the adult reproductive mechanism can operate.

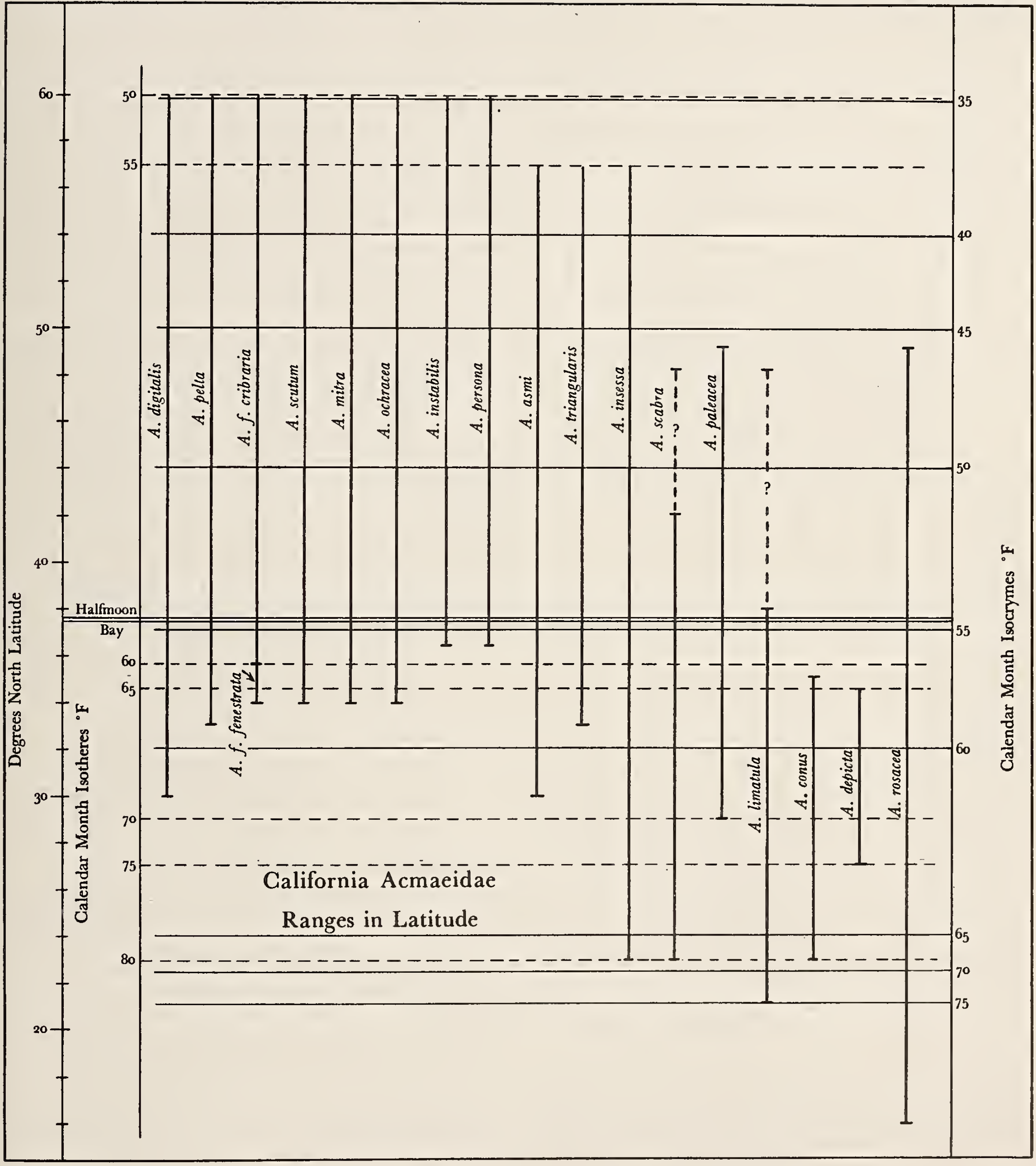
Acmaea scutum Eschscholtz, 1833

Geographic range: Aleutian Islands to San Pedro, California
Latitudinal range: 60° - 34° N. Lat.
Isothere range: 50° - 65.5° F. (15.5°)
Isocryme range: 35° - 58° F. (23°)

The population of this moderately eurytopic limpet is reproductively active throughout the year (Plate 17, Part II). The gonads redevelop subsequent to each spawning and no sexually indeterminate period is found. There is, however, a tendency toward a summer latent period at which time the gonad is fully developed but spawnings are reduced or stopped. In the absence of data on this species from more southern points, it is difficult to suggest what effect increasing temperature has on its reproduction. Does it, at the southern end of its range, become sexually indeterminate or does it develop gametes without shedding them? Orton (op. cit.) believes that the production of eggs capable of being fertilized is sufficient evidence of breeding activity. Thorson (1946) disagrees with this and points out that in certain regions the temperatures are such that the animals can ripen their gonads but spawning will not occur. As will be shown later, this is presumably the case for two species of Acmaea investigated and may also be true for A. scutum. It is interesting to note that in 1949, 1950, and 1951 the first fall spawning occurred at a time when water temperature was at or very near its maximum. The larvae are thus probably able to survive at sea temperatures near 60° F. and the range of A. scutum in relation to isocrymes substantiates this, since the range of the species terminates at the 58° isocryme.

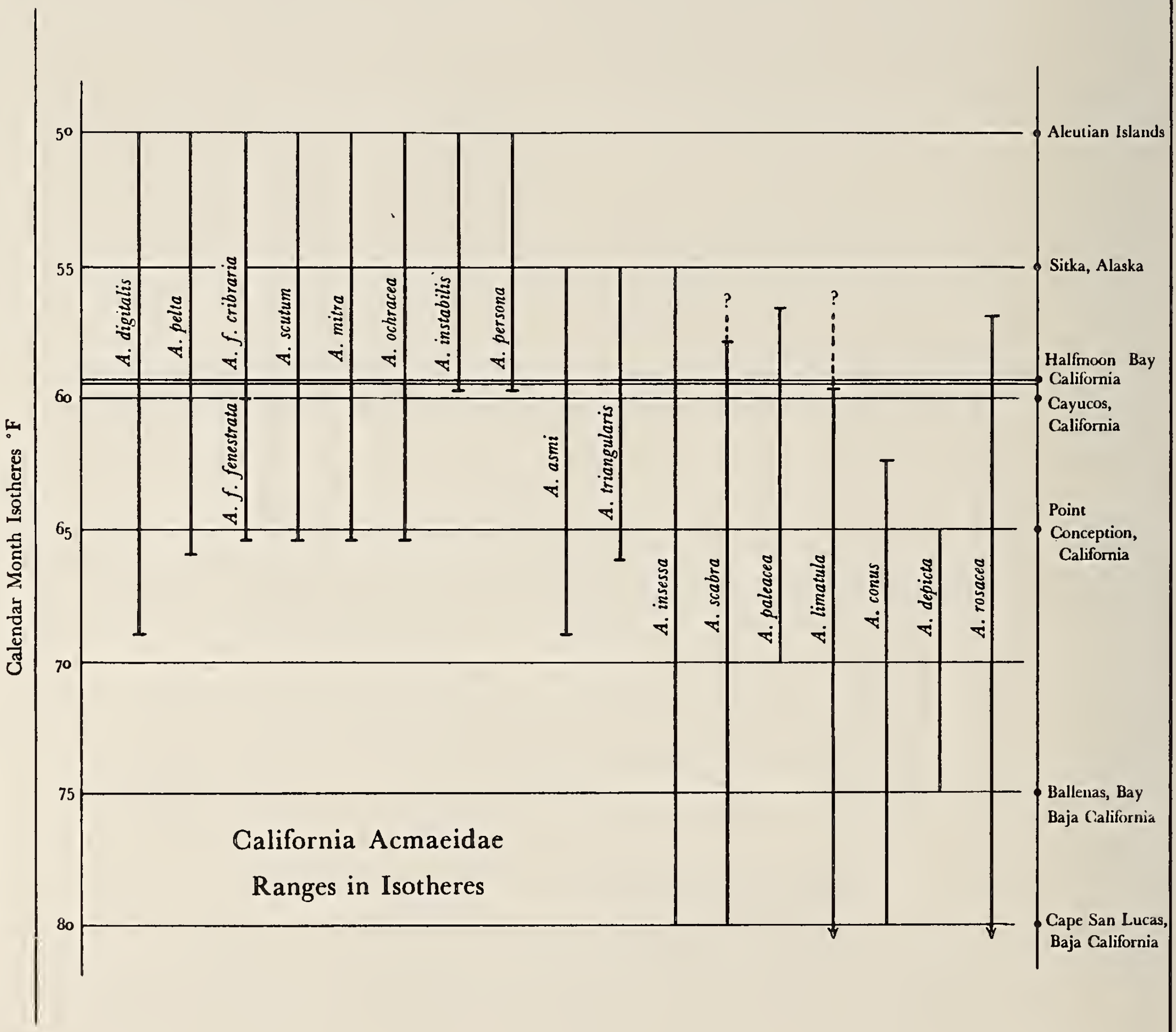
Acmaea mitra Eschscholtz, 1833

Geographic range: Chirikoff Island, Alaska, to Punta Santo Tomas, Lower California
Latitudinal range: 60° - 31° 35' N. Lat.



California Acmaeidae

Ranges in Latitude


Calendar Month Isotheres °F
50
55
60
65
70
75
80
A. digitalis
A. pelta
A. f. cribraria
A. f. fenestrata
A. scutum
A. mitra
A. ochracea
A. instabilis
A. persona
A. asmi
A. triangularis
A. insessa
A. scabra
A. paleacea
A. limatula
A. conus
A. depicta
A. rosacea
?
?
Aleutian Islands
Sitka, Alaska
Halfmoon Bay California
Cayucos, California
Point Conception, California
Ballenas, Bay Baja California
Cape San Lucas, Baja California
California Acmaeidae
Ranges in Isotheres

Isothere range: 50°-65.5° F. (15.5°)
Isocryme range: 35°-58° F. (23°)

On Plate 10, Part I, it can be seen that this species is a winter breeder, spawning when the sea temperature is at or near its minimum. The population studied shows a slow redevelopment of the gonads and a fully ripe condition may be reached as early as July, although spawning may not occur until December or January. The maximal temperature at which spawning occurred was in February, 1952, when the surface waters were about 53.5° F. If this value is tentatively taken as the upper limit for spawning and is compared with the isocryme at the southern end of the range (Plate 32), it is seen that the latter figure is approximately 58° F., or 4.5° in excess of the postulated maximal temperature. This discrepancy is probably explained by the fact that Acmaea mitra becomes subtidal somewhere on the central or southern California coast and thus may remain in temperature ranges suitable to it.

It is interesting to observe that, in Acmaea mitra, the sensitive point in its reproductive physiology is its spawning mechanism and the activity of the gonad seems to be unimpaired unless the slow redevelopment after spawning is so regarded. From the above discussion, it seems certain that A. mitra is restricted in its southern distribution by the maximal temperature at which spawning can occur.

Acmaea pelta Eschscholtz, 1833

Geographic range: Aleutian Islands to San Diego, California
Latitudinal range: 60°-33° N. Lat.
Isothere range: 50°-66° F. (16°)
Isocryme range: 35°-59° F. (24°)

This eurytopic species is reproductively active throughout the year and is known to spawn at sea temperatures from 48.5° F. to 60.0° F. (Plate 9, Part III). Furthermore, there is no long summer period during which the gonads are ripe but unspawned as is found in Acmaea scutum. This may be related to the slightly greater southern range of A. pelta, which itself seems to be uncertain since Keen (1937) lists the species from 19° N. Lat. and Test (1937), while giving San Diego as a southern termination, suggests that it may extend even further.

When a species is reproductively active throughout the year, it is difficult to account for the distribution in terms of temperatures encountered since no critical temperatures have been defined. The best that can be done with Acmaea pelta is to accept tentatively the highest known spawning temperature, 60.0° F., and compare the species range with this particular isocryme. If a relationship is present, the two may be expected to coincide within a few degrees. Plate 32 shows that the range of this species terminates at the 59° F. isocryme, only 1° from the highest determined spawning temperature. It may thus be assumed that A. pelta, like other northern species, is restricted to the south by the maximal temperature at which it can spawn. Whether the gonad shows a summer indeterminate phase in the more southern latitudes is not known.

Acmaea digitalis Eschscholtz, 1833

Geographic range: Aleutian Islands to Guadalupe Island, Mexico
Latitudinal range: 60°-30° N. Lat.
Isothere range: 50°-69° F. (19°)
Isocryme range: 35°-61° F. (26°)

Disagreement exists concerning the southern limits of this species which is listed by Keen (1937) as 19° N. Lat. and by Test (1937) as Guadalupe Island, Mexico. Specimens in the collection of the California Academy of Sciences from Guadalupe Island are unmistakably Acmaea digitalis, and this is the most southern point from which they have recorded the species. It does not occur on Socorro Island as listed by Dall (1921).

The data on reproduction from the population at Moss Beach (Plate 13, Part III) suggest that the species is active at this latitude throughout the year. The maximum temperature at which spawning occurred was in June-July, 1951, the mean temperature for the period being 56° F. The isocryme for this temperature does not even closely agree with the southern limit of the range, the 56° isocryme falling approximately at 36° N. Lat. or just south of Monterey, California. This continuous breeding is to be expected when the area of study lies near the center of the range of temperature tolerance of a species as is the case for Acmaea digitalis.

The data from the Rockaway Breakwater population of Acmaea digitalis (Plate 12, Part III) are perhaps more reliable because interpolation, as explained previously, was not necessary to localize spawning periods. The minimum temperature at which spawning occurred was 49.5° F. during February, 1950. This value is approximately the isothere for the northern limit of the species. Despite the extreme conditions of temperature and desiccation which the breakwater population must endure, there can be no doubt that it is an adequate habitat for the adult limpets. Were this not so, the continual collections which were made there over a period of three years and which totaled more than 9'000 individuals would certainly have drastically reduced the population. This did not happen, and thus the settlement of larvae and their growth must have been continuous. It seems that the extreme environmental conditions affected primarily the activity of the gonads and resulted in the sexually indeterminate summer phase. If it be assumed that this condition is realized throughout the most southern ranges of this species, it is clear that the time of development of the adult gonad restricts breeding times to the period most favorable to the larvae. Presumably the ultimate response of this species, like A. persona, to increasing temperatures would be a nonfunctioning gonad.

Acmaea limatula Carpenter, 1864

Geographic range: Tomales Bay, California, to Tres Marias Islands, Mexico
Latitudinal range: 38° - 21° N. Lat.
The open coast range terminates approximately at Santa Cruz, California, a distribution for which the following temperature ranges are given.
Isothere range: 60°-80° F. (20°)
Isocryme range: 55° - 75° F. (20°)

This southern species is given a southern limit by Keen (1937) of 24° N. Lat. which is near the southern tip of Lower California. However, Strong and Hanna (1930) found it on the Tres Marias Islands, and the California Academy of Sciences possesses an unmistakable specimen from Socorro Island of the Revillagigedos. The southern range is therefore extended to 21° N. Lat. According to Test (1937) the species is numerous at Pacific Grove, California, but, except for an occasional specimen, is not found north of there or Santa Cruz on the open coast. Pockets of warm water do exist which support the species, one of which is Tomales Bay. Keen (1937) lists the northern limit as Puget Sound, but it is not reported by Curtiss (1941) nor has the author collected it despite extensive collecting there and in the San Juan Islands.

In Tomales Bay the so-called subspecies Acmaea limatula moerchii Dall, 1878, spawns once a year during September at a time when water temperatures are at a maximum of about 60° F. on the open coast (Plate 10, Part III). This is followed by a period when spawned and sexually indeterminate animals are found and when the gonad is slowly reformed. This cycle correlates well with the distribution of the species, since it terminates just northward of the 60° F. isothere (Plate 31). It appears that this species is limited in its northward distribution by the temperature required for its spawning. The gonad can redevelop even during the coldest part of the year as shown by the decrease in the numbers of indeterminate animals during the winter months. But, as previously indicated, the gonads of this population do not develop the extreme turgor seen in most of the other species suggesting that the temperatures do not favor maximal reproductive activity.

Acmaea asmi (Middendorf, 1847)

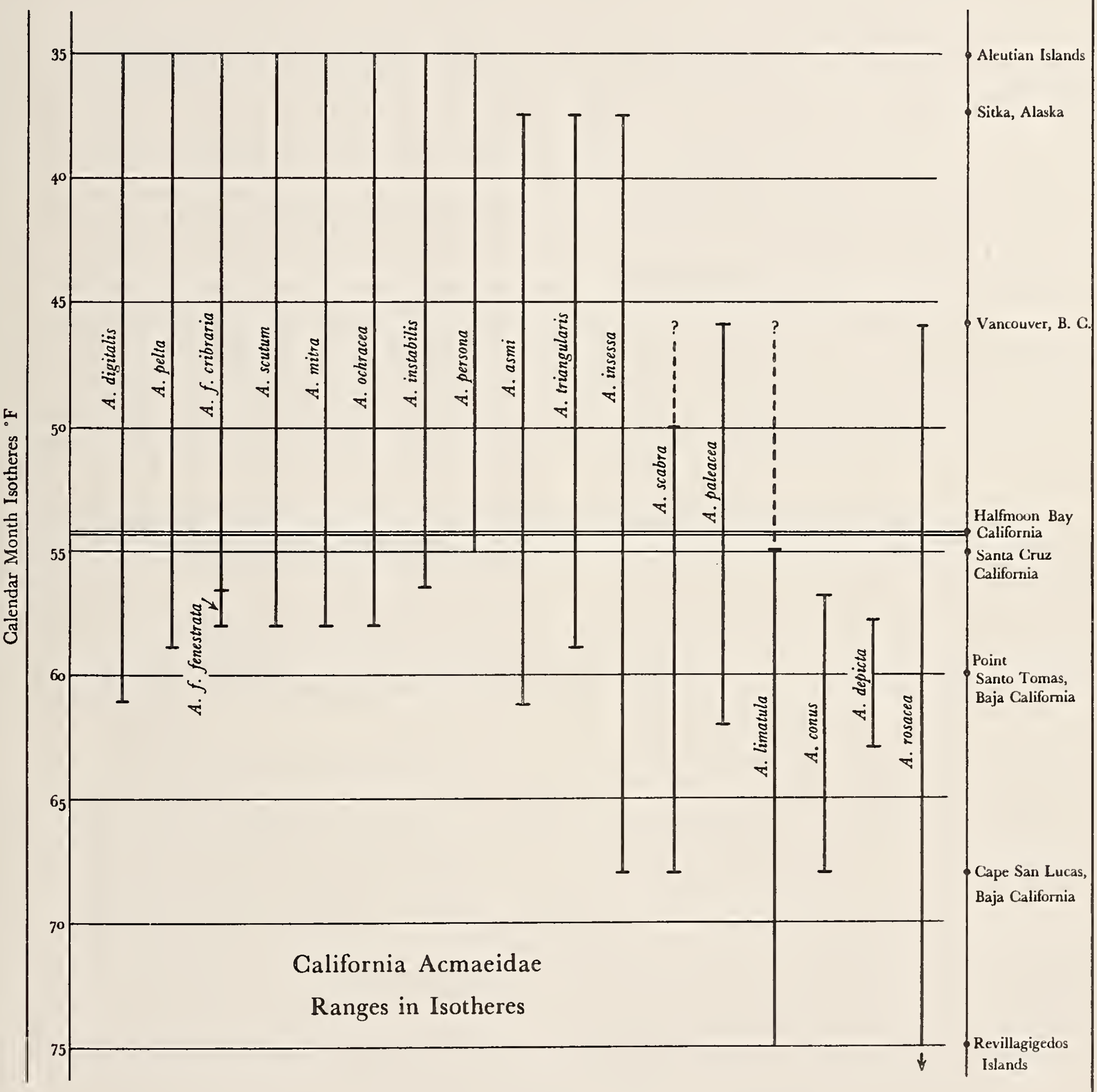
Geographic range: Sitka, Alaska, to San Quintín Bay, Lower California
Latitudinal range: 57° - 30° N. Lat.
Isothere range: 55° - 69° F. (14°)
Isocryme range: 38° - 61° F. (23°)

Acmaea asmi, as would be expected of a species with a southern distribution, is reproductively active during a period from April to September or October and then enters a period of reproductive latency until the following March when gonad redevelopment begins (Plate 11, Part III). The minimum water temperature at which it is known to have spawned at Moss Beach is 52° F. in April, 1951. This figure agrees reasonably well with the 55° F. isothere which forms the northern limit of the species near Sitka. The reproductive cycle of this species appears to be controlled as much by the effect of low temperature on the gonad as by the requirement for a certain spawning temperature since, unlike A. limatula, its gonad is nonfunctional during the winter months. It would be interesting to know if the animals become sexually indeterminate during the winter in Alaskan waters.

Acmaea scabra (Gould, 1846)

Geographic range: unknown point in Northern California or southern Oregon to Cape San Lucas, Lower California
Latitudinal range: unknown point near 42° to 23° N. Lat.
Isothere range: 58° (California-Oregon border) to 80° F. (22°)
Isocryme range: 50° (California-Oregon border) to 68° F. (18°)

This species is listed by Keen (1937) as



California Acmaeidae
Ranges in Isotheres

extending to Puget Sound. Like Acmaea limatula, it is not reported by Curtiss (op. cit.) nor have I found it in these waters. Furthermore, it has been rarely, or doubtfully, reported from the vicinity of Coos Bay, Oregon. Hence, the California-Oregon border is taken as a tentative northern limit.

Acmaea scabra does not show any reproductive phenomenon which can be correlated with a critical temperature. Consequently, few conclusions can be drawn between its reproduction and distribution. It is, at this latitude, a year around breeder (Plate 14, Part III). This is quite strange considering that the area of study lies probably within 2° F. of the northern limit of the species in isotheres. It would be expected that it would be a late summer breeder like A. limatula while, in actuality, it spawns at sea temperatures ranging from 50° to 57° F. However, two items are worth noting. One is that A. scabra did not develop the extreme turgor of the gonad which characterizes the typically ripe limpet, a condition also seen in A. limatula, and which may be correlated with the colder waters of Central California. The second is that A. scabra from the Rockaway Breakwater does not undergo a summer indeterminate period as does A. digitalis which may reflect the adaptation of A. scabra to the higher temperatures of its southern distribution. However, it must be admitted that A. scabra, because of its possession of a home scar on the rock and its inclination toward horizontal surfaces, would not receive the severe desiccation of A. digitalis.

Acmaea insessa (Hinds, 1842)

Geographic range: Sitka, Alaska, to Cape San Lucas, Lower California
Latitudinal range: 57° - 23° N. Lat.
Isothere range: 55° - 80° F. (25°)
Isocryme range: 38° - 68° F. (30°)

It is unfortunate that the reproductive data on this very eurythermal southern species are rather confused as a result of this limpet's tendency to spawn readily. Such data as are available indicate that spawning occurs throughout the year, spawnings having been recorded from November, 1949; January and February, 1950; April and May, 1950; and in July, 1950 (Part II). Spawnings in the laboratory have occurred at temperatures ranging from 10° C. to 19° C. (50° - 66° F.), the latter value being at least 6° F. in excess of sea temperatures normally encountered at this latitude. Plate 31 shows that the area of study lies well to the north of the midpoint of the isothere range of the species, a fact that cannot be reconciled with its presumed continuous breeding which, theoretically, should be confined to the summer. As with Acmaea scabra, the lack of an established critical temperature prevents establishment of relationships between reproduction and distribution.

Summary

The above analysis reveals that the reproduction of the acmaeids is affected in several ways as the various species approach the ends of their geographic ranges.

1. The production of gametes may be entirely suspended at unfavorable periods of the year. For northern forms like Acmaea persona, A. fenestrata cribraria, and A. digitalis, this occurs during the summer months. In A. asmi, a southern species, gonad activity is curtailed during the winter. In these cases the physiology of gametogenesis appears to be the factor limiting the species range, since at more extreme latitudes the gonad would presumably become entirely nonfunctional.

2. Another limiting response is that of the spawning reactions of the adult. In such species as Acmaea mitra and A. limatula, and perhaps also A. pelta and A. scutum, the limits of the range are correlated with the spawning temperature required by the species. Thus, although the gonad may be fully ripe, as is the case with A. mitra, spawning may not occur because of lack of proper water temperature stimuli.

3. A third response is the reduced activity of the gonad of southern forms in more northern latitudes. This has been observed in Acmaea scabra and A. limatula where the turgor, characteristic of the ripe gonad, is seldom attained.

The data accumulated here all suggest that the ranges of the limpets studied are determined by the failure of the reproductive mechanism and that death of the adults is probably not involved except, perhaps, in extreme northern waters where freezing may occur.

Acknowledgment

The author desires to express his appreciation for the many helpful suggestions made by Drs. J. W. Durham, Frank Pitelka, and Ralph I. Smith, all of whom read the original manuscript. I also would like to thank Dr. Willard Hartman for his help and encouragement and Drs. R. Stohler and Cadet Hand for guidance in its publication.

Literature Cited

Curtiss, Ruby M.
1941. An ecological and taxonomic survey of the Acmaeidae of the Northwest Pacific area. M. S. thesis, Univ. of Washington.

Dall, William Healey
1921. Summary of the marine shellbearing mollusks of the northwest coast of America, from San Diego, California, to the Polar Sea, mostly contained in the collection of the United States National Museum, with illustrations of hitherto unfigured species. U. S. Nat. Mus. Bull. 112: pp. 1-217, pls. 1-22.

Fritchman, Harry K.
1961a. A study of the reproductive cycle in the California Acmaeidae (Gastropoda). Part I. Veliger 3(3): 57-63.

——, ——
1961b. A study of the reproductive cycle in the California Acmaeidae (Gastropoda). Part II. Veliger 3(4): 95-101.

——, ——
1961c. A study of the reproductive cycle in the California Acmaeidae (Gastropoda). Part III. Veliger 4(1): 41-47.

Grant, Avery R.
1937. A systematic revision of the genus Acmaea Eschscholtz, including consideration of ecology and speciation. Ph. D. thesis, Univ. California, Berkeley.

Hutchins, L. W.
1947. The bases for temperature zonation in geographical distribution. Ecol. Monogr. 17 (3): 325-335.

Hutchins, L. W., & M. Scharff
1947. Maximum and minimum monthly mean sea temperatures charted from the "World atlas of sea surface temperatures". J. Mar. Res. 6 (3); 264 to 268.

Keen, A. Myra
1937. An abridged check list and bibliography of west North American marine mollusca. Stanford Univ. Press. 87 pp.

Orton, J. H.
1920. Sea temperature, breeding and distribution in marine mammals. J. Mar. Biol. Assoc. N. S. 12: 339-366.

Runnstrom, S.
1927. Über die Thermopathi der Fortpflanzung und Entwicklung mariner Tiere in Beziehung zu ihrer geographischen Verbreitung. Bergens Mus. Aarbok, Nat. Rekke 2: 1-67.

——, ——
1929. Weitere Studien über die Temperaturanpassung der Fortpflanzung und Entwicklung mariner Tiere. Bergens Mus. Aarbok, Nat. Rekke 3: 1-46.

——, ——
1936. Die Anpassung der Fortpflanzung und Entwicklung mariner Tiere an die Temperaturverhältnisse verschiedener Verbreitungsgebiete. Bergens Mus. Aarbok, Nat. Rekke 10: 1-36.

Stohler, Rudolf
1959. Range extensions of some west N. A. marines. Nautilus 72 (4): 127-130.

Strong, A. M., & G. Dallas Hanna
1930a. Marine mollusca of the Revillagigedos Islands, Mexico. Proc. Calif. Acad. Sci., 4th ser., 19(2): 7-12.

——, —— & ——, ——
1930b. Marine mollusca of the Tres Marias Islands, Mexico. Proc. Calif. Acad. Sci., 4th ser., 19(3): 13-22.

Test, A. R. see Grant, Avery R.

Thorson, Gunnar
1946. Reproduction and larval development of Danish marine bottom invertebrates. Medd. Komm. Dan. Fisk. -og Havunders., ser. Plankton, 4: 523 pp.

Revision of Some Hawaiian Mitrid Species

by

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(Plates 33, 34 & 35)

There are several Mitrids from Hawaiian waters which have proved difficult to identify, particularly some of the deep-water species dredged during the 1959 Pele Expedition. The research necessary to identify some of these forms has brought to light certain problems of synonymy which, to the best of my knowledge, have never been discussed.

The only readily available illustrated references pertaining specifically to the Hawaiian marine gastropod fauna are Pilsbry (1920), Edmondson (1946), Morris (1952) and Tinker (1958); none of these works covers all of the Hawaiian species. The checklist of Hawaiian Mitra published in the Hawaiian Shell News (1956) indicates about 100 species recorded from Hawaii, and a second list shows 22 additional species which are undescribed Dall manuscript names. In the four works cited, Edmondson illustrates five of these 100 species, Morris eight, and Tinker 33, although Tinker has also included illustrations of several unidentified species.

I found on further investigation that some of the Pilsbry Hawaiian species, supposedly endemic, resembled very closely certain long-known Indo-Pacific species. The Pilsbry type figures are rather unsatisfactory, and it was not possible, based on them alone, to work out a definite answer as to whether all of the Pilsbry names are valid or merely synonyms of earlier-named species. It was therefore my good fortune when a vacation in the northern California area last spring coincided with the loan of some of the Pilsbry types from the Academy of Natural Sciences of Philadelphia to the Paleontology Department of Stanford University. At that time I had the privilege of examining this material at first hand and the opportunity of comparing it with similar species in the Stanford Collection. I am greatly indebted to Dr. Myra Keen for directing my attention to this material, for offering the use of the Stanford Paleontology Department's collection and library, and for providing me with excellent photographs of many of the Pilsbry type specimens through the facilities of her department.

The photographs made it possible for me to pursue the study of these 13 species after returning home, comparing them at leisure with similar specimens in my own collection and with the literature pertaining to worldwide Mitridae. I found that certain of the species were undoubtedly synonyms, while others were valid and some of these apparently endemic to Hawaii. I shall report my findings on each of the 13 species separately here, following the same order in which they appeared in the original publication:

1. Mitra kamehameha
2. Mitra thaanumiana
3. Mitra ostergaardi
4. Mitra lugubris honoluluensis
5. Mitra ticaonica vagans
6. Mitra olivellaeformis
7. Mitra langfordi
8. Mitra emersoni
9. Mitra waikikiensis
10. Vexillum thaanumi
11. Vexillum xenium
12. Vexillum micra
13. Vexillum turben kanaka

To explain some points to be raised later, I should like to mention that I have had the additional good fortune to have on loan examples of each of the species in the very large and well catalogued Mitra collection of Mr. Ditlev Thaanum of Honolulu. This valuable collection, certain maps and charts of remote Pacific atolls, and his catalog lists have very generously been made available to me by Mr. Thaanum to use in my current work with the Mitridae, and have proved invaluable in identifying some species not in my own collection. Mr. Thaanum's field notes provide the only ecological information available on some of the species.

Many other species of Hawaiian Mitra have been sent me, both on loan and as gifts, by Mr. Clifton S. Weaver of Honolulu; among these are many which were dredged during the Pele Expedition of 1959. Still others have been sent by several of the enthusiastic Hawaiian collectors including Evelyn Gage, R. P. Gage, Jr., and Elizabeth Harrison. To all these kind people I wish to express my gratitude for their willingness to help, both with specimens and information.

The collection of Professor Jens M. Ostergaard of Mountain View, California, was examined in the course of the research for this paper, as his collection contains paratype and topotype material of some of the Pilsbry species, and was a part of the nucleus for Dr. Pilsbry's work.

With the single exception of Mitra olivellaeformis, one of the more common of the 13 species, the types of all of the Pilsbry Hawaiian species discussed here were collected by either Ostergaard, Thaanum or D. B. Langford. Mr. Langford was Mr. Thaanum's close personal friend and fellow collector for over 50 years; his collected material is now in the Thaanum Collection which, together with the Ostergaard Collection, probably constitutes the bulk of the remaining Pilsbry type material not presently in the Academy of Natural Sciences of Philadelphia.

After the preliminary manuscript for this paper had been completed, an unexpected trip to the east coast made it possible to verify my views by examining the collections at the American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the United States National Museum. This trip broadened the scope of the study by giving me the opportunity to see additional specimens of the 13 species and comparative material, as well as to record further locality data; without exception, the findings remained the same as my original conclusions. I am grateful to Mr. William E. Old, Jr., Miss Virginia Orr and Dr. J. P. E. Morrison of these institutions for expediting my work during the brief stops at each place.

While at the National Museum in Washington, I was able to see the 22 unpublished Hawaiian Mitra species of W. H. Dall; some of these were found to be synonymous with the Pilsbry species and are so recorded here. Pending validation, the Dall manuscript names listed in the Hawaiian Shell News are nomina nuda and are presently unavailable.

1. Mitra kamehameha Pilsbry, 1920 = Mitra ustulata Reeve, 1844
   [Plate 33, figure 1; holotype of M. kamehameha]

This species was described from a single decollate subfossil specimen from the dredger dump at Honolulu Harbor. Pilsbry mentioned its similarity to Mitra ustulata, the chief difference being in the lengths of the apertures, which he described as "less than half the total length of ustulata, more than half in kamehameha". As may be seen in the accompanying photograph of the type specimen of M. kamehameha, the aperture and spire would be of about equal lengths in that specimen if the spire were complete. This photograph closely matches the Reeve type figure of M. ustulata (Conch. Icon., sp. 89), the Sowerby figure of that species (Thes. Conch., fig. 227), and the Tryon figure (Man. Conch., Pl. 35, fig. 51).

Specimens of Mitra ustulata from the Viti Isles, Aden and the Paumotus in the American Museum of Natural History match it also, except that the surface sculpturing of a few of these specimens is rougher and deeper than in the Pilsbry holotype of M. kamehameha; this might be explained by the fact that the subfossil shell is smooth through being worn.

A juvenile subfossil specimen of this species was collected by R. P. Gage, Jr. in 1960. Three specimens in the Academy of Natural Sciences of Philadelphia were collected by Dr. C. M. Burgess in 25 to 50 feet of water, inside coral heads at Nanakuli, Oahu. Mitra ustulata is rare in Hawaii, and to the best of my knowledge is represented in collections there largely by dead specimens.

Mitra ustulata somewhat resembles M. abbatis Dillwyn, 1817 and M. ignobilis Reeve, 1844 which are also found uncommonly in Hawaii. They differ in that M. ustulata is proportionately longer, slimmer, and smoother, with M. abbatis bearing strong spiral sculpture, a spire considerably longer than the aperture, and a more obese body whorl. Mitra ignobilis is intermediate between the other two species in its sculpture; that is, ignobilis is more strongly sculptured than ustulata but less so than abbatis; the spire is shorter than the last whorl, and the last whorl is more ventricose. The colors and markings of these species are similar.

2. Mitra thaanumiana Pilsbry, 1920 = Mitra coffea Schubert and Wagner, 1829 (Mitra fulva Swainson, 1832)
   [Plate 33, figure 2; type specimen of M. thaanumiana]

There is little doubt that these two species are synonymous; Pilsbry's types and written description of Mitra thaanumiana are identical with Schubert and Wagner's type figure and description and Swainson's figure of M. fulva, as well as with examples of M. coffea from various parts of the Pacific.

Mitra ambigua Swainson, 1832 and M. fulva Swainson, 1832 have been considered synonymous by some authors, which could explain the error in identification frequently encoun-

Explanation of Plate 33

Figure 1: *Mitra ustulata* Reeve 1844. Ventral and dorsal aspects of the holotype of *Mitra kamehameha* Pilsbry, 1920 (ANSP No. 46 753, height 59.4 mm.) Figure 2: *Mitra coffea* Schubert & Wagner, 1829. Holotype and paratype of *Mitra thaanumiana* Pilsbry, 1920 (ANSP No. 46 810, height of left-hand specimen 53.4 mm.) Figure 3: *Mitra ostergaardi* Pilsbry, 1920. Ventral and dorsal aspects of the holotype (ANSP No. 46 770, height 43.5 mm.) Figure 4: *Mitra tiarella* A. Adams, 1851. Holotype and paratype of *Mitra lugubris honoluluensis* Pilsbry, 1920 (ANSP No. 46 797, height of left-hand specimen 23.0 mm.) Figure 5: *Mitra ticaonica* Reeve, 1844. Holotype and paratype of *Mitra ticaonica vagans* Pilsbry, 1920 (ANSP No. 46 790, height of right-hand specimen 25.0 mm.)

(Figures 1 to 5 photographs by Perfecto Mary, courtesy of Stanford University)

Figure 6: *Mitra olivaeformis* Swainson, 1821. Dorsal aspects of typical variants (left to right): 1. Resembles the unfigured punctate holotype of *Mitra olivellaeformis* Pilsbry, 1920. From Kauai. 2. A typical smooth specimen, from Oahu. 3. With produced and punctate spire, from Okinawa. 4. A slender specimen, from the Caroline Islands. 5. An obese specimen, from Kauai. 6. With mucronate spire, from Kauai.

(Photograph by Victor Duran, Scientific Photographic Laboratory, University of California; twice natural size.)
(Specimens 1 to 4 ex Cate Collection; 5 & 6 ex Thaanum Collection.)

Figure 1

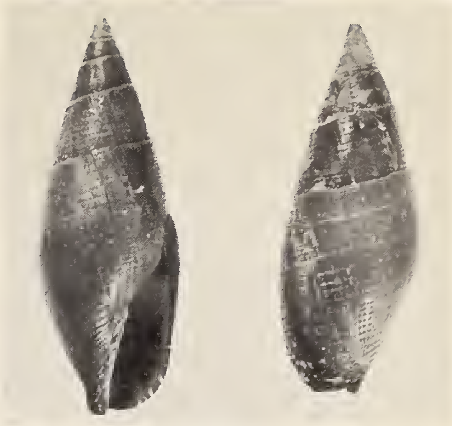

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

tered in connection with these species. The original figures of both appear on the same page (Swainson, Zoological Illustrations, Part 2, Plate 30) and are obviously separable, *M. ambigua* having a wide whitish band a short distance below the sutures and stronger punctate spiral sculpture, besides being more attenuate anteriorly; *M. fulva* is a smoother shell with no color pattern. However, the name *coffea* was applied to this species three years earlier than Swainson's name and thus has priority.

The error in identification and its application to the present species is seen in a note in the species catalog of Mr. Ditlev Thaanum, listing this entry:

> "*Mitra ambigua* Swainson. #1519. Keaukaha, Hilo, Hawaii. Th., Coll., '03. Under rocks. Rare. Id. by Dr. W. H. Dall as *Mitra ambigua* Swainson. This is type lot of *M. thaanumiana* Pilsbry."

Mitra coffea is chestnut brown inside and out, with five or six white folds on the columella and many white denticles on the outer lip. The spiral sculpturing is weakly punctate throughout; the lip is constricted above, effuse below; the canal is short and sharply recurved abaxially. Its range includes Madagascar, the Philippines, Marianas, Guam, Samoa, Tahiti and Polynesia. Considered rare in Hawaii, it has been collected in 10 to 15 feet of water off Waikiki, Oahu (Dranga and Thaanum), and under rocks at Keaukaha Ponds, Hawaii (Thaanum).

3. *Mitra ostergaardi* Pilsbry, 1920
[Plate 33, figure 3; syntypes of *M. ostergaardi*; Plate 35, figure c; ex. Cate coll.]

Pilsbry erred in comparing this species with *Mitra ambigua*; he apparently accepted Tryon's synonymizing of that species with *M. fulva* Swainson (= *M. coffea* Schubert and Wagner, 1829). It differs, however, in its slimmer and more cylindrical form, its pure white aperture, and a smooth adapical edge to the labrum (whereas that of *M. coffea* is denticulate for its entire length). *Mitra ostergaardi* has fewer punctate spiral grooves than *M. coffea*, strongest on the upper whorls, shoulder and neck of the shell, with the periphery nearly smooth.

The types of *Mitra ostergaardi* are faded subfossil specimens from the dredger dump at Honolulu, and therefore differ to a certain extent from live-collected specimens. Freshly collected shells are a deep chocolate brown with a faint indication of a paler narrow subsutural band. Some have tiny speckles of pure white on the lower half of the last whorl. The aperture is constricted above, effuse at the base, as in *M. coffea*; there are five columellar folds.

Living specimens have been collected in recent years in deep water at Oahu, Hawaii: in 30 to 40 feet of water under dead coral, Kailua Bay (C. S. Weaver), dredged in 100 feet on a sand and coral rubble substrate off Waianae (Pele Expedition), in 25 to 35 feet on top of the reef at Nanakuli (C. M. Burgess, ANSP specimens), in 45 feet in coral heads off Makua (C. M. Burgess, AMNH specimens). *Mitra ostergaardi* has also been reported in dredgings from the lagoon on the north side of Kwajalein Atoll in the Marshall Islands in 1943 (R. V. Dietrich).

The type of *Mitra ostergaardi* is at the Academy of Natural Sciences of Philadelphia.

Mitra pararhodia Dall (MS.) is probably the same species. USNM specimens bearing this label were collected at Sand Island, Midway, by Bartsch in 1907.

4. *Mitra lugubris honoluluensis* Pilsbry, 1920
= *Mitra tiarella* A. Adams, 1851
[Plate 33, figure 4; type specimens of *M. l. honoluluensis*]

This subspecies was erroneously assigned by Pilsbry to *Mitra lugubris* Swainson, 1822. It is more closely related to *M. coronata* Lamarck, 1811 (*non* Helbling, 1779), a species similar to *M. lugubris* in some ways and frequently confused with it.

Mitra tiarella A. Adams, 1851 was first figured by Sowerby (1874); it differs from *M. coronata* in that its crenulations are lightly tipped with white instead of occupying a wide, solid-white subsutural zone, and *M. tiarella* bears also a narrow pale band below the crenulations which does not appear in *M. coronata*.

In Hawaii *Mitra tiarella* has been collected off Maili, Oahu (Thaanum), in 20 to 30 fathoms off Waikiki, Oahu (Thaanum), under dead coral in 30 to 40 feet (C. S. Weaver), dredged in 100 feet in coral rubble and sand off Waianae, Oahu (Pele Expedition), and many subfossil specimens are known from the dredger dump in Honolulu. The species is also known from the Sulu Sea (F. Dayrit), Japan (Thaanum), and the Ryukyu Islands (Thaanum, A. Scott). With so much confusion regarding the identification of specimens labelled *Mitra coronata* and *Mitra lugu-*

bris, due possibly to errors in Sowerby (1874) and Tryon (1882) (see page 132), I prefer not to list further locality records beyond those specimens which I have personally seen and regard as unquestionably M. tiarella.

Mitra assimilis Pease, 1867 is very similar, but Pease in his description says "there is not the slightest evidence of crenation at the sutures" and his holotype will have to be studied before a decision may be made as to whether it is conspecific with M. tiarella.

Mitra crassula Dall (MS.) is the same species (USNM No. 339'899).

5. Mitra ticaonica vagans Pilsbry, 1920 = Mitra ticaonica Reeve, 1844
[Plate 33, figure 5; type specimens of M. t. vagans]

Pilsbry's basis for separating his subspecies from the typical Philippine Mitra ticaonica was that the Hawaiian specimens were smoother on the last whorl and less deeply grooved on the spire. After examining many museum specimens from various other points in the Pacific from Samoa to Tawi-Tawi (including the type locality, the island of Ticao), I believe the two geographical forms are not separable morphologically. The subspecies was described from two worn subfossil shells which could be expected to exhibit less sculpturing than live-collected specimens; any other discernible differences appear to be merely normal variations within the species. Some specimens are shorter and more obese than others and a few show more pronounced sculpturing, but these differences appear throughout the range of the species with no more emphasis on one locality than another.

Live-collected specimens taken by Thaanum on the reefs at Kewalo, Oahu are chocolate brown and have fine spiral striae throughout, these becoming somewhat more coarse at the neck of the shell. The aperture is also dark brown, with four white columellar folds and a strong, pale brown nodule in the throat. Specimens are frequently so encrusted that only the aperture may be seen.

Mitra pupiformis Dall (MS.) is the same species (USNM No. 338'028).

6. Mitra olivellaeformis Pilsbry, 1920 = Mitra olivaeformis Swainson, 1821
[Plate 33, figure 6; ex. Cate coll.]

Since Pilsbry's species, admittedly very similar to Mitra olivaeformis, is found living in the same populations with that species in Hawaii and elsewhere throughout the Pacific, it would appear that M. olivellaeformis is not deserving of specific rank. Its only difference lies in the presence of punctate spiral sculpture on the last whorl which is not usually present in the typical olivaeformis. This punctate character is frequently seen in other Mitrid species; in M. pontificalis Lamarck, 1811 and M. papalis Lamarck, 1811, for example, the upper whorls are entirely punctate while the last whorl is smooth. Therefore, young specimens would appear punctate while adults of the same species would not. Mitra olivaeformis seems to be one of the more variable of Mitrid species, and the punctate sculpture noted by Pilsbry merely one of its variations.

Other even more obvious differences within the species may be seen, with large series to study. Some specimens have a very strongly produced spire, while others are mucronate; in some the upper whorls are swollen and bulbous, while the usual form of an average specimen has sloping shoulders. The fact that all forms, smooth and punctate, produced and mucronate, swollen and gradate, slender and obese, are found in the same populations within the range of the species seems ample reason to consider them merely intrapopulation variants and to retain the original name Mitra olivaeformis for all of the variations. Even if Pilsbry's M. olivellaeformis were considered a separate taxon, it should be made a subspecies of M. olivaeformis, as its differences are too minor to justify full species rank for this form.

The photographs on Plate 33 (figure 6) illustrate some of the extremes mentioned above. The first shell resembles Pilsbry's unfigured type of Mitra olivellaeformis, while the second is a typical smooth specimen.

Mitra olivaeformis is recorded from localities throughout the entire central Pacific area, reported by Garrett (1880) as "very abundant and gregarious in sand inside the reefs". It has been collected in depths ranging from one or two feet to 30 fathoms (off Waikiki, Oahu; Thaanum).

7. Mitra langfordi Pilsbry, 1920 = Mitra peasei Dohrn, 1860
[Plate 34, figure 1; syntypes of M. langfordi]

Pilsbry compared this species with Mitra granatina Lamarck, with M. gracilis Reeve, M.

filosa Born, M. bernardiana Philippi, and M. circula Kiener, but unfortunately overlooked Dohrn's M. peasei, which is identical with Pilsbry's type specimens of M. langfordi.

Mitra peasei is a white shell with a buff periostracum. Its aperture is china-white, with a pink tinge in young specimens. It is encircled with slender, rather beaded brown spiral cords, the brown color on these sometimes interrupted. There is fine cancellate sculpture in the interstices, caused by the intersection of a fine median spiral cord with equally fine axial impressed lines. The surface of the shell frequently shows irregular brown clouding, especially in young specimens. The protoconch is rosy-pink, conical-multispiral, deviated, homeostrophic, and unlike many Mitrid species, the protoconch persists in most specimens into adulthood.

Two notations in Mr. Thaanum's catalog on the page devoted to Mitra peasei are of interest here; the first refers to a set of shells collected in Maui:

> "No. 1710, e. Id. by Dr. W. H. Dall, 1920, as Mitra peasei Dohrn."
>
> The second note reads as follows:
>
> "No. 1710. Honolulu, Oahu, harbor entrance in 6-10 fathoms of water. D. B. L., Coll., 1915. This is type lot of Pilsbry's Mitra langfordi."

With patronymic names being applied to new species so freely today in honor of persons who have made no real contribution to malacology, it is regrettable that the name of D. B. Langford should be lost in this case through an oversight. His carefully documented collections throughout the Pacific area over a period of some 50 years contributed greatly to the science.

The type locality of Mitra peasei is Australia.

8. Mitra emersoni Pilsbry, 1920
[Plate 34, figure 2; type specimens of M. emersoni; Plate 35, figure d; ex. Cate coll.]

This species, as Pilsbry stated, is "closely related to Mitra crenifer (sic) Lamarck" (= M. clathrus Gmelin, 1790). His basis for separating the Hawaiian form is that it is "smaller, the vertical impressed lines about twice as far apart". The relative size is a poor criterion for establishing a new species; however, it may be readily seen with a much larger series than Pilsbry had available that there is an appreciable difference in its proportions from those of the typical M. clathrus from Japan and the Philippines. Mitra emersoni is a slimmer species with a more produced spire, averaging nearly two millimeters narrower at the periphery than M. clathrus specimens of comparable length.

Additional differences include the further-apart vertical impressed lines noted by Pilsbry, a fainter and less distinct though very similar color pattern, and the prominence and beaded appearance of the raised spiral bands. In Mitra clathrus the surface is uniformly cancellate; in M. emersoni the interstices between the spiral bands exhibit additional, finer ornamentation.

The color of Mitra emersoni is white under a buff periostracum; nucleus and base are pink, with a pink blush extending onto the columella in fresh specimens. The interior of the aperture is white, the pattern and intermittent sections of the spiral threads chestnut brown.

Mitra emersoni is a deep-water species, recorded by Thaanum in from 25 to 75 feet off Laniupoko Camp and Mala Bay, West Maui; off Waikiki, Oahu in 20 to 30 fathoms; in Waialua Bay, Oahu in 12 to 15 fathoms; at the entrance to Pearl Harbor in 6 to 10 fathoms (type lot); and in 150 feet in sand off the entrance to Pearl Harbor during the Pele Expedition. Further records in the U. S. National Museum indicate its occurrence at Koloa, Kauai; at Pearl and Hermes Reef; and at Sand Island, Midway.

The type specimens of Mitra emersoni are at the Academy of Natural Sciences of Philadelphia.

9. Mitra waikikiensis Pilsbry, 1920
[Plate 34, figure 3; type specimens of M. waikikiensis; Plate 35, figure a; ex. Cate coll.]

Mitra waikikiensis is a distinctive species, easily separable from any other Miters in the Hawaiian fauna. It is characterized by its nodulose sculpture throughout, and ornamented with two brown bands from which the glossy white nodules protrude. In specimens still retaining the periostracum, the nodules are very dark blackish-brown, as is the protoconch; the remainder of the periostracum is a cinnamon-brown color. The nodules are arranged in rows in a very precise manner, suggesting the nodulose sculpture seen on the parietal wall of Distorsio anus (Linnaeus, 1758).

Pilsbry's species was described from two specimens dredged by D. B. Langford off Waikiki in 35 to 50 fathoms. Both are small shells, the larger of the two measuring only 12.5 mm. In addition to the type specimens, I have seen nine of comparable size in the Thaanum Collection and approximately 35 live-taken and dead specimens which were dredged during the Pele Expedition. Except for eight very large shells dredged in 60 fathoms in Keehi Lagoon, Oahu, all of these were also approximately the same small size. The Keehi shells, one of which is illustrated on Plate 35 (fig. a), are twice as large as the type specimens, ranging from 23 mm. to 29 mm. in length.

With over 45 specimens at hand, it was possible to make certain observations about the species which were not noted by Pilsbry in his original description. In addition to the unusually large size of the eight examples noted above, other observations include a variability in the number of columellar folds; Pilsbry mentioned three folds, the lower one quite small. The majority of shells in the series studied possess four folds, but one is seen to have five and only four have three folds. The protoconch is conical, glossy-white except as noted in those specimens still retaining the epidermis, and consists of about $2\frac{1}{2}$ to 3 whorls.

Mitra waikikiensis is apparently a deep-water species; the shallowest record among my notes is off Mala Bay, West Maui, dredged by Thaanum in 25 to 75 feet; otherwise, it is recorded only from depths of 100 to 360 feet on sand, or a sand and coral rubble substrate (Pele Expedition), and from 60 to 500 feet (Thaanum).

Mitra waikikiensis bears a striking resemblance to the type figure and description of M. loricata Reeve, 1844 (Conch. Icon., sp. 174) and to Sowerby's figure of the same species (Thes. Conch., Plate 10, fig. 148), but since I have not seen examples of typical M. loricata it seems best at this time not to conclude that the two species are synonymous.

The type specimens of Mitra waikikiensis are in the Academy of Natural Sciences of Philadelphia.

Mitra colpophila Dall (MS.) is the same species (USNM No. 337'991).

10. Vexillum thaanumi Pilsbry, 1920
[Plate 34, figure 4; ex. Cate coll.; Plate 35, figure e; ex. Cate coll.]

One of the most beautiful of all the Mitrid species, Vexillum thaanumi is apparently known only from Hawaii, and of rare occurrence even there. It is a deep-water form, most of the known specimens having been dredged in from 25 to 300 feet of water. The type lot was dredged off Waikiki, Oahu, in 200 to 300 feet by D. B. Langford in 1916; V. thaanumi has also been collected in 4 to 12 fathoms off Mt. Lihau; in 28 to 43 fathoms in the Auau Channel; in Waialua Bay; off West Maui; at the entrance to Pearl Harbor, and in Keehi Lagoon.

The photographs of this species on Plate 34 do not illustrate the type specimens, which are somewhat encrusted and unattractive. The shells figured here were collected during the Pele Expedition in from 100 to 150 feet at the entrance to Pearl Harbor, Oahu, and are from the Cate Collection.

Pilsbry's original description of this species is as follows:

Explanation of Plate 34

Figure 1: *Mitra peasei* Dohrn, 1860. Ventral and dorsal aspects of syntypes of *Mitra langfordi* Pilsbry, 1920 (ANSP No. 46805, height of left-hand specimen 35.3 mm.) Figure 2: *Mitra emersoni* Pilsbry, 1920. Holotype and paratype (ANSP No. 46804, height of left-hand specimen 29.4 mm.) Figure 3: *Mitra waikikiensis* Pilsbry, 1920. Syntypes (ANSP No. 46788, height of left-hand specimen 12.5 mm.) Figure 4: *Vexillum thaanumi* Pilsbry, 1920 Ex Cate collection (height of left-hand specimen 23.3 mm.) Figure 5: *Vexillum xenium* Pilsbry, 1920. Type and paratype (ANSP No. 116983, height of left-hand specimen 18.0 mm.) Figure 6: *Vexillum micra* Pilsbry, 1920. Type figure of holotype and paratype (ANSP No. 116986, height of left-hand specimen 7.5 mm.) Figure 7: *Vexillum turben* (Reeve, 1844). Ventral and dorsal aspects of the holotype of *Vexillum* (*Idiochila*) *turben kanaka* Pilsbry, 1920 (ANSP No. 46763, height 23.0 mm.) Figure 8: *Vexillum turben* (Reeve, 1844). Typical specimen from Mauritius.

(Figures 1 to 3 and 5 to 8, photographs by Perfecto Mary, furnished through the courtesy of Stanford University)
(Figure 4, photograph by Victor Duran, Scientific Photographic Laboratory, University of California.)

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

"Vexillum thaanumi, n. sp.

"The shell is fusiform, rather slender, white, with a cinnamon brown band below the periphery. At the periphery there are narrow vinaceous or brownish spots between the ribs, surmounted by a continuous, cinnamon line. On the penult whorl this line is median.

"Sculpture of vertical ribs weakening towards the base, the intervals with short impressed lines in a spiral direction; on the last whorl there are 11 ribs and about 19 spirals, exclusive of those on the siphonal fasciole. On the penult whorl there are 10 or 11 impressions in an interval.

"The aperture is slightly pink tinted within, lirate in the throat. Five columellar plaits, the lower one very small.

"Length 25.3, diameter 8, aperture 12 mm; 10 whorls.

"Off Waikiki, Oahu, in 200-300 feet. D. B. Langford.

"Mitra interstriata Sowerby (Thes. Conch. fig. 392) resembles this species somewhat in color, but it is wider, contracted more above the more prominent siphonal fasciole, and has a wider aperture."

The largest specimen I have seen (in the U. S. National Museum Collection) measures 31.6 mm. in length; the smallest adult shell, in the same collection, is just under 8 mm. long.

The type specimens are in the Academy of Natural Sciences of Philadelphia.

11. Vexillum xenium Pilsbry, 1920
[Plate 34, figure 5; type specimens of V. xenium; Plate 35, figure b; ex. Weaver coll.]

Vexillum xenium is rare in collections and is presently known only from Hawaii. A few live specimens were taken during the Pele Expedition, dredged on a sand and coral substrate at 17 fathoms at the entrance to Keehi Lagoon, Oahu.

Vexillum xenium is said to resemble V. approximata (Pease, 1860), but is a distinct species, according to Dr. Alison Kay of the University of Hawaii (personal communication) who has seen and photographed the unfigured Pease holotype.

The original description of Vexillum xenium follows:

"Vexillum xenium n. sp.

"The shell is fusiform, white with a chestnut band traversed by several paler spiral lines, below the periphery, two or three paler interrupted lines above it on the summits of the ribs only, and a few widely spaced blackish-brown spots below the suture, on the ends of some of the ribs. The first three whorls are also deep brown. Sculpture of smooth, longitudinal ribs, 22 on the last whorl, equal to their interstices, the latter marked with short impressions in spiral series, 6 on the penult whorl in each interval; base spirally grooved over ribs and intervals forming about 4 spiral series of tubercles. Two obliquely spiral cords are more prominent just above the siphonal fasciole. Aperture shorter than the spire, the throat with 9 thin beaded lirae. Columella with 5 thin plaits.

"Length 18, diameter 7.5, aperture 8.4 mm., 10 whorls.

"Off Waikiki, Oahu, 25-50 fathoms. D. B. Langford.

"Turricula approxima (sic) Pease (P. Z. S. 1860) is described as convexly angulated at the sutures and with 4 plaits; it seems therefore to be a different species."

The type specimens of Vexillum xenium are in the Academy of Natural Sciences of Philadelphia.

12. Vexillum micra Pilsbry, 1920
[Plate 34, figure 6; type specimens of V. micra]

Vexillum micra is a tiny species, just over $\frac{1}{4}$ inch long. It is rare in collections, possibly because of its small size and deep-water habitat.

This species is not represented on the color plate (Plate 35) which illustrates the other five valid Pilsbry species from Hawaii, due to its unavailability for photographing in color. However, the black-and-white photograph on Plate 34 (figure 6) which was furnished through the courtesy of Stanford University, is the type figure of Vexillum micra, as no previous illustration has been published.

Pilsbry's original description follows:

"*Vexillum micra*, n. sp.

"The shell is fusiform, vinaceous tawny with a band at the periphery and another at the base of burnt umber. Sculpture of many vertical rounded ribs, about 30 on the last whorl, the intervals with wide, low spiral cords separated by impressed lines, of which there are 4 on the penult whorl; base with spiral cords. Aperture colored like the outside. Columella with four plaits. The embryonic shell is long-conic, of about $3\frac{1}{2}$ smooth whorls.

"Length 6.5, diameter 2.7, aperture 3 mm.; $5\frac{1}{2}$ post-embryonic whorls.

"Off Waikiki, Oahu, in 15-50 fms. D. B. Langford.

"One specimen is a little stouter and lacks the lower brown band."

The type specimens are in the Academy of Natural Sciences of Philadelphia.

13. *Vexillum* (*Idiochila*) *turben kanaka* Pilsbry, 1920 = *Vexillum* (*I.*) *turben* (Reeve, 1844) [Plate 34, figure 7: a type specimen of *V. t. kanaka*; figure 8: typical *V. turben* (Reeve)]

This subspecies was described from three subfossil dredger-dump shells, after apparently having been compared with only one other example of *Vexillum turben* (Reeve, 1844). To quote Pilsbry's description, "on comparison with a specimen of Reeve's species they show certain differences of shape which seem to be of racial significance". The illustrations on Plate 34 include one of the Pilsbry types (figure 7) and a second ANSP specimen of *V. turben* from Mauritius (figure 8). The only outstanding difference between the two seems to be in size, the Honolulu specimen being considerably larger than that from Mauritius and exhibiting proportionately larger dimensions throughout. Museum specimens from Mauritius, Lubang, Maeiret and Midway were examined in New York, Philadelphia and Washington and compared with several Hawaiian examples, and no morphological differences could be discerned which would justify subspecific rank for the Hawaiian specimens.

Vexillum turben is the type species of Pilsbry's section *Idiochila*, a small section containing only one or two additional species, one of these as yet undescribed. *Vexillum turben* is a very distinctive species bearing little resemblance to most other forms of *Mitra*. It is obesely pyriform, closely ribbed, finely striated in the interstices, with deep sutures and strong spiral grooves at the base. Its labrum is closely and finely lirate, the columella bears five or six strong folds and a parietal callus. The abapical edge of the outer lip is evidently a weak point in this species, as all the specimens I have seen give the appearance of having been broken away at this point; Reeve mentions this characteristic also in the original description. The typical color of a living specimen is unknown to me, as I have seen only pale yellow subfossil dredger-dump shells in Hawaiian collections and similarly faded specimens from other parts of its range in museum collections. The type locality is the Philippine Islands. It is a rare species worldwide.

To sum up the conclusions derived from this study, I list here what I consider the present status of the 13 species described from Hawaii by Pilsbry in 1920:

Explanation of Plate 35

Five of the Six Valid Species of *Mitra* and *Vexillum* Described by Pilsbry in 1920 as from Hawaii

a: *Mitra waikikiensis* Pilsbry, 1920. Dredged in 60 fathoms on sand, Keehi Lagoon, Oahu (Pele Expedition, August 1959). Height 27.2 mm. Cate Collection No. HD 754.

b: *Vexillum xenium* Pilsbry, 1920. . Endemic to Hawaii. Dredged in 17 fathoms in sand and coral. Keehi Lagoon, Oahu (Pele Expedition, April 1959). Height 23.0 mm. ex Weaver Collection.

c: *Mitra ostergaardi* Pilsbry, 1920. Fell out of broken-up dead coral in 65 to 70 feet. Makua, Oahu. Height 28.7 mm. leg. C. S. Weaver, October 1958. Cate Collection No. H 164.

d: *Mitra emersoni* Pilsbry, 1920. Dredged in 25 fathoms in sand, off entrance to Pearl Harbor, Oahu (Pele Expedition, April 1959). Height 24.7 mm. Cate Collection No. HD 501.

e: *Vexillum thaanumi* Pilsbry, 1920. Endemic to Hawaii. Dredged in 16 to 25 fathoms in sand, entrance to Pearl Harbor, Oahu (Pele Expedition, April 1959). Height 22.5 mm. Cate Collection No. HD 489.

Kodachromes by Victor Duran

Tip in Plate 35

1. *Mitra kamehameha* Pilsbry, 1920 = *Mitra ustulata* Reeve, 1844
2. *Mitra thaanumiana* Pilsbry, 1920 = *Mitra coffea* Schubert and Wagner, 1829
   = *Mitra fulva* Swainson, 1832
3. *Mitra ostergaardi* Pilsbry, 1920 Valid
   = *Mitra pararhodia* Dall (MS.)
4. *Mitra lugubris honoluluensis* Pilsbry, 1920 = *Mitra tiarella* A. Adams, 1851
   = *Mitra crassula* Dall (MS.)
5. *Mitra ticaonica vagans* Pilsbry, 1920 = *Mitra ticaonica* Reeve, 1844
   = *Mitra pupiformis* Dall (MS.)
6. *Mitra olivellaeformis* Pilsbry, 1920 = *Mitra olivaeformis* Swainson, 1821
7. *Mitra langfordi* Pilsbry, 1920 = *Mitra peasei* Dohrn, 1860
8. *Mitra emersoni* Pilsbry, 1920 Valid
9. *Mitra waikikiensis* Pilsbry, 1920 Probably valid; cf. *Mitra loricata* Reeve, 1844
10. *Vexillum thaanumi* Pilsbry, 1920 Valid; endemic
11. *Vexillum xenium* Pilsbry, 1920 Valid; endemic
12. *Vexillum micra* Pilsbry, 1920 Valid; endemic
13. *Vexillum turben kanaka* Pilsbry, 1920 = *Vexillum turben* (Reeve, 1844)

Acknowledgment

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Literature Cited

Adams, Arthur
1851. Descriptions of fity-two new species of the genus *Mitra* from the Cumingian collection. Proc. Zool. Soc. London, Pt. 19: 132-141.

Dietrich, Richard V., & Percy A. Morris
1953. Mollusks from Kwajalein. Nautilus 67 (1): 16.

Edmondson, Charles Howard.
1946. Reef and shore fauna of Hawaii. B. P. Bishop Mus. Spec. Publ. 22, iii + 381 pp., figs. 1-223, (family Mitridae: pp. 128-130, fig. 58 e-i).

Garrett, Andrew
1880. Catalogue of the Polynesian Mitridae. J. Conch. 3: 1-73.

Hawaiian Shell News
1956. Check list of Hawaiian Miters. H.S.N. 4 (4): 38 to 39.

——, ——
1959. Check list of Hawaiian gastropods, Mitridae. H.S.N. 11 (7): suppl. pp. 23-28.

Martini, Friedrich Heinrich Wilhelm, & J. H. Chemnitz
1829. Neues systematisches Conchylien Cabinet, fortgesetzt von Gotthilf Heinrich von Schubert und Johann A. Wagner. Vol. 12, Abtlg. 1. Nürnberg.

Morris, Percy A.
1952. A field guide to shells of the Pacific coast and Hawaii; Mitridae pp. 194-196, pl. 39.

Pilsbry, Henry A.
1920. Marine mollusks of Hawaii. Proc. Acad. Nat. Sci. Phila., 72: 309-318, pl. 12.

Reeve, Lovell Augustus
1844-1845. Conchologia Iconica. Monograph of the genus *Mitra*. pls. 1-39.

Sowerby, George Brettingham
1874. Thesaurus conchyliorum. Vol. 4, Monograph of the genus *Mitra*: 1-46, pls. 1-28.

Swainson, William
1820-1821. Zoological illustrations, Conchology, Series 1, vols. 1 & 2, pts. 1-3, 72 pls.

——, ——
1829-1833. Zoological illustrations, the shells, Series 2.

Tinker, Spencer Wilkie
1958. Pacific sea shells (rev. ed.). The Miter shell family. pp. 140-160, illus.

Tryon, George W., Jr.
1882. Manual of conchology, 4 (Mitridae): 106-200; pls. 32-58. Philadelphia.

Preliminary Report on Growth Studies in *Olivella biplicata*

by

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(Plate 36)

While making observations on Olivella biplicata (Sowerby, 1825) for the studies reported on previously (Stohler, 1952, 1960), it became apparent that an estimate of the life span of this species was not possible on the basis of distinct size classes of the shells. As was indicated (op. cit., 1960), Olivella exhibited mating behavior at every low-tide period when observations were possible, and thus distinct and chronologically separable size classes could not be expected. However, the growth rate, as well as the life span, was of interest to me. A possible approach to the study of these two problems presented itself when the populations of Olivella were seen in the Flood Control Channel in San Diego. The following facts seemed to make these particular populations especially suitable for an experimental approach to the problem. The Flood Control Channel is closed to the ocean, at least for the major part of the year, by an extensive sand bank, yet in the study area the water changes with each tidal cycle, although the change is somewhat retarded. The water flows through a dike along the north side of the area. This dike forms the boundary between the entrance to Mission Bay and the Flood Control Channel and consists of large quarried rocks relatively loosely piled upon each other. Furthermore, adjacent to these large rocks there is a relatively extensive area consisting of small boulders and gravel, thus effectively preventing the Olivella living in the deeper sand bed from escaping, yet permitting free exchange of the water. That the ecological conditions in the area are suitable for the animals is borne out by the fact that the populations seem to be thriving.

It will be seen, then, that it is possible to collect some of the animals living in this restricted area, measure them, mark them, and return them to their usual habitat with a fair probability of being able to recapture a percentage of the marked animals at a later date. It need hardly be mentioned that this approach would not be feasible in the usual habitats where Olivella biplicata occurs along the California coast, namely, on the open shore.

The problem, however, was to find a suitable method of marking the shells. The first approach was to file an area near the apex of the shell so that a flat surface was obtained on which numbers were written with a crow-quill pen and India ink. In a preliminary test, 100 individuals were marked in this manner and released in 1958. This method of marking, however, had to be abandoned because experience showed that the numbers became illegible after approximately six months.

A second experiment consisted in applying a pressure-sensitive tape on which had been printed numbers with a specially prepared printing ink. For further protection of the printed number, adhesive cellulose tape was placed over this patch. This method proved to be unsuitable within less than three months; the pressure-sensitive tape was lost in the water.

It was unfortunate that individually measured and marked specimens could not be observed by the use of one or the other of these methods. As an alternative method, it was then decided to collect a large number of individuals, measure them, and pick out a particular size class, mark all individuals of that selected size class, and release all captured animals. The mark consisted of a notch filed into the whorl just above the body whorl, opposite of the aperture. Care had to be exercised in preventing the file from cutting through the wall of the shell, thus injuring and exposing the living animal.

On July 25, 1959, 242 Olivella biplicata, from 11.0 to 13.0 millimeters, were marked in

Figure 1

Figure 2

Blaker, *photo.*

this fashion and released. On January 9, 1960, six of these marked animals were recovered and measured. It was found that they had attained a length of 16.3 to 23.4 millimeters. The return of only approximately three percent, in spite of prolonged and careful search, was considered insufficient to allow making any conclusions of value as to the growth rate of this species. A much larger number of marked animals was desired, but the mechanical difficulties of marking them adequately with a triangular file was a serious handicap. As a further experiment, another group of Olivella was collected in the Flood Control Channel area on July 16, 1960. Of approximately 1'500 specimens, 266 were selected in the size class 16.0 to 18.0 millimeters. The marks were made with a dental drill, and while the shell was still dry from the friction exerted by the action of the drill, the groove was covered with India ink. These animals were then returned as usual.

On November 6, 1960, 964 animals were collected in the Flood Control Channel; of these, five were clearly marked ones, but included one dead shell. The measurements ranged from 18.6 to 20.25 millimeters. On January 28, 1961, a total of 754 specimens was collected, including seven marked ones. The sizes of these ranged from 18.8 to 21.9 millimeters. On April 22, 1961, of 1'925 shells collected, four were of the marked group, with a size range of 17.7 to 20.9 millimeters.

From these preliminary results, it seemed to become apparent that Olivella is a relatively slowly growing gastropod, and further, it seemed plausible that a shell of 30 millimeters or over in length might indicate a life span of several years. However, I felt that these experiments were not revealing enough, inasmuch as they gave no information as to the possibility of different growth rates at different stages of development. Such information could be obtained, of course, with individually marked shells; that is, shells whose exact measurement is known initially and which could be positively identified on subsequent recapture. However, as indicated above, all efforts in this direction were unsuccessful. The use of the dental drill for marking the shells seemed to offer a possible way out of the difficulty. On July 3, 1961, 1'350 specimens of Olivella ranging in size from 14.0 to 24.0 millimeters were collected at Solano Beach. On July 4 a total of 2'612 individuals ranging over the same measurements were obtained from the Flood Control Channel; all these shells were separated into size classes of two millimeter range, i. e., 14.1 to 16.0 millimeters, etc., with one exception: the group from 22.1 mm. on up was divided into two classes, namely, 22.1 to 23.0 and 23.1 to 24.0 mm. All 3'967 individuals (1'035 marked and 2'932 unmarked) were liberated in the experimental area in the Flood Control Channel.

The technique employed may be best explained by referring to Figures 1 and 2, Plate 36. The handpiece of the dental drill was securely fastened in a clamp and the shell could be pressed against the rotating drill, either pushing it up at right angles to the longitudinal axis (figure 1) or along an extension of the longitudinal axis (figure 2). By a combination of marks made, it was possible to distinguish the different size classes.

It is planned to endeavor a recapturing of these Olivellas at three-month intervals, and it is hoped that the large number of marked specimens, together with the diversity of size classes marked, will make possible a reasonable appraisal of growth rate and life span of Olivella biplicata.

Acknowledgment

This study could not be successful without the unusually generous and wholehearted cooperation of several people whose contributions I wish to acknowledge here: Mr. and Mrs. Alan H. Wolfson of San Diego, their son Arthur, and, occasionally, various of their friends have spent (and plan to spend in the future) many hours in diving for the Olivella. Dr. E. W. Fager generously made available to me the facilities of his laboratory at Scripps Institution of Oceanography in La Jolla, where the animals were kept alive while out of their natural habitat during the days of measuring and marking.

Literature Cited

Stohler, Rudolf

1952. Studies on mollusk populations II. Nautilus 65 (5): 135-137.

——, ——

1960. Studies on mollusk populations: IV. Nautilus 73 (2, 3): 66-72 and 95-103; figs. 1-3.

A New Deep-Water *Anadara* from the Gulf of California

by

Bruce Campbell

Conchological Club of Southern California, Los Angeles 7, California

(Plate 37, 1 Textfigure)

During the month of June, 1959, while spending a week diving at Guaymas, Mexico, I had occasion to visit several times my friend Captain Xavier Mendoza who was at that time manager for Productos Marinos, the largest shrimp fishing organization in Guaymas. On the day I returned home he gave me, among several other things, a live specimen of an Anadara that had just come off one of the shrimp boats. That fall it was sent to Dr. Myra Keen who reported that she knew of no other Anadara with such a felt-like periostracum. As there was no precise locality data available at the time, the shell was held for confirmation of its occurrence which has since been gained through the dredging of odd valves at several stations off Cabo Haro, Guaymas, Mexico.

Arcacea
Arcidae
Anadarinae
Anadara Gray, 1847
(*Scapharca*) Gray, 1847

Anadara (*Scapharca*) *hyphalopilema* Campbell, spec. nov.

(Plate 37, Figures 1 to 8)

Shell large, thin, strongly and evenly convex, markedly inflated, with the anterior end roundly sloping ventrally; posterior end rounded and obliquely produced at an angle of about 75 degrees; color white internally, externally white except for a brownish stain over the dorsal two-thirds of both valves. Height equal length, with the highest portion at the posterior third; umbones full, passing forward into small prosogyrate beaks located at the anterior third; posterior dorsal extremity slightly flared and the anterior dorsal extremity unusually shortened; both valves with 41 squarish ribs that are proximally solid and distally sculptured with four to five radial riblets; narrower interspaces concentrically sculptured by small cords about 0.75 mm. apart that slightly involve the ribs, giving an impression of corrugations; inequivalved with left valve slightly overlapping right; interiorly, the ventral margin deeply fluted by the ends of the ribs; hinge long, straight, narrow with a continuous series of short fine converging teeth that become larger at the extremities; midpoint of hinge less than 1 mm. thick; cardinal area wide, covered completely by the ligament, traversed by three to four slightly arched lines; periostracum dark brown, with a fine velvety texture and up to 2 mm. thick over the posterior end.

Measurements of the holotype: Length 60 mm., height 60 mm., diameter 55 mm.

Holotype: Stanford University Paleontological Type Collection No. 8'629.

Paratypes: A paratype will be deposited in the U. S. National Museum, Campbell collection, Mendoza collection, and Shasky collection.

Explanation of Plate 37

Anadara (*Scapharca*) *hyphalopilema* Campbell, spec. nov.

Figure 1: Exterior right valve of Paratype 1. Figure 2: Posterior view of Holotype. Figure 3: Exterior of left valve of Paratype 5. Figure 4: Interior of left valve of Holotype. Figure 5: Dorsal view of Holotype. Figure 6: Interior of right valve of Paratype 4. Figure 7: Exterior of right valve of Holotype. Figure 8: Exterior of left valve of Holotype.


Figure 1


Figure 2

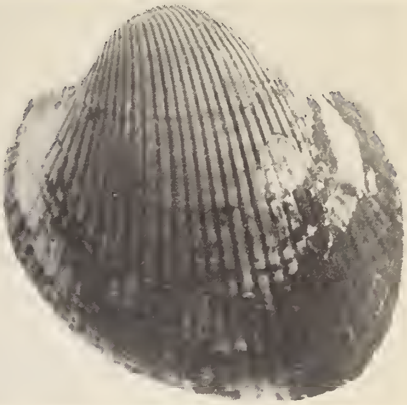
Figure 3

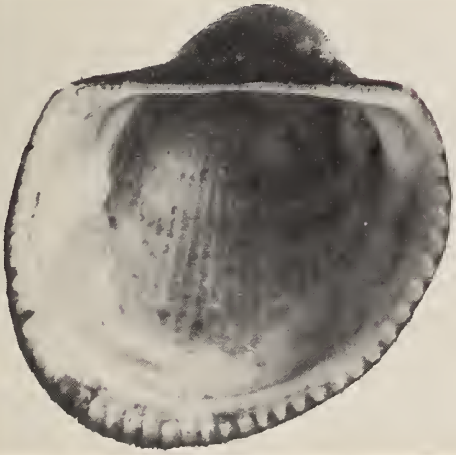
Figure 4


Figure 5

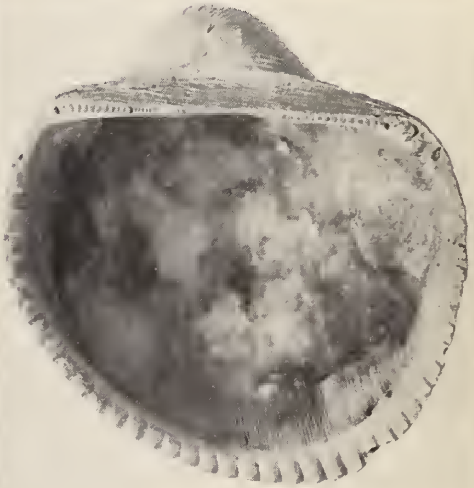
Figure 6

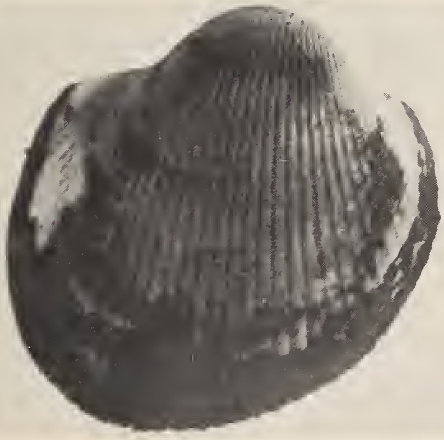
Figure 7


Figure 8

CAMPBELL, *photo.*

Table 1: Comparison of Holotype and Paratypes

	Valve	Length	Height	Semidiameter	Rib number	Riblets	Semidiameter:Height
		(measurements in millimeters)					(in percent)
Holotype	left	60	60	28	41	4-5	47
Holotype	right	60	60	27	41	4	45
Paratype 1	right	78	77	39	42	5-7	50
Paratype 2	left	74	74	35	42	5-7	47
Paratype 3	left	73	76	35·5	43	5	49
Paratype 4	right	69	68	33	43	4-5	48
Paratype 5	left	60	58	26	42	4-5	43
Paratype 6	left	58	57	25·5	40	4-5	44

Type locality: The holotype was brought in by the shrimp boats that were at that time working in the vicinity of Cabo Haro, Guaymas, Sonora, Mexico. Lat. 27° 50' N., Long. 40° 55' W. June, 1959. The paratypes were trawled off Cabo Haro, in about 50 fathoms, December 27 and 31, 1959. Collectors: B. Campbell, X. Mendoza, T. Schowalter, and D. Shasky.

The specific name is derived from the combination of two Greek words in order to signify a unique anatomical feature and the habitat of the mollusk. The Greek adjective hyphalos means "under the sea"; pilema is the Greek noun for "felt". The combination hyphalopilema indicates a species with a soft periostracum that resides offshore. As hyphalopilema is a neuter noun in apposition, no change in ending can be made.

Discussion

The most distinctive feature that separates this species from any of the other recent eastern Pacific Anadara is the soft felt-like covering displayed by the holotype and one paratype, which resembles more the periostracum of a Noetia with close-packed, overlapping scales, arranged like thatch; in addition, A. hyphalopilema is finely carpeted with hair. This is one of the largest members of the subgenus Scapharca that has been described from the Panamic region. One paratype is 78 mm. in length. The largest Scapharca is A. cepoides (Reeve, 1844) [Olsson (1961) records a specimen with a length of 90 mm.] with which the paratypes were confused, but A. cepoides is broader and less inflated (see Table 2) with 32 to 35 smooth ribs

Table 2: Comparison of Species

	Length	Height	Diam.	Rib number	Riblets	Diameter:Length	Height:Length
	(measurements in millimeters)					(in percent)	
Anadara hyphalopilema CAMPBELL, sp. nov.							
Holotype	60	60	55	41	4-5	92	100
Paratypes (aver.)						94[1]	100
Arca hopkinsi PILSBRY & OLSSON, 1941							
Type	93	85	78[2]	38	5-7	84	91[1]
Anadara cepoides (REEVE, 1844)							
[in Olsson, 1961]	90	85	77·3	33-34	none	86	94
[in Olsson, 1961]	70	60	46	33-34	none	66	86
SUPTC no. 5332	62	57	48	35	none	77	92
right valve		54					
[in Keen, 1958]	59	53	45	32	none	76	90
Oldroyd coll. no. 1150	44	41	34	34	none	77	93
right valve		38					

[1] based on semidiameter [2] based on semidiameter of left valve

and olive-brown or olive-green periostracum, and the posterior end is not as obliquely produced. The umbonal areas are more subcentral than those of A. hyphalopilema which are located at the anterior third.

The species to which Anadara hyphalopilema is closely related is Arca (Scapharca) hopkinsi Pilsbry and Olsson, 1941. This species was described from the Canoa formation of the Pliocene from Western Ecuador. Comment was made in the description: "This fine, large species is not closely related to any living or fossil ark known to us from this region." There are several points of difference separating A. hyphalopilema from Arca hopkinsi. Anadara hyphalopilema is smaller and more inflated with a proportionally greater height (see Table 2), and somewhat differently shaped (see Textfigure 1). It also has 41 ribs slightly corrugated concentrically, 43 in two paratypes, compared with 38 radially sculptured ribs in Arca hopkinsi. The anterior extremity is not nearly as prominent as that of Arca hopkinsi.

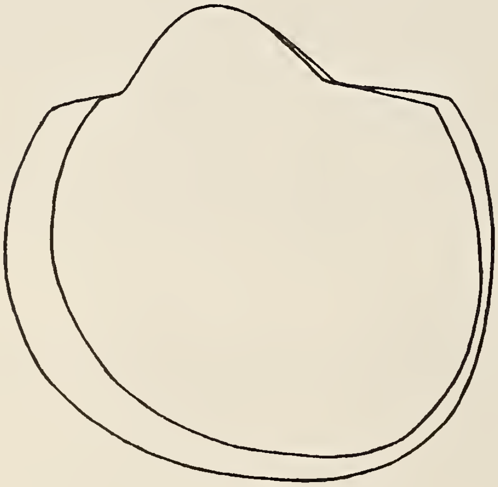

Figure 1: Outer, tracing of *Arca hopkinsi* Pilsbry & Olsson, 1941 (from their plate); inner, tracing of *Anadara hyphalopilema* Campbell, spec. nov., from paratype 3

So far as known, Anadara hyphalopilema has only been collected from the Guaymas area in deep water. A possible explanation why this species has not come to light sooner is that the Mexican fishermen would have no reason to save dead valves coming up in the shrimp nets, and only when a live specimen appears — such as the holotype — would it be salvaged, as a food item.

Acknowledgment

I wish to thank Dr. Myra Keen for her assistance and helpful suggestions, and also Dr. Donald Shasky for the loan of the unmatched valves used as paratypes.

Literature Cited

Hertlein, Leo George, & A. M. Strong
1943. Eastern Pacific expeditions of the New York Zoological Society. Mollusks from the west coast of Mexico and Central America. Zoologica pt. 2, 28: 149-168, pl. 1.

Keen, A. Myra.
1958. Sea shells of tropical west America; marine mollusks from Lower California to Colombia. Stanford, Calif., Stanford Univ. Press; xi + 624 pp., illus.

Lowe, Herbert N.
1935. New marine mollusca from West Mexico, together with a list of shells collected at Punta Penasco, Sonora, Mexico. Trans. San Diego Soc. Nat. Hist. 7 (6): 15-34, pls. 1-4.

Olsson, Axel A.
1961. Mollusks of the tropical eastern Pacific, particularly from the southern half of the Panamic Pacific faunal province (Panama to Peru). Part I. Panamic-Pacific pelecypoda. Paleont. Res. Inst. Ithaca, New York. pp. 1-574, pls. 1-86.

Pilsbry, Henry A., & Axel A. Olsson
1941. A Pliocene fauna from Western Ecuador. Proc. Acad. Nat. Sci. Phila. 93: 1-79, pls. 1-19.

Reinhart, P. W.
1943. Mesozoic and Cenozoic Arcidae from the Pacific slope of North America. Spec. Paper Geol. Soc. Amer., No. 47: i-xi, 1-117, pls. 1-15.

Rost, Helen
1955. A report on the family Arcidae. Allan Hancock Pacific Exped. 20 (2): 177-249, pls. 11-16, textfigs. 79-95.

Two New Opisthobranch Mollusks from Southern California

by

JAMES R. LANCE

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(Plate 38, 8 Textfigures)

The coastal waters of Southern California abound in numbers and species of opisthobranch mollusks and those forms regularly inhabiting or seasonally occurring in the intertidal regions have become relatively well known. A distributional list of all the opisthobranchs (excluding the pteropods and cephalaspideans) occurring between Point Conception, California, and the Mexican border for which there have been published descriptions sufficient to permit reidentification, has been compiled by Lance (1961). Of the 65 species listed only two (Platydoris macfarlandi Hanna, 1951, and Tritoniopsis aurantia Mattox, 1955) are known exclusively from subtidal regions. Consideration of this fact by itself might lead to the conclusion that the local opisthobranch fauna is almost completely represented in the intertidal zone. Such, however, is not the case, and it merely reflects the degree of limitation to which our observations have been subject. Recent investigations incorporating self-contained diving gear at depths of 30 to 200 feet have shown that certain local rocky areas are far richer in these mollusks than are comparable regions of the intertidal. Thus it seems probable that knowledge of the total opisthobranch fauna along this as well as any other coastal region is in reality quite incomplete since the vast majority of specimens have been collected only in regions uncovered by the tides.

Several undescribed conspicuous forms of opisthobranchs have recently been found in the subtidal regions of the San Diego, California, area and it now seems appropriate to offer descriptions of two such species.

The systematic concepts of Odhner (1939) who achieved order out of chaos for the higher taxa of Opisthobranchiata are almost universally accepted. Those arrangements are here followed.

I am very grateful to the Scripps Institution of Oceanography, Marine Life Research Program, for providing funds for the color plate. Also, I appreciate Miss Joan Steinberg's kindness in supplying me with specimens of Phidiana from Central California.

NUDIBRANCHIA

Doridacea

EUDORIDACEA

Cryptobranchia

DORIDIDAE

Glossodoridinae

Cadlina limbaughi LANCE, spec. nov.

(Plate 38, Textfigures 1 to 3)

Synonymy: *Cadlina spec.*, Lance, 1961

The body in general shape is very similar to other species of Cadlina described from the Pacific Coast of North America. The largest of four specimens measured 27 mm. long and 11 mm. broad when alive; the smallest was 11 mm. long and 5 mm. broad. Thus it would seem that the length-width ratio changes as the animals mature. The notum is elongated with parallel lateral margins which are slightly more rounded in front than behind. The median arch slopes rapidly to leave a free flat margin laterally and anteriorly. The notum covers the entire body in the smallest specimen, but in larger individuals the foot extends for a short distance beyond the posterior brim. It is warty and somewhat gritty to the touch due to a network of spicules, some of which project freely in bundles above the surface.

The entire body is white with highly contrasting rhinophores and branchiae which appear black. Closer examination shows that the clavi of the rhinophores are very dark reddish brown with the distal two-thirds of the branchiae being a lighter shade of the same color. The most posterior branch of the branchial circlet lacks this dark pigment in all four specimens. The rhinophore stalks are white. Numerous opaque white subepidermal glands occur scattered over the notum. These are somewhat larger around the lateral margins and smaller and less numerous at the anterior and posterior ends. The dorsal and ventral surfaces of the foot and the sides of the body are sparsely sprinkled with minute black dots which are absent on that portion of the foot extending beyond the notum. In the smallest specimen these dots were much reduced in number.

The foot is rather narrow, slightly expanded anteriorly, and shallowly bilabiate. The lower lip is thick, the upper lip thinner, not notched in the middle. The tail is bluntly rounded.

The head is distinct with thick, triangular, auriform tentacles grooved on their outer margins (textfig. 1). Pronounced, retractile, rhinophores with deeply perfoliate clavi composed of 11 folds in the smallest individual and 18 in the largest, are borne on short stalks. The sheaths of the rhinophores are low and smooth.

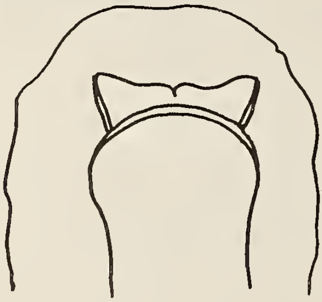


Figure 1: *Cadlina limbaughi* Lance, spec. nov.
Antero-ventral view

There are six bipinnate and tripinnate retractile branchial filaments joined at their bases in a crescent in the smallest specimen and seven to eight in the others. The most anterior filament is the largest. The conical anal papilla is low, fleshy, and surrounded by the crescentric branchial base. The genital aperture is located about a third of the way back on the right side of the body.

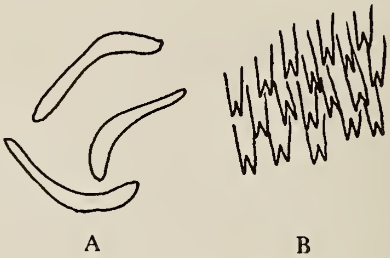


Figure 2: *Cadlina limbaughi* Lance, spec. nov.
Elements of the labial armature
A: marginal elements
B: central elements

The central elements of the labial armature (textfig. 2) are slender, closely set, and terminally bifid. Those of the margins are irregularly curved and smooth on the ends. An individual 27 mm. in length had the dental formula 102 x 44-1-44. The rachidian tooth (textfig. 3b) is composed of four to six blunt denticles of nearly equal size. Most of the first laterals (textfig. 3c) have three inner denticles, a large central spine, and six outer denticles. The outward laterals become elongated, and the 30th (textfig. 3a) has a large central cusp with 14 small denticles. The outermost laterals (textfig. 3d) are shortened, denticulate, and lack the prominent central cusp.

Type locality: La Jolla, California. Lat. 32° 52' N., Long. 117° 15' W. Further distribution: Los Coronados Islands, Mexico, 32° 24' N., 117° 14' W. Bathymetric range: Subtidal, 50 to 140 feet. Unknown from the intertidal.

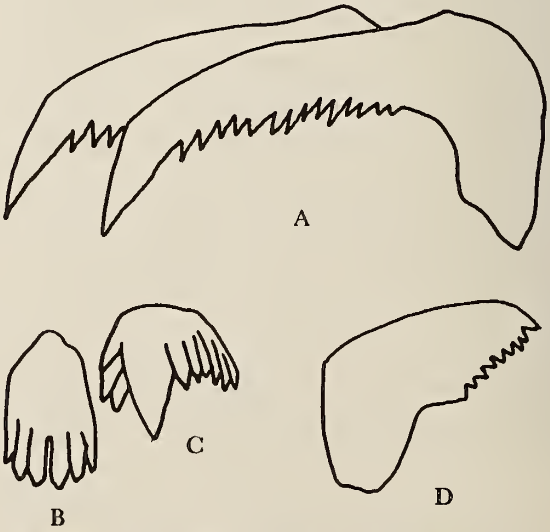
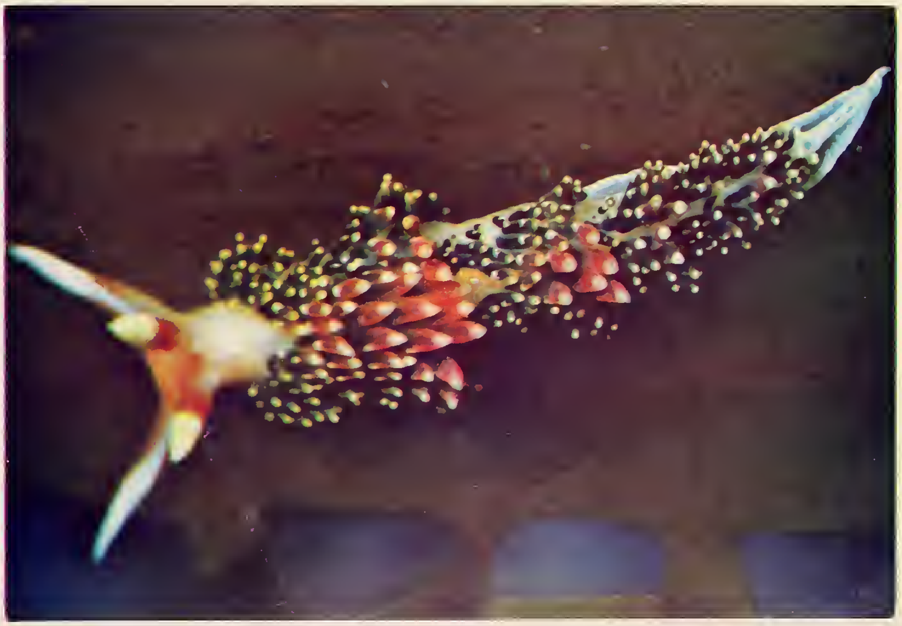


Figure 3: *Cadlina limbaughi* Lance, spec. nov.
Teeth of the radula
A: Thirtieth and thirty-first lateral teeth
B: Rachidian plate
C: First lateral
D: Outermost lateral

Cadlina limbaughi Lance, spec. nov.



Phidiana pugnax Lance, spec. nov.

Kodachromes by J. R. Lance

Tip in Plate 38

The specific name limbaughi was chosen to honor the late Conrad Limbaugh who was the first to collect this and many other subtidal species of opisthobranchs, and Mrs. Nan Limbaugh whose interest in this group has resulted in the acquisition of previously unknown bathymetric distributions for many forms.

The holotype is deposited at the California Academy of Sciences where it is registered as Paleo. Type Coll. No. 12'396; it will be incorporated into the Frank Mace MacFarland Memorial Collection of Nudibranchs.

Remarks: Four other species of Cadlina have been recorded from the Pacific Coast of North America. MacFarland (1906, p. 128) has compared the details of the radula for C. pacifica, C. marginata, and C. flavomaculata; and Marcus (1961, p. 15) has described and figured that of the fourth species, C. sparsa. The following list offers distinguishing characteristics of the color patterns of each species and will serve to readily identify living animals.

1. Cadlina pacifica Bergh, 1880

   Body bluish white; rhinophores yellow, at least in the preserved state; nine tripinnate gills; known only from Bergh's original material from the Aleutian Islands, Alaska.

2. Cadlina flavomaculata MacFarland, 1905

   Body dead white to yellowish white; rhinophores dark brown; six to eleven or more yellow spots in a row on either side of the notum; ten to twelve unipinnate and bipinnate gills; Vancouver Island, British Columbia, to Point Eugenia, Mexico.

3. Cadlina marginata MacFarland, 1905

   The largest Cadlina so far described from this coast; up to 80 mm. long and 40 mm. broad; body white to yellowish white covered with low tubercles each tipped with bright yellow; a narrow band of yellow around the border of the notum; six bipinnate gills; Vancouver Island, British Columbia, to Point Eugenia, Mexico.

4. Cadlina sparsa (Odhner, 1921)

   Body pale yellowish white to light tan with the rhinophores and gills a slightly darker shade of the same color; an uneven row of small black or dark brown spots often with yellow or orange centers present all around the notum or groups of similar spots on either side of the body; 12 unipinnate gills; San Diego, California, to the Juan Fernandez Islands, Chile.

5. Cadlina limbaughi spec. nov., Lance

   Body white with opaque white spots scattered over the notum; rhinophores very dark reddish brown; six bipinnate and tripinnate gills of the same color but a slightly lighter shade; San Diego, California, to Los Coronados Islands, Mexico.

NUDIBRANCHIA

Eolidacea

CLEIOPROCTA

FACELINIDAE

Facelininae

Phidiana pugnax LANCE, spec. nov.

(Plate 38, Textfigures 4 to 8)

Synonymy: *Phidiana spec.*, Lance, 1961

The largest of 36 specimens collected measured 63 mm. long, 10 mm. broad, and 9 mm. high when actively crawling. The specimen (holotype) upon which this description is based was of average size and measured 37 mm. long, 6 mm. broad, and 6 mm. high when alive. The general shape of the body is eolidiform; the sides nearly vertical with their sharply defined dorso-lateral margins running parallel to the blunt tail. The dorsal surface is very slightly rounded.

The body is translucent white through which the internal organs may be seen faintly. A line of intense red-orange color starts on the anterior side at about the midpoint of one head tentacle, runs across the front of the head, and terminates at the same point on the other tentacle. A spot of this color occurs on the opposite side of each tentacle. The stalk of the rhinophore is white, the proximal half of the clavus is red-orange, and the distal half of a highly contrasting cream color. The liver diverticula show through the cerata causing them to appear black. The larger, more median cerata in most of the groups are usually colored a brilliant pink for their distal half although this may be replaced by a cream coloration. A pink spot without defined borders is often present on the head just anterior to the rhinophores. An irregular line of opaque white spots runs along either side of the body about midway up from the foot, and a similar one, often consisting of fewer spots or totally lacking, occurs on the midline of the dorsal surface starting between the rhinophores and running posteriorly to the tip of the tail where it appears on a distinct caudal crest. The foot is edged with opaque white and most of

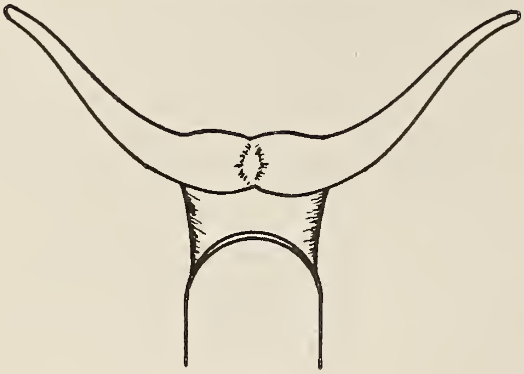


Figure 4: *Phidiana pugnax* Lance, spec. nov.
Antero-ventral view

the cerata have a spot of the same color about three-fourths of the way up on their anterio-lateral surface.

The foot (textfig. 4) is rounded anteriorly, bilabiate, not expanded, and extends beyond the sides of the body for about the distal third of its length.

The cerata start just below and slightly posterior to the rhinophorial attachments and occur in six major groups, the first three of which are easily distinguishable. Each group is composed of numerous oblique rows attached along a narrow dorso-lateral line of the body. For the most part the back is free.

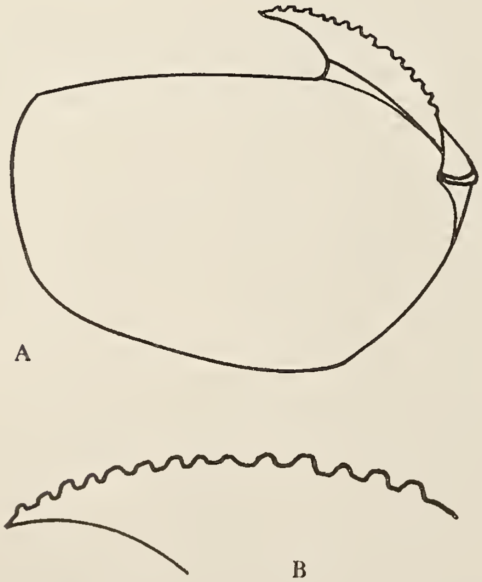


Figure 5: *Phidiana pugnax* Lance, spec. nov.
A: Inner side of mandible
B: Detail of the masticatory process

The head tentacles are large, measuring 13 mm. long in a 60 mm. individual. The rhinophores are nonretractile and robust with about 11 complete folds and 11 intercalary ones on the posterior side.

The jaws (textfig. 5) are horn colored and provided with a prominent masticatory process which bears a single row of 14 denticles. The radula consists of a single row of teeth, 19 in number. Each tooth is of the angular horseshoe shape and bears a prominent median spine flanked by six to seven smaller lateral spines which decrease in size towards the tip (textfig. 6). Only eight of the 19 teeth were symmetrical, i. e., having either six or seven denticles on both sides of the same tooth.

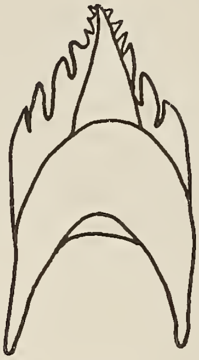


Figure 6: *Phidiana pugnax* Lance, spec. nov.
Tooth of the radula

The genital papilla is located on the right side of the body about halfway up from the foot and below the lateral-most cerata of the posterior oblique row of the first major group. The male pore lies on the tip of a papilla and the female opening occurs as a slit immediately anterior. The large penis (textfig. 7) is white and bears a black hook just proximal to the apex. In living animals the hook appears to be located at the apex.

The anal papilla (textfig. 8) is a prominent cylinder and lies far back near the right dorsolateral line between the third and fourth oblique rows of the third major group of cerata.

Type locality: Point Loma, San Diego, California. Lat. 32° 40' N., Long. 117° 14' W. Further distribution: Pacific Grove, California, 36°

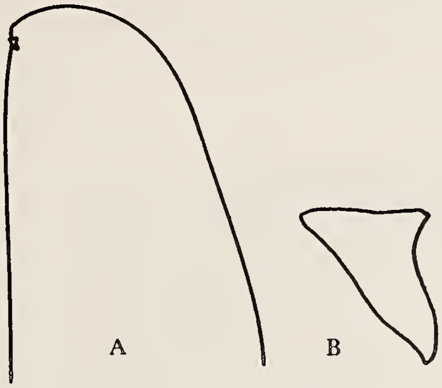


Figure 7: *Phidiana pugnax* Lance, spec. nov.
A: penis
B: detail of the hook

Figure 8: *Phidiana pugnax* Lance, spec. nov.
Lateral view of anal papilla within
the third group of cerata
f = foot s = side of body

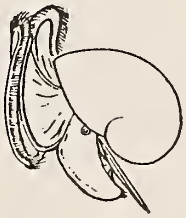
38' N., 121° 55' W.; Los Coronados Islands, Mexico, 32° 24' N., 117° 14' W. Bathymetric range: Low intertidal to 120 feet.

The specific name pugnax was chosen to call attention to the pugnacious nature of this form which it often exhibits by attacking and dismembering other eolids upon accidental contact and by the violent waving motions of the cerata which occur when the animal is disturbed.

The holotype is deposited at the California Academy of Sciences, San Francisco, California, where it is registered as Paleo. Type Coll. No. 12'397. It will be incorporated into the Frank Mace MacFarland Memorial Nudibranch Collection. Paratypes are available from the author.

Literature Cited

Bergh, (Ludwig S.) Rudolph
1880. On the nudibranchiate gasteropod mollusca of the North Pacific Ocean. Part 1. Proc. Acad. Nat. Sci. Phila.; 71-132, pls. 1-8.
Hanna, G. Dallas
1951. A new West American nudibranch mollusk. Nautilus 65 (1): 1-3.
Lance, James R.
1961. A distributional list of Southern California opisthobranchs. Veliger 4 (2): 64-69.
MacFarland, Frank Mace
1906. Opisthobranchiate mollusca from Monterey Bay, California, and vicinity. Bull. U. S. Bur. Fish. for 1905, 25: 109-151.
Marcus, Ernst
1961. Opisthobranch mollusks from California. Veliger 3 (Suppl., pt. I): 1-84, pls. 1-10.
Mattox, N. T.
1955. Studies on the Opisthobranchiata: I. A new species of the genus Tritoniopsis from Southern California, Bull. So. Calif. Acad. Sci. 54 (Pt. I): 8 to 13, pls. 4-5.
Odhner, Nils
1939. Opisthobranchiate mollusca from the western and northern coasts of Norway. Kgl. Norske Vidensk. Selsk. Skr. No. 1, 93 pp.



Egg-Laying in *Fusitriton oregonensis* (Redfield)

by

Faye B. Howard

Research Associate in Conchology
Santa Barbara Museum of Natural History, Santa Barbara, California

(Plate 39)

Early in the morning of June 19, 1959, while on the way from the village of Baranoff at Warm Springs Bay, on Baranoff Island's east coast, around the north end of the island to Sitka on the west coast, a stop was made at a small charted but unnamed island just offshore from the larger Baranoff Island. This small island is washed on the eastern side by Chatham Strait and on the north by Peril Strait (lat. 57° 20' N. and long. 134° 50' W.).

The tide was approximately -3.0 feet. The word approximately is used advisedly because, in all the inland passages, there is great variation from the printed tide tables. Wind direction may hasten or delay the time quoted — may hurry or hold back the water — thus changing the expected level.

Among all the shells observed that morning, the one that attracted the most attention was Fusitriton oregonensis (Redfield, 1848). In the small cove where the boat had been beached, about 18 specimens were observed. The beach was composed of sand and clean stones set fairly close together. All the shells seen were in a very narrow depth zone — not over 12 inches variation — some just under the surface and some just above. Eggs were being deposited on medium-sized stones, that is, stones from six to ten inches in diameter. In nearly every case the cluster of eggs was facing the zenith. When this was not true, the mass was on a smaller stone that could possibly have been shifted by the tidal action.

The pictures (Plate 39, figures 1 and 2) were taken after the stone with the spawning female had been lifted to the bow of the boat for closer observation. This change of position in no way disturbed the egg-laying process. The female was moving, egg by egg, in a counter clockwise direction as the eggs were laid. She would deposit one egg, proceed the precise distance, hesitate for perhaps 20 seconds and deposit another, and so on around her spiral path. After she finished this process, she reversed her direction and, as can be seen in figure 2, extended her body across the egg mass and in drawing back left a heavy mucus sheet over the whole group of eggs. Other females that had not been disturbed were also watched. They, at the end of the mucus spreading stage, were seen proceeding directly toward deeper water.

No copulation was observed; but a male, picked up within a few inches of a spawning female, showed some evidence of excitement. By a slight tug on the lip side of the operculum, he could be stimulated to extend the copulatory organ. He responded to this stimulus many times. This may suggest that mating possibly takes place very shortly before the eggs are to be laid.

A few egg clusters were seen at about the spot where the previous low tide probably had been. They were slightly higher on the beach and were more or less obscured by sand that had washed over them.

Naturally, one tide's worth of observation does not answer very many of the questions that are bound to occur to the observer. Chatham Strait, at this collecting station, is about six miles wide and drops off to over 400 fathoms about a mile offshore. Do these shells ordinarily live much deeper and come up to spawn? (They were not taken at any other station during 17 days of collecting.) Does the sun have a part in the incubation process? (The shape of the egg mass and its aiming at the position of the noon sun for best exposure suggests this possibility.) Further, the fact that the eggs were laid early in the series of minus tides, thus insuring daily exposure to sun and air for several days at the time of low tide, gives added support to this idea. Is the mucus covering for protection during this exposure? Only more field work can add to the slender store of information now available.

Figure 2

Figure 1

Kodachromes by FAYE HOWARD

Tip in Plate 39

Notes & News

Reinstatement of the Specific Name *Macoma inquinata* (Deshayes)

by

A. Myra Keen

Stanford University, California

In 1934, Dr. A. E. Salisbury (Proc. Malac. Soc. London, vol. 21, pt. 2, pp. 74-91, pls. 9-14) published figures of the exteriors for the holotypes of Tellina inquinata Deshayes, 1855 (type locality, "Columbia", which is interpreted as Columbia River, Oregon) and T. irus Hanley, 1845 (type locality, "Guinea?"), which are in the collections of the British Museum (Natural History). He concluded that the two forms are conspecific. Hinge illustrations not being available, we had no basis for questioning his decision as to identity, although there were small dissimilarities in outline that might or might not be significant. Later, someone from Japan must have studied the British Museum material, for in 1952 Habe (Genera of Japanese Shells, Pelecypoda 3, p. 218) proposed the generic name Heteromacoma, with Hanley's species as type. He cited Fragilia yantaiensis Crosse and Debeaux, 1863 (also known as Gastrana) in the synonymy, as well as "T." inquinata Deshayes.

Revising the Tellinidae for the "Treatise on Invertebrate Paleontology," I have been faced with the resolution of this discrepancy. Comparing specimens of "G. yantaiensis" with Salisbury's figures, I found that the outline matched much better than for any West American specimens at hand. I then made up a list of the hinge characteristics separating the West Coast and Japanese forms and asked for a reexamination of the two holotypes in this light. Mr. Peter Dance, of the Mollusca Section, British Museum (N. H.), now reports (letter dated October 26, 1961) that the hinges reveal all the differences I had enumerated, the hinge of "T." irus being relatively wider and heavier, with stronger teeth than in "T." inquinata. The right valve of "T." irus has a pseudo-lunule that makes the margin sinuate, whereas it is smooth in the latter. Thus, to bring our terminology into line with that already adopted by Japanese workers, we must revive the name Macoma inquinata (Deshayes) as the correct one for the West Coast shell that we have been citing in recent years as M. irus. This species is a true Macoma; its range is from Bering Strait to the Los Angeles Area. The range of Heteromacoma irus (Hanley) outside Japan is a matter for further study: this form may or may not be identical with the true Fragilia yantaiensis from the Chinese coast.

On the Systematic Place of *Cypraea mus*

by

A. Myra Keen

Stanford University, California

In a discussion of sizes in cypraeid species recently, Dr. F. Schilder (The Veliger, vol. 4, no. 2, pp. 107-112, October, 1961) on p. 109 cited this form as Siphocypraea mus (Linnaeus). Probably he has difficulty at his laboratory in East Germany keeping abreast of American literature; hence, he has evidently overlooked Woodring's discussion of the species and proposal of the subgeneric name Muracypraea for it (The Nautilus, vol. 70, no. 3, pp. 88-89, January, 1957). As Woodring showed, the type of Siphocypraea is S. problematica (Heilprin, 1887), from the Pliocene of Florida, a unique form of slender outline, with a very deep spiral channel at the apical end. The group of Muracypraea, of which Cypraea mus is the type, originated during Miocene time in the Caribbean, with a number of fossil forms that occur at widely separated localities, such as Venezuela, Florida, and the Atlantic Coast of Panama. Cypraea (M.) mus is the sole modern survivor of a group characterized by a rather chunky, triangular, heavily-callused shell, with low, irregular ridges (not a channel) in the apical area.

Two recent publications of Dr. Schilder's that may escape notice are cited below. Both mention Pacific species.

Schilder, F. A.
Zur Kenntnis der Cypraeidae. No. 2. Archiv für Molluskenkunde, Bd. 89, no. 4/6, pp. 185-192, pls. 14-15, 1960.

Schilder, F. A., & M. Schilder
Zur Kenntnis der Cypraeidae. No. 3. Länge und Reihenzahl der Radula. Ibid., Bd. 90, no. 1/3, pp. 33-42, March 1, 1961.

A Living Fossil

by

EMERY P. CHACE

Natural History Museum, San Diego, California

The only known living specimen of Nassarius delosi (Woodring, 1946) was reported on in 1957 (Chace, 1957) although it had been previously recorded as N. californiana (Conrad, 1856). A second living specimen of this rare species was found by Mrs. Charlene Neeb at a low tide in July, 1961, on a sandflat on the shore of Mission Bay, San Diego. As Mrs. Neeb did not recognize the animal, she brought it to the Natural History Museum of San Diego for identification. It proved to be N. delosi, thus becoming the second known Recent specimen. The sculpture of the specimen in question is very similar to that shown in Bulletin 112 (Dall, 1921) as N. californiana and for which Woodring proposed the name N. delosi. This second specimen is 28 mm. in height and has a diameter of 16 mm.; it is deposited in the Natural History Museum of San Diego, where it bears the lot number 42'927. It may be worth mentioning that this species, though extremely rare as a living form, is rather common in the Pleistocene exposure of the Los Angeles Area.

Literature Cited

Chace, Emery P.
1957. Nassa delosi Woodring. Nautilus 70 (3): 108.
Dall, William Healey
1921. Summary of the marine shellbearing mollusks of the northwest coast of America, from San Diego, California, to the Polar Sea, mostly contained in the collection of the United States National Museum, with illustrations of hitherto unfigured species. U. S. Nat. Mus. Bull. 112: pp. 1-217, pls. 1-22.
Woodring, W. P., M. N. Bramlette, & W. S. W. Kew
1946. Geology and paleontology of Palos Verdes Hills, California. U. S. Geol. Survey Prof. Paper 207, v + 145 pp., 37 pls.

A. M. U. - P. D.

Asilomar, Pacific Grove, California

June 27 - 30, 1962

The 1962 annual meeting of the Pacific Division, American Malacological Union, will be held at Asilomar, Pacific Grove, California, on June 27 through 30, inclusive. For details concerning reservations, contact Mrs. Lucille Zellers, 714 Elm Street, El Cerrito, California; for details concerning presentation of papers, contact Robert R. Talmadge, Box 71, Willow Creek, California; for details on displays, contact Mr. Gale Sphon, 1109 Cacique Street, Apt. E, Santa Barbara, California.

RRT

Information Desk

What's the Difference?

Genotype - Phenotype

by

R. STOHLER

Department of Zoology
University of California, Berkeley 4, California

The two terms in our subtitle have been used by students of genetics to designate the genetic constitution of an individual and the visible appearance of an individual, respectively. Unfortunately, the word genotype has been used by various authors in taxonomic papers to indicate what we now call the type species of a genus. Both terms, it should be emphasized, are not a part and parcel of the taxonomist's vocabulary regarding type specimens of one sort or another. Yet in recent literature of a systematic nature, these two terms, used either in their noun or in their adjective form, are appearing more and more frequently. The concepts for which the terms stand are, of course, of importance to the systematist at least as much as to the geneticist. We will endeavor here to explain the meanings of these terms and point up some of the ramifications of importance to the student of taxonomy.

Any individual (plant or animal) inherits a series of characteristics from its ancestors in a very orderly fashion. It is, of course, not the purpose of this discussion to elucidate the mechanisms involved, nor to enumerate the consequences of the facts of inheritance. It is sufficient to mention that hereditary traits include many factors known and understood, as well as many more as yet unknown or only partially understood. It is also known that the genotype — the genetic equipment — of an individual is unalterably determined at the moment the egg is fertilized; it is also understood that the outward appearance (the phenotype) of an organism is governed by the genotype. This, at first glance, might imply that the phenotype is also unalterably determined at the time of fertilization. In a great number of cases this holds true, but there are many instances known where the phenotype may be affected in one way or another.

While such characters as hair color or eye color in human beings or mammals are easily understood, there are other traits that are not as readily recognized as being inherited by means of the same mechanisms. We have come to realize that, to mention one example, stature in human beings may be affected by variations in nutrition during critical growth periods; thus a child of relatively short parents may develop into a tall individual if properly fed during the growing period, yet at the same time, another individual may be properly fed and still remain short. This would simply indicate that the first individual had genotypically the ability to become tall if properly fed and the ability to remain short if improperly fed, while the second individual genotypically did not have this ability to respond in the same manner to the environmental effect. We might express this same situation by saying that both individuals are phenotypically of short stature, assuming the first individual was improperly nourished, but genotypically they are still different from each other, one having inherited the possibility of responding in different ways to environmental factors, while the other individual did not inherit such an ability.

From the foregoing it becomes clear, then, that many organisms may inherit the ability of responding to a variety of outside factors — factors situated in the environment in which the individual lives; we might call such individuals, for convenience in our discussion, "plastic forms". Other species not having inherited the ability of response to the environment by producing a different phenotype, by the same token, may be called "set forms".

The student of mollusk shells may become aware of these differences when he studies and compares the shells of one and the same species obtained from various points of a wide range of distribution. He will find, probably, that in some species there is no difference recognizable, no matter from where the shells were obtained. This would be the case in a "set" species. In other species, on the other hand, it may be possible for the experienced collector to look at a given shell and know the exact geographical locality from which it came ("plastic" species). It seems unnecessary to stress that many apparently "set" species of mollusks may possess a much greater range of distribution than is at present known, and having at the same time genotypically the ability to respond to different environmental conditions by producing different shell characteristics, thus actually being "plastic". In such a case, representatives obtained from scattered areas of the entire range of distribution may be mistakenly considered as different taxonomic entities. Only experimental transplantations of groups of individuals from one area into the other could reveal whether they are individuals of a "plastic" or "set" species. The assumption that they are part of a "plastic" species would gain strength, possibly, if specimens could be collected from all intermediate areas of the known localities.

From the foregoing, two observable facts can possibly be understood. First, it is an almost logical conclusion that a "set" species would have, generally speaking, a much more limited range of distribution than a "plastic" species may possess, simply because of the inability to produce different phenotypes in different environments, since it may be assumed, again generally speaking, that the different phenotypes of "plastic" species are better equipped to cope with the conditions in the particular environment in which they developed, although the possibility that there is no advantage (but also no disadvantage!) accruing to such variable forms must also be borne in mind. Secondly, that "plastic" species occupying large ranges of distribution have, once again generally speaking, acquired long lists of synonyms.

It is, however, also clear that the terms phenotypic and genotypic cannot be used correctly as truly alternative terms, since both "plastic" and "set" phenotypes are determined by the particular genotypes. If a student wishes to bring out the differences between a "plastic" and a "set" species, he may have to coin new terms (such as we have done here) to designate unmistakably, unequivocally, and logically what he really means. It is obviously inaccurate to state that a certain character in a particular species is phenotypic while another one is genotypic, when actually the student means that one character is a "plastic" character while the other one is a "set" character.

Books, Periodicals, Pamphlets

HOW TO KNOW THE AMERICAN MARINE SHELLS

by R. Tucker Abbott

Signet Key Book, 1961. 75¢.

This fine little book should prove very helpful for all beginners in the field of conchology. Much valuable information is contained in the 222 pages and the color illustrations are, in part, magnificent. West coast species are well represented, which up to now has been rather unusual in books written and published in the East. We would take exception only to two points in the whole work, one being what Dr. Abbott is saying about our journal, The Veliger. In a personal letter to your editor, sent before the booklet reached the market, Dr. Abbott indicated that he was aware that his statement no longer held true, and he explained the lapsus as due to the time necessary in the production of a work such as this. The other point with which we cannot wholeheartedly agree is Dr. Abbott's consistent habit of translating the scientific names and giving them in a manner as if they were generally accepted vernacular names. This practice in many instances yields a "common" name which is more awkward and more difficult to remember than the real scientific name. Aside from these minor points, we feel that this book can be recommended without reservation and will fill a long-felt need — a source to which the many beginners can be referred when they inquire of shell club secretaries about shell collecting.

RS

JOURNAL DE CONCHYLIOLOGIE

Vol. 101, No. 1, for January 1, 1961.

"Malformations et colorations spécifiques chez plusieurs Cypraea de la Nouvelle-Calédonie et de la Polynésie française", L. J. Bouge.

MK

PRINCIPLES OF ANIMAL TAXONOMY

by George Gaylord Simpson

Columbia University Biological Series,
No. XX, 1961. $6.—.

The author is Alexander Agassiz Professor of Vertebrate Paleontology at the Museum of Comparative Zoology, Harvard University. He has been a member of the staff of the American Museum of Natural History and on the faculty of Columbia University. He is the author of The Meaning of Evolution; Horses; The Major Features of Evolution; Life, An Introduction to Biology; and Quantitative Zoology.

This book provides a detailed introduction to the fundamental principles of animal taxonomy. It is the only general study available in English on the principles underlying the classification of animals, and the only modern treatment of the subject in any language.

The author defines taxonomy as "the theoretical study of classification, including its bases, principles, procedures, and rules". He begins by considering order in nature and discusses the scientific ordering responsible for the modern classification of organisms. He examines the kinds of taxonomic evidence available to the scientist and discusses the historical development of taxonomy from Linnaeus to the present, including the relationship of taxonomy and evolution. Special chapters are devoted to the lower and the higher taxonomic categories.

JQB

THORACIC CIRRIPEDIA OF THE GULF OF CALIFORNIA

by Dora Priaulx Henry

Univ. Washington Publ. Oceanography,
vol. 4, no. 4, pp. 135-215, pls. I-V. December 27, 1960. University of Washington Press. Seattle. $1.—.

This paper is based on a collection of barnacles collected by Walter J. Eyerdam in the vicinity of Guaymas, Sonora, Mexico, in January, 1959. A total of 14 species and subspecies are covered, including Balanus eyerdami, new species. Dr. Henry includes a useful table (pp. 146-147) of the 21 species of thoracic cirripedia reported from the Gulf of California with their localities, habitats, and distributional ranges. The plates contain excellent photographs of Balanus eyerdami, new species, and its characteristic component parts. Dr. Henry's paper is an important contribution to knowledge of the invertebrate fauna of the Gulf and is a necessary reference for students of the barnacle group.

AGS

SHELLS OF THE NEW YORK CITY AREA

by Morris K. Jacobson
and William K. Emerson

Argonaut Books, Inc., 1961. $4.—.

A handbook of the land, fresh water, and marine mollusks ranging from Cape Cod to Cape May, with 150 drawings by Anthony d'Attilio. Over 140 species of shells are described, and each is illustrated by an exquisitely executed line drawing.

Several unique features enhance the usefulness of this handbook.

1. A map of the area, keyed to the principal collecting localities.
2. A listing of all the shells to be found in each major collecting area, cross-referenced to the pages on which the shells are described.
3. A listing of all the shells according to their scientific arrangement by class and subclass, order and suborder, superfamily, family, and subfamily, also cross-referenced to the text of the book.

Another feature that will be welcomed by collectors is the fact that the illustration for every shell is located within one page of its description. The combination of an informal and entertaining style with authoritative technical data makes this book a "must" for both the beginning nature student and the advanced collector or malacologist.

JQB

CARIBBEAN SEASHELLS
A Guide to the Marine Mollusks of Puerto Rico and Other West Indian Islands, Bermuda, and the Lower Florida Keys

by Germaine L. Warmke
and R. Tucker Abbott

Livingston Publishing Company. 1961.
$8.95.

This book is a unique shelling guide and authoritative identification book designed for both the amateur conchologist traveling in the West Indies and for students of Caribbean marine biology. Over 800 species are accurately classified and described. Forty-four plates of photographs (some in full color), habitat notes, and geographical ranges simplify finding and naming the shells of this tropical area. Although primarily designed for students and research workers at Puerto Rico's Institute of Marine Biology, the book includes most of the seashells of the Lower Florida Keys, Bermuda, the Bahamas, and the Lesser Antilles.

A series of distributional maps at the end of the book gives the reader a useful picture of what species are most likely to be found in any one area of the tropical Western Atlantic region.

JQB

EAST AFRICAN SLUGS OF THE FAMILY UROCYCLIDAE, THE GENUS TRICHOTOXON

by B. Verdcourt and R. Polhill

Journal of the East Africa Natural History Society, Special Supplement No. 7,
36 pp., 42 textfig. April 1961. $1.50.

This is a scholarly paper, illustrating and discussing the anatomy of the species, their habits, and includes a well-prepared key to the species.

JQB

VENUS: THE JAPANESE JOURNAL OF MALACOLOGY

Vol. 21, No. 3, August, 1961.

Molluscan shells from Southern Kii. T. Kuroda and Kôdô Itô.

Latisipho: Notes on two species of the genus *Latisipho.* T. Habe.

Three new gastropods from Japan. T. Habe.

On Japanese Terebrid fossils and a few new facts of the family. K. Oyama.

Review of nomenclature of Japanese shells (4). K. Oyama.

On three new species of *Notoacmea* (*sic*). T. Kira.

Descriptions of six new species of Japanese marine gastropoda. M. Azuma.

Solariella nektonica, sp. nov. Description . . . with special reference to its swimming behaviour. T. Okutani.

On the family Triphoridae (Gastropoda) from Amami Islands. S. Kosuge.

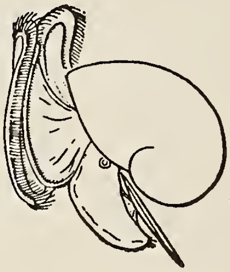
MK

MOLLUSCS, AN INTRODUCTION TO THEIR FORM AND FUNCTIONS

by J. E. Morton

This scholarly book was previously reviewed in The Veliger, Vol. 2, No. 3, p. 68. It is now available paperbound from Harper & Bros., Inc. $1.40.

JQB



THE VELIGER is open to original papers pertaining to any problem concerned with mollusks from the Pacific Region.

This is meant to make facilities available for publication of articles from a wide field of endeavor. Papers dealing with ecological, morphological, anatomical, physiological, distributional, taxonomic, etc. aspects of marine, fresh water or terrestial mollusks from any region bordering on or situated within the Pacific Ocean, will be considered. Even topics only indirectly concerned with mollusks may be acceptable.

It is the editorial policy to preserve the individualistic writing style of the author; therefore any editorial changes in a manuscript will be submitted to the author for his approval, before going to press.

Short articles containing descriptions of new species or lesser taxa will be given preferential treatment in the speed of publication provided that arrangements have been made by the author for depositing the holotype with a recognized public Museum. Museum numbers of the type specimens must be included in the manuscript. Type localities must be defined as accurately as possible, with geographical longitudes and latitudes added.

Short original papers, not exceeding 500 words, will be published in the column "NOTES & NEWS"; in this column will also appear notices of meetings of the American Malacological Union, as well as news items which are deemed of interest to our subscribers in general. Articles on "METHODS & TECHNIQUES" will be considered for publication in another column, provided that the information is complete and techniques and methods are capable of duplication by anyone carefully following the description given. Such articles should be mainly original and deal with collecting, preparing, maintaining, studying, photographing, etc., of mollusks or other invertebrates. A third column, entitled "INFORMATION DESK," will contain articles dealing with any problem pertaining to collecting, identifying, etc., in short, problems encountered by our readers. In contrast to other contributions, articles in this column do not necessarily contain new and original materials. Questions to the editor, which can be answered in this column, are invited. The column "BOOKS, PERIODICALS, PAMPHLETS" will attempt to bring reviews of new publications to the attention of our readers. Also, new timely articles may be listed by title only, if this is deemed expedient.

Manuscripts should be typed in final form on a high grade white paper , 8½" by 11", double spaced and accompanied by a carbon copy.

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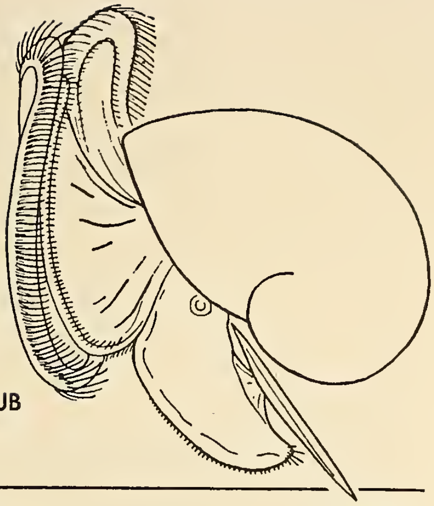

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[CONTINUED]

Note: The various taxa above species are indicated by the use of different type styles as shown by the following examples:

ORDER, Suborder, **DIVISION, Subdivision,** SECTION,
SUPERFAMILY, FAMILY, Subfamily, *Genus*, (*Subgenus*).

Revision of the Clavagellacea

BY

LEE ANDERSON SMITH

Department of Geology, Stanford University, California

(9 Textfigures)

The restudy of this unusual and interesting pelecypod group was undertaken as a revision for the "Treatise on Invertebrate Paleontology", in which a résumé of the taxa and types of the superfamily will appear. It seems advisable, however, to publish a more complete account at an earlier date. Two type designations are contained herein which, it is hoped, will help stabilize the nomenclature of the group.

I have adopted the style used in the "Treatise on Invertebrate Paleontology" for nomenclatural notation. The style is brief and therefore conserves space but may not be self-explanatory to all readers. Readers having access to any of the "Treatise" volumes may refer to the discussion of nomenclatural notation given in the front of each.

During the investigation, it was necessary to place as many species as possible in their respective genera and subgenera. They are listed here as briefly as possible after the description of each generic or subgeneric taxon. If they could not be placed in a subgenus or do not actually belong in the family, they are given immediately after the description of the genus, (s. l.). Names cited and questioned are from references not available to me, and their systematic placement is based on information given by earlier authors.

The study was made possible through access to the library and museum facilities of Stanford University, the California Academy of Sciences, and the University of California at Berkeley. Grateful acknowledgment is extended to Dr. Myra Keen for continuous advice, assistance, and encouragement during the investigation and for critically reading the final manuscript. However, the writer accepts full responsibility for any errors of transcription or of judgment.

CLAVAGELLACEA ORBIGNY, 1844

nom. trans., THIELE, 1934, *ex* CLAVAGELLIDAE

Shell nacreous, free when young, degenerate in adult; with one or both valves at least partially imbedded in an elongate calcareous tube, an adaptation for burrowing; hinge-plate wanting; ligament external. U. Cret. (Turonian)-Rec.

Characters of the hinge, material of the shell, and gill structures of the animal suggest a systematic position for the Clavagellacea between the Pandoracea and the Poromyacea.

Eames (1957) proposed Kitsoniidae as a family that he provisionally placed in the Clavagellacea. The Eocene form from Nigeria, upon which Eames' "family" is based, is definitely not a clavagellid. Characters of the hinge, lack of nacreous shell material, and general configuration of the shell strongly suggest a position in the Arcticacea.

CLAVAGELLIDAE ORBIGNY, 1844
[= ASPERGILLIDAE GRAY, 1858]

Tube anteriorly rounded or discoid and smooth or fringed with simple or branching tubules, or partially closed by a calcareous disc having several pedal foramina. U. Cret. (Turonian)-Rec.

Ecology and Anatomy

An excellent account of the anatomical features of Penicillus, s. s., (= Aspergillum) was given by Lacaze-Duthiers (1870, 1883) from the study of preserved specimens. The lack of firsthand observations of living specimens has misled earlier authors concerning the living position and habits of the animal. As late as 1958, Morton stated that Penicillus (= Brechites) lies horizontally on the sea floor. Earlier reports even suggested burial in a vertical position with the perforated disc exposed above the substrate, an impossible suggestion considering pelecypod functional morphology. The reverse and true position was described by H. & A. Adams (1858).

Living specimens of Penicillus penis (Linnaeus) have been observed in Java, and Purchon (1956, 1959) gives an excellent account of the musculature, movements, and ciliary feeding and cleansing mechanisms in the mantle cavity. Purchon (1959) stated that the specimens were found "a little above the low-water mark of spring tides, in an area of muddy sand sparsely colonised by the marine flowering plant, Enhalus sp." The second live specimen found "was lying vertically in the substratum with the posterior circular orifice of the shell projecting slightly above the surface of the soil; . . . the siphonal process was expanded and the inhalant and exhalant apertures" were visible close to the upper end of the tube. "When disturbed, a small jet of water was emitted in the usual fashion and the siphonal process was withdrawn from view."

In the laboratory he observed muscular contractions that occurred irregularly and sometimes resulted in posteriorward, sometimes anteriorward, movements of the anterior pallial septum. Purchon (1959) suggested that "these movements cause water to be drawn into the shell from the substratum through the anterior perforated disc of the shell" [tube]. He believed it to be a mechanism for becoming more deeply imbedded in the substrate and "may also provide a subsidiary source of food material."

As with other burrowing forms, the siphons are highly developed and generally the largest part of the animal. The calcareous tube is secreted around the siphons and fused with one or both of the valves near the anterior end. Clavagella, s. l., may reach three feet in length and two inches in diameter, but most species of clavagellids are much smaller, averaging probably not more than three to four inches in length. Some species are only a few millimeters in length.

Several present-day species are found living intertidally or in shallow subtidal areas, and the sediments and faunas associated with fossil forms suggest shallow marine habitats. However, small and rare survivors belonging to Clavagella, s. s., are reported from depths exceeding 100 fathoms in Australasian seas.

Habit, Morphology and Taxonomy

Members of the family live either buried in sand or sandy-mud, or attached to or within openings in a solid substratum. The three modes of life do not directly account for the three-fold subdivisions of the family, but they certainly control subgeneric groupings.

Forms living in a soft substrate, e. g., Penicillus, s. l., and Stirpulina, are able to achieve and maintain greater symmetry. The forms restricted to openings in a solid substrate, e. g., Bryopa and Dacosta, are forced to conform to their rocky habitat. A three-fold division, purely based on mode of life, would place Clavagella, s. s., and Stirpulina with the penicillids, an arrangement with which characters of the shell and soft parts would not agree.

The separation of Humphreyia as a third generic taxon may be questioned, but Humphreyia appears to be intermediate between Clavagella and Penicillus in both morphology and habit. In Clavagella, s. l., only one valve merges with the tube, and most of the valve is visible externally even in the adult. In Penicillus, s. l., both valves merge early with the calcareous tube and only the umbonal portion of the valve is visible externally in the adult.

In Humphreyia, according to Gray (1858), the young becomes attached to a rock by one valve, and both valves merge into a single curved plate, which forms most of the bag-like cavity. A large part of the opposite valve is visible in the adult. If Gray's observations are factual, Humphreyia has both valves merging with the tube as in Penicillus, s. l., but has one adult valve exposed externally as in Clavagella, s. l. I have noticed in the Stanford collection juvenile specimens of clavagellids attached by one valve to one side of an opening in rock, which they presumably would have filled had they grown to adulthood. Therefore, although both valves merge with the tube, the mode of attachment and life habits of Humphreyia suggest a closer alliance with Clavagella, s. l., than with Penicillus, s. l., with which it has most often been placed.

The geologic history of the group suggests also that Humphreyia may be a Recent branch of the clavagellid line. Clavagella, s. l., is the oldest group and Humphreyia the youngest; but Penicillus, s. l., was clearly separated by Late

Oligocene, and it seems unlikely that a "primitive penicillid" should have survived since that separation undetected in the geologic record. It seems even less likely that a modern and true penicillid should revert to the habits and grotesque form of Humphreyia.

Geographic and Geologic Distribution

Clavagella, s. s., is apparently the most primitive group, with questionable records from strata older than the Turonian of Cretaceous in Europe and Africa. The suggestion is consistent with the shell and tube morphology, as Clavagella, s. s., has the appearance least altered from that of a normal burrowing pelecypod. The siphonal portion of the tube is smaller in diameter than the shell, and the adult valves still dominate the anterior portion.

Two distinct groups of clavagellids are reported from strata of Late Cretaceous (Turonian) age in Europe, North America, and in India. The existence of two distinct lines at that time suggests earlier beginnings for the group, perhaps during Early Cretaceous. The Late Cretaceous Clavagella, s. s., and Stirpulina are both found in Europe and before the end of Cretaceous Clavagella, s. s., appeared in Asia and Stirpulina in North America. The exact synchroneity of these occurrences is not known. The two groups may have developed independently in the Pacific and Atlantic areas, but it seems more likely that they branched from a single stock in the European area.

Stirpulina, which did not live beyond Cretaceous in North America, survived with Clavagella, s. s., until Late Pliocene in Europe. Clavagella, s. s., may have a small surviving representative in the moderately deep waters off Australia {C. (C.) multangularis Tate}, and Stirpulina is represented in the Recent faunas by C. (S.) ramosa Dunker in Japanese waters.

The earliest records of Bryopa are from strata of Late Oligocene (Aquitanian) age in France. There are several survivors in the Mediterranean and a few in Indo-Pacific and Australasian provinces.

Dacosta and Humphreyia are known only from living forms in Australia, and neither group is well established.

Penicillus, s. s., is recorded from Late Oligocene strata of N. W. Borneo, Miocene of N. Borneo, Pliocene over the Indo-Pacific area, and Pleistocene of the Indo-Malay and Philippine regions. Though rare, it is reported from a large part of the Western Pacific and Indo-Pacific areas today.

Pseudobrechites is the only penicillid group reported from European strata, and only a single species has been recorded. The specimens were collected from Late Oligocene strata of France, and no other penicillids have been reported from nearer to Europe than the present Red Sea.

Foegia is an entirely Pacific-Indo-Pacific form. Earliest records are from Miocene and Pliocene strata of Sumatra, Formosa, and Japan. It is presently living in the Indo-Pacific and Australasian areas.

Warnea is reportedly living in the Red Sea and in Australasian and Japanese waters. The earliest records are from Pliocene strata of Japan.

The Clavagellacea is at present primarily an Indo-Pacific-Australasian group. Original development in the European area is suggested, and the group has apparently since declined and moved eastward. All of the penicillids have geologic records from at least Pliocene, and only Dacosta and Humphreyia are Recent developments, probably of the clavagellid line.

Generic, Subgeneric, and Specific Taxa

Clavagella Lamarck, 1818
[* *C. echinata;* SD Children, 1823]

[= Bacilia Gray, 1858, ex Valenciennes MS (obj.) Clavigella, spelling error] One valve never merging with the tube, and both adductors persistent in the adult. U. Cret. (Turonian)-Rec.

C. (?) cenomaniana Orbigny, 1844, p. 157 [nom. nud.] Cret., Fr.
C. (?) dubia Muenster, 1835, p. 435 [nom. nud.]
C. (?) ligeriensis Orbigny, 1844, p. 233 [nom. nud.] Cret., Fr.
C. (?) altavillae Aradas & Calcara, 1843, p. 221; (not seen)
C. (?) dalpiazi Venzo, 1941; (not seen) Olig., Italy
C. (?) lodoiska Caillat, 1835, p. 237 (not seen)
C. (?) lybica Parona, 1923, p. 51; (not seen) U. Cret., Afr.
C. (?) prisca Goldfuss, 1840, p. 285; (not seen)
C. (?) zebuensis Broderip; (not seen) Rec. Philippines

Clavagella (*Clavagella*)

Siphonal end of tube simple; tube free, elongate, clavate, compressed and symmetrical in shape; with irregular spine-like tubules on the anterior portion of the tube. U. Cret. (Turonian)-Rec., Eu.-India-Australas. —Fig. 1. C. (C.) echinata, M.-U. Eoc. (Lut.-Bart.), Paris Basin.

C. (C.) brocchii Lamarck, 1818, p. 432, U. Plioc., Italy
C. (C.) brongniarti Deshayes, 1824, p. 11, U. Eoc., Fr.
C. (C.) cretacea Orbigny, 1845, p. 300, Cret., Fr.
C. (C.) cristata Lamarck, 1818, p. 432, M. Eoc., Fr.
C. (C.) echinata Lamarck, 1818, p. 432, M.-U. Eoc., Fr.
C. (? C.) exiqua Zittel, 1865, p. 107, U. Cret., Austria
C. (C.) lagenula Deshayes (not seen) U. Eoc., Fr.
C. (? C.) lamarcki Deshayes (not seen) M. Eoc., Fr.
C. (C.) multangularis Tate, 1886, Rec., Austral.
C. (? C.) primigenia Deshayes (not seen) M. Paleoc., Fr.
C. (C.) semisulcata Forbes, 1846, p. 139, U. Cret., India
C. (? C.) tibialis (Lamarck, 1818), p. 432 [Fistulana] Eoc., Fr.

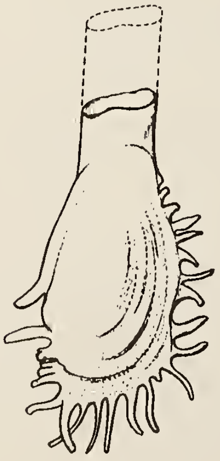
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Figure 1
Clavagella (*Clavagella*)

Clavagella (*Stirpulina*) Stoliczka, 1870
[* *C. coronata* Deshayes, 1824]

[=Styrpulina, spelling error. May prove to be synonym of Tubolana BIVONA-BERNARDI, 1832 (type-species: T. digitata=Aspergillum bacillaris DESHAYES, 1830; Tubulana, spelling error)] Siphonal end of tube periodically expanded, anterior end with tubules formed only in terminal corona; tube long with a more or less distinct anterior slit. U. Cret. (Turonian)-Rec., N. Am.-Eu.-Afr.-Asia —Fig. 2. C. (S.) coronata, U. Eoc. (Bart.), Paris Basin.

✓ C. (S.) armata Morton, 1833, p. 129, U. Cret., N. Jersey
C. (S.) aspergillum Bronn, 1828, p. 5 [= C. (S.) bacillum (Brocchi, 1814)]
C. (S.) bacillum (Brocchi, 1814), p. 273 [Teredo], Mioc., Austria
C. (S.) bacillum bacillaris (Deshayes, 1830), p. 239, Plioc., Fr.
C. (? S.) clavata (Roemer) Orbigny, 1850, p. 233, ? Cret., Germany
C. (S.) caillati Deshayes (? MS) M. Eoc., Fr.
C. (? S.) cornigera Schafhaeutl, 1863, p. 179, U. Cret., Bavaria [both valves may be free = ? pre-Clavagella]
C. (S.) coronata Deshayes, 1824, p. 8, U. Eoc., Fr.
C. (S.) digitata (Bivona-Bernardi, 1832), p. 56, ? Plioc., Italy [= C. (S.) bacillum bacillaris (Deshayes, 1830)]
C. (? S.) elegans Müller (not seen) U. Cret., Germany
C. (S.) goldfussi Philippi, 1846, p. 44, L. Olig., Germany
C. (S.) maniculata (Philippi, 1836), p. 1, ? Plioc., ? Italy [? = C. (S.) bacillum bacillaris (Deshayes, 1830)]
C. (S.) oblita Michelotti, 1861, p. 53, U. Olig. (Tongrian), Hungary-Egypt
C. (S.) ramosa Dunker, 1882, p. 172, Rec., Japan


(x 0.4)

Figure 2
Clavagella (*Stirpulina*)

Clavagella (*Bryopa*) Gray, 1847
[**C. aperta* Sowerby, 1823]

[= *Tiria* GREGORIO, 1886 (*C. aperta* Sowerby; herein desig., Smith, 1962, obj.)] Siphonal end of tube periodically expanded, anterior end smooth; with small short tubules through the tube around the valves. *U. Olig.* (*Aquitanian*)-*Rec*., Medit.-Indo-Pac. — Fig. 3, *C.* (*B.*) *aperta*, Rec., Malta.

C. (? B.) *angulata* Philippi, 1844, p. 2, Rec., Sicily [?= C. (B.) *melitensis* Broderip, 1835]
C. (B.) *aperta* Sowerby, 1823, XIII, Figs. 1-4, Rec., Medit.
C. (? B.) *astraeicola* Jouss. (not seen)
C. (B.) *balanorum* Scacchi, 1844, p. 4, Rec., Medit. [? = C. (B.) *aperta* Sowerby, 1823]
C. (B.) *brochoni* Benoist, 1877, p. 313, U. Olig., Fr.
C. (B.) *laqueata* Sowerby (in Reeve), 1873, Rec., ? Medit.
C. (B.) *lata* Deshayes, 1839, p. 25, Rec., Ind. O.-Austral.
C. (B.) *melitensis* Broderip, 1835, p. 116, Rec., Medit.
C. (B.) *philippiana* Sowerby (in Reeve), 1873 [*ex* Desh. MS] Rec., Medit.
C. (? B.) *senilis* Jouss. (not seen)
C. (B.) *sicula* Chiaje, 1830, pl. 83, Rec., Medit. [? = C. (B.) *aperta* Sowerby, 1823]
C. (? B.) *socialis* Jouss. (not seen)

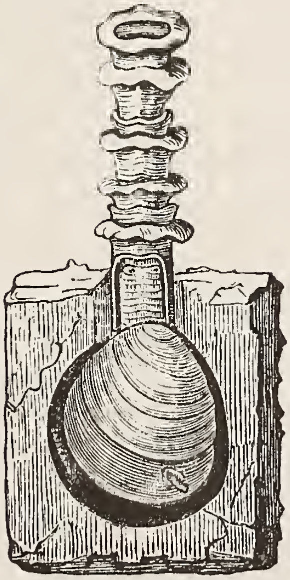
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Figure 3
Clavagella (*Bryopa*)

Clavagella (*Dacosta*) Gray, 1858 (? *recte Dacostaia*)
[**C. australis* Sowerby, 1829, *ex* Stutchbury MS]

Siphonal end of tube not expanded, anterior end smooth, rounded; with small, very short tubules through the tube around the valves. *Rec*., W. Pac. — Fig. 4, *C.* (*D.*) *australis*, Rec., Austral.

C. (D.) *australis* Sowerby, 1829, app. p. 3, Rec., Austral.

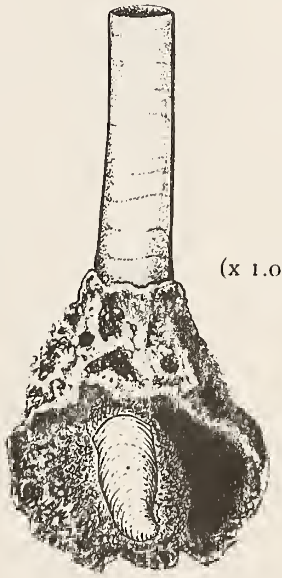
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Figure 4
Clavagella (*Dacosta*)

Humphreyia Gray, 1858
[* *Aspergillum strangei* A. Adams, 1854]

[= *Humphreysia*, spelling error] Tube twisted and irregularly square in cross-section, both valves united into a single plate forming most of anterior bag-like cavity. *Rec*., W. Pac. —Fig. 5. *H. strangei* (A. ADAMS), Rec., Austral.

H. *coxi* Brazier, 1872, p. 23, Rec. Austral.
H. *strangei* (A. Adams, 1852), p. 91, Rec., Austral.

Figure 5
Humphreyia

Penicillus Bruguière, 1789
[* *P. javanus* = * *Serpula penis* Linnaeus 1758;
SD Habe, 1952]

[=Brechites GUETTARD, 1770 (non-binom.); Penecilli DACOSTA, 1776 (vernacular); Penecillus, Penicellus, spelling errors; Verpa ROEDING, 1798 (obj.); Aquaria PERRY, 1811 (A. radiata, herein desig., Smith, 1962, obj.); Bunodus BLAINVILLE, 1817 (nom. nud.) ex GUETTARD (non-binom.); Arytene OKEN, 1815 (obj.; rejected ICZN, 1956); Arytaena OKEN, 1817 (obj.; Arythaena, Arytene, spelling errors); Aspergillum LAMARCK, 1818 (obj.; Adspergillum, Aspergillium, Aspergillus, spelling errors); Clepsydra SCHUMACHER, 1817 (obj.; Clepydra, spelling error)] Both valves merging with tube; tube circular in cross-section; anterior adductor degenerate, posterior adductor absent in adult. U. Olig. (Aquitanian)-Rec.

"Aspergillum cretaceum" Rominger, 1847, p. 659 [nom. nud.] [? = Clavagella (Stirpulina) cornigera Shafhaeutl, 1863]
Aspergillum javanum of Authors=P. (P.) penis (Linnaeus)
Aspergillum sparsus Sowerby =P. (P.) penis (Linnaeus)

Penicillus annulatus Lamarck, 1816 [?= Polychaete Ann.]
Penicillus capitatus Lamarck, 1816 [?= Polychaete Ann.]
Penicillus kobeltianus (Löbbeck, 1879), p. 95 [nom. nud.]
P. (?) listeri (Gray, 1825), p. 135 (not seen)
Penicillus phoenix Lamarck, 1816 [?= Polychaete Ann.]

Penicillus (*Penicillus*)

Siphonal end of tube simple; anterior end fringed with single row of distinct simple tubules; anterior disc with a slit. U. Olig. (Aquitanian)-Rec., Indo-Pac.-Austral.—Fig. 6, P. (P.) penis (LINNAEUS), Rec., Singapore

P. (P.) annulatus (Thiele, 1934), p. 943, ex Deshayes ? MS
P. (P.) annulus (Gray, 1858), p. 312, ex Deshayes MS, Pleist., Indo-Malay-Philippines
P. (P.) clavatus (Chenu, 1843), p. 4, Hab.-?
P. (P.) coronatus (Sieverts, 1934), p. 267 Plioc., Indo-Pac.
P. (P.) dichotomus (Chenu, 1843), p. 3, Plioc., Java
P. (P.) disjunctus Sowerby in Reeve, 1860, sp. 12, ex Deshayes MS, U. Plioc., Indo-Malay
P. (P.) incrassatus (Chenu, 1843), p. 4, ? Rec., Austral.
P. (P.) ornatus (Chenu, 1843), p. 4 [= P. (P.) tuberculatus (Chenu, 1843)]
P. (P.) penis (Linnaeus, 1758), p. 788, Rec., Ind. O.
P. (P.) pulcher Sowerby in Reeve, 1860, ex Deshayes MS, Rec., Singapore
P. (P.) pulcher fossilis (Sieverts, 1934), p. 269, Mioc., N. Borneo
P. (P.) radiatus (Perry, 1811), pl. 52, Hab.-? [= P. (P.) penis (Linnaeus, 1758)]
P. (P.) radix Gray (not seen) ex Deshayes MS, U. Plioc., Indo-Malay
P. (P.) recluzianus (Chenu, 1843), p. 4 [=P. (P.) incrassatus (Chenu, 1843)]
P. (P.) semifimbriatus (Chenu, 1843), p. 4, Rec., ? Red Sea
P. (P.) strangulatus (Chenu, 1843), p. 3, Rec., Austral.
P. (P.) tuberculatus (Chenu, 1843), p. 3, Rec., Moluccas
P. (? P.) venustulus (Beets, 1942), p. 230, Mioc., N. W. Borneo

Figure 6
Penicillus (Penicillus)

Penicillus (*Pseudobrechites*) Magne, 1941
[* *Aspergillum leognanum* Hoeninghaus, 1827]

Similar to P. (Penicillus), but fringe tubules shorter, less distinct, and anterior disc without central slit. U. Olig. (Aquitanian), Eu. —Fig. 7. P. (P.) leognanus (HEONINGHAUS, 1827), p. 4, U. Olig., Fr.

Figure 7
Penicillus (Pseudobrechites)

Penicillus (*Foegia*) Gray, 1847
["*Aspergillum novaezelandiae*" (= * *P. novaezelandiae* Bruguière, 1789)]

Umbo almost covered with swollen prominence; fringe indistinct, formed like slit in disc, of short thick tubules. U. Olig. (Aquitanian)-Rec., Indo-Pac.-W. Pac. —Fig. 8. P. (F.) novaezelandiae BRUGUIÈRE, Rec., Australas.

P. (F.) agglutinans Lamarck, 1818), p. 430, Rec., Indo-Pac.
P. (F.) cumingianus (Chenu, 1843), p. 3, Rec., Austral.
P. (F.) giganteus (Sowerby, 1888), p. 290, Mioc.-Plioc., Sumatra, Formosa, Japan; Rec., Japan
P. (?F.) imbricatus (Perry, 1811), pl. 52, Hab.-?
P. (F.) novaehollandiae (Chenu, 1843), p. 4, Rec., New Holland [=P. (F.) agglutinans (Lamarck, 1818)]
P. (F.) novaezelandiae Bruguière, 1789, p. 129, Rec., Austral.
P. (F.) novaezelandiae incertus (Chenu, 1843), p. 4, Rec., Austral.
P. (F.) philippiensis (Chenu, 1843), p. 3, Rec., Philippines
P. (F.) zebuensis (Chenu, 1843), p. 3, Rec., Philippines [=P. (F.) agglutinans (Lamarck, 1818)]

Figure 8
Penicillus (Foegia)

Penicillus (*Warnea*) Gray, 1858

[* *Aspergillum australe* Chenu, 1843; SD Stoliczka, 1871]

Tube cylindrical, siphonal end with series of plaited ruffles; fringe distinct, of a single series of thick simple tubules. Plioc.-Rec., Red Sea-Australas.-Japan — Fig. 9, P. (W.) australis (Chenu), Rec., Australas.

P. (W.) australis (Chenu, 1843), p. 3, Rec., Australas.

P. (W.) delessertianus (Chenu, 1843), p. 3, Rec., Red Sea

P. (W.) vaginiferus (Lamarck, 1818), p. 430, Rec., Red Sea

P. (W.) yokoyamai (Shikama, 1955), Plioc.-Rec., Japan

(x 0.8)

Figure 9
Penicillus (*Warnea*)

Literature Cited

Adams, H., & A. Adams
1858. The genera of recent mollusca. Vol. 2: 649-650. Van Voorst, London.

Bruguière, M.
1789. Encyclop. Méthod. (Vers), vol. 1 (xv): 126-130, genus 33.

Eames, F. E.
1957. Eocene mollusks from Nigeria (a revision). Bull. Brit. Mus. (Nat. Hist.), 3 (2): 68-69.

Gray, J. E.
1847. Genera of recent mollusca, their synonyma and types. Proc. Zool. Soc. London 15: 129-219.

——, ——
1858. On the families Aspergillidae, Gastrochaenidae, and Humphreyidae. Proc. Zool. Soc. London 26: 313.

Lacaze-Duthiers, H. de
1870. Sur l'organisation de l'arrosoir, Aspergillum javanicum. C. R. Acad. Sci. Paris 70: 268-271.

——, ——
1883. Morphologie des acéphales, premier mémoire, Anatomie de l'arrosoir. Arch. Zool. Exp. Gen. 2 (1): 1-68.

Lamarck, J.-B. P.
1818. Animaux sans vertèbres, VI: 428-432.

Morton, John E.
1958. Molluscs. Hutchinson, London. p. 195.

Purchon, R. D.
1956. A note on the biology of Brechites penis (L.) (Lamellibranchia). J. Linn. Soc. 43: 43-54.

——, ——
1960. A further note on the biology of Brechites penis (L.) (Lamellibranchia). Proc. Malac. Soc. London, 34 (1): 19-23.

A New Dampierian *Cypraea*

BY

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(Plate 40; 1 Textfigure)

During the summer of 1960, Mr. A. R. Whitworth of Carnarvon, Western Australia, sent me three specimens of an unknown Cypraea from Vlaming Head, Northwest Cape, Western Australia, asking if they might belong to the subspecies Cypraea cernica tomlini Schilder, 1930. Mr. Bernard C. Cotton of the South Australian Museum had identified one of these shells as C. cernica Sowerby, 1870, referring to the illustrations of that species in Cotton and Steadman (1946, p. 522) and Allan (1956, p. 94). (Personal communication to Mrs. T. Hartley, May 1960.)

To me, the shells were readily enough recognizable as related to Cypraea cernica, though they seemed to differ in a general way from that species and from typical C. c. tomlini; moreover, the type locality of C. c. tomlini (Lifu, New Caledonia) is far enough removed from Western Australia to give me further reason for hesitating to put either name on the unknown shells. Consequently, I asked Mr. Whitworth for additional shells to study; he sent me the remaining six in his collection. None of the shells were live-taken (all having been picked up on the beach after storms), but most are in reasonably good to excellent condition.

Cypraea cernica at present comprises four geographical races. Schilder (1938: p. 223, Map 1) has defined certain geographical provinces and regions which have rather definite limits. The "races" are groups of individuals of one species separated by zones of nonoccurrence. Cypraea cernica's four races (C. c. cernica, C. c. tomlini, C. c. ogasawarensis, and C. c. mariellae) are located in the following Schilderian geographical regions: Lemurian, Melanesian, Japanese, and Hawaiian, respectively.

Since the Western Australian form shows certain morphological and color differences from Cypraea cernica s. s., and since its typical locality is in a completely different geographical area (the Dampierian Region) separated by zones to the north and south in which no forms of C. cernica are presently known to exist, it is my opinion that the Western Australian specimens belong to a new subspecies.

Cypraea (*Erosaria*) *cernica viridicolor* CATE, subspec. nov.

Shell solid, humped, pyriformly ovate, narrowing abapically; base and sides rounded, right and left margins excurvate, callous; inductura distinctly and evenly pitted above marginal edge; aperture fairly straight, narrow, curving sharply left adapically; both terminals produced, abapical terminal more so. Teeth fine, well defined, centrally short on columella, lengthening obliquely on the labial area adapically; outer labial teeth heavier, longer, covering most of outer lip except at central marginal edge; terminal ridge extending across fossula; first four or five teeth extending across and terminating prominently on adaxial edge of fossula. Dorsal inductura smooth, glossy, light olive-green, very generously covered with irregularly sized small white spots; white mantle line traverses length of upper right dorsum; base, teeth, interstices white; numerous large and small chestnut spots on upper marginal surface, ocellating some white spots, and continuing over terminal collars.

In Cypraea cernica viridicolor the shell is more flattened and less humped than in C. c. cernica, though approaching it more nearly than in the other subspecies; the base from the left margin to the columella is narrower and straighter; the teeth are finer, shorter, and less elevated, particularly on the outer lip; on the fossula they are less numerous and weaker. Cypraea c. viridicolor differs in being larger, broader in relation to its length, flatter and more solid in general. Its color is a lighter greenish-beige, with the lateral spots much larger, more numerous, and more distinct.

The name viridicolor stems from the Latin viridis, meaning green, and color, meaning hued, in reference to the peculiar greenish hue.

The type locality of Cypraea cernica viridicolor is Vlaming Head, Northwest Cape, Western Australia (21° 50' S. Lat., 114° 10' E. Long.). Knowledge of its range is limited at this time, with only two known collecting stations, Vlaming Head and Quobba Point, approximately 40 miles north of Carnarvon.

The holotype will be deposited in the Paleontological Type Collection at Stanford University, Stanford, California (No. 9'506). Paratypes and hypotype are in the respective collections of C. N. Cate and A. R. Whitworth.

Addition of the new subspecies brings the recognized number of geographical races of *Cypraea cernica* to five, two others being of doubtful standing (*C. c. percomis* Iredale, 1931, and *C. c. prodiga* Iredale, 1939). Starting in the westernmost region with the typical species and working in a more or less counter-clockwise direction, these races may be enumerated as follows (see map, textfigure 1):

Subspecies	Region	Type Locality
Cypraea cernica cernica Sowerby, 1870	Lemurian	Mauritius
Cypraea cernica viridicolor subspec. nov.	Dampierian	Vlaming Head, NW Cape
Cypraea cernica tomlini Schilder, 1930	Melanesian	Lifu, New Caledonia
Cypraea cernica marielae Cate, 1960	Hawaiian	Maui, Hawaii
Cypraea cernica ogasawarensis Schilder, 1945	Japanese	Bonin Islands

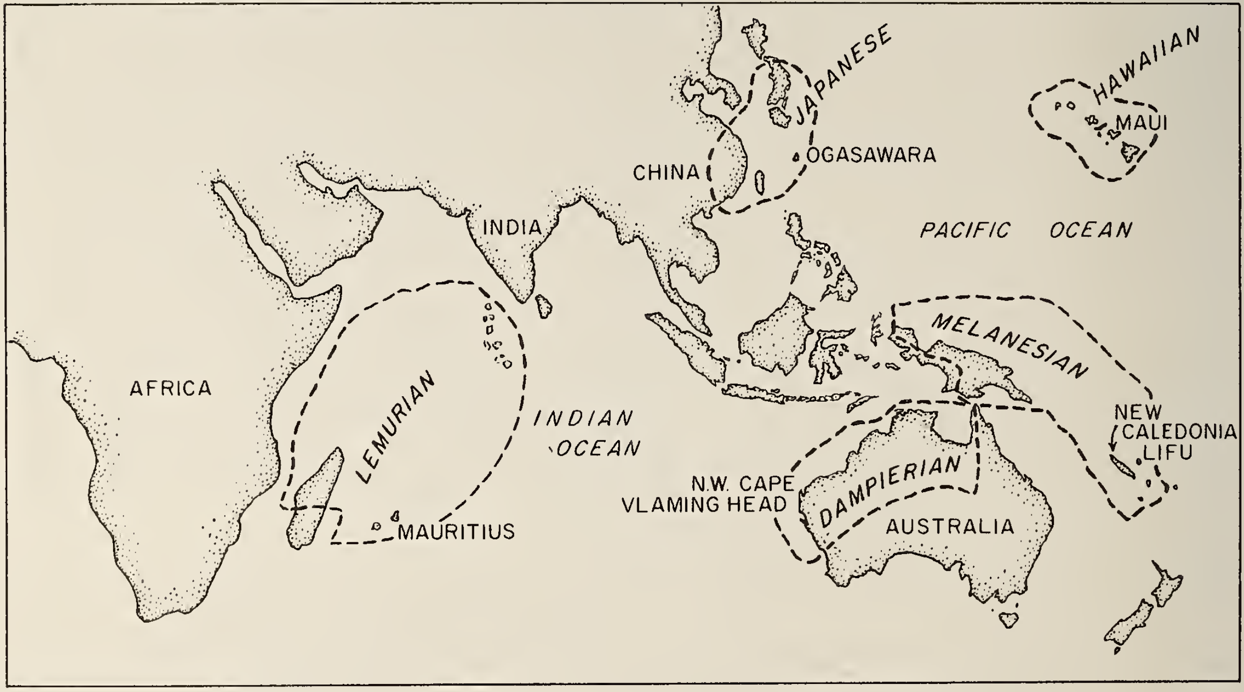

Figure 1: Map showing the boundaries of five geographical regions according to Schilder (1938)

Explanation of Plate 40

Cypraea cernica viridicolor C. Cate, subspec. nov.

Figure 1: Holotype; Figure 2: Hypotype No. 1; Figure 3: Paratype No. 3; Figure 4: Paratype No. 4; Figure 5: Paratype No. 5; Figure 6: Paratype No. 6; Figure 7: Paratype No. 7; Figure 8: Paratype No. 1; Figure 9: Paratype No. 2. Hypotype No. 1 collected just north of Carnarvon, all others at Vlaming Head; Paratypes 1 and 2 are subfossil specimens. Photos by Takeo Susuki. (x 2)

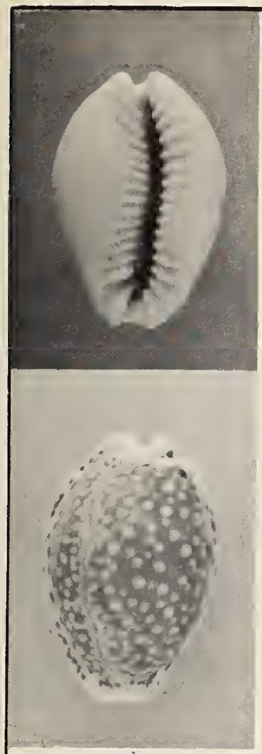

Figure 1

Figure 2

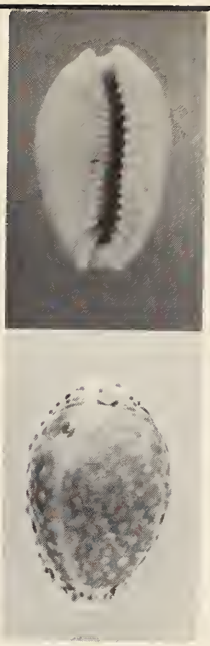

Figure 3

Figure 4

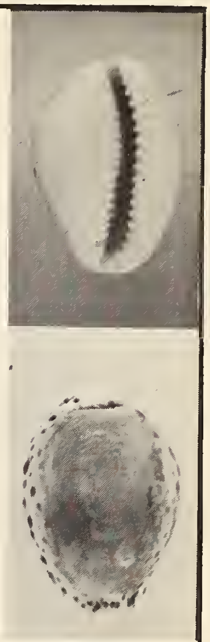

Figure 5

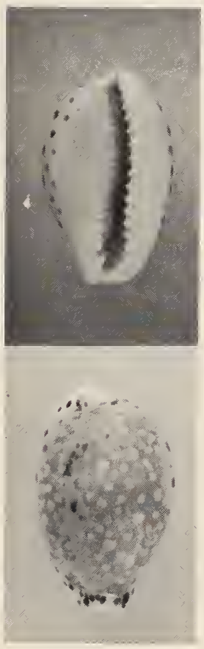

Figure 6

Figure 7

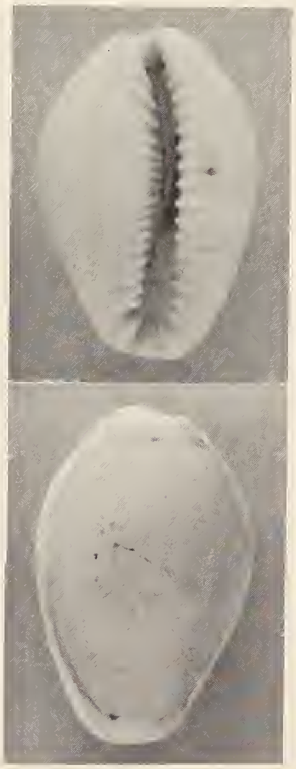

Figure 8

Figure 9

Takeo Susuki, *photo.*

Table 1:

Measurements (in millimeters) of Types of *Cypraea cernica viridicolor* CATE, subspec. nov.

Vlaming Head Specimens						
	Length	Width	Height	Denticles		Location
				Outer Lip	Columellar Lip	
Paratype 1 †	28.2	18.5	13.8	20	17	C. N. Cate Collection
Holotype	21.4	14.4	10.8	18	14	Stanford University Paleo. Type Coll. No. 9506
Paratype 2 †	20.2	12.3	10.0	18	16	C. N. Cate Collection
Paratype 3	18.6	11.7	9.0	18	16	C. N. Cate Collection
Paratype 4 *	18.3	11.1	9.2	19	15	C. N. Cate Collection
Paratype 5	18.0	12.9	10.0	17	14	C. N. Cate Collection
Paratype 6 *	17.5	11.0	8.9	17	15	C. N. Cate Collection
Paratype 7	16.0	10.0	8.1	16	15	C. N. Cate Collection
Quobba Point Specimen						
Hypotype 1	25.9	17.2	12.8	17	15	A. R. Whitworth Collection

† Dead, subfossil specimen * Subadult specimen

Average length 20.4 mm. Average number of teeth: outer lip, 18; columellar, 15.

Just before this issue went to press, a parcel was received from Mr. Whitworth containing 18 additional specimens of this subspecies. All 18 were collected in beach drift at Vlaming Head, North West Cape. The presence of a total of 27 specimens, matching the morphological characters mentioned above in all respects, further corroborates my conclusions. I regret that the statistics relating to the recently collected specimens must be omitted here but would like to note that one of these specimens is larger than Paratype 1 listed in Table 1, measuring 31.0 mm. long, 20.1 mm. wide, and 16.3 mm. high.

Acknowledgment

I wish to thank my friend and co-worker Mr. Arch Whitworth of Carnarvon, Western Australia, for his very helpful assistance and for his generosity in sending specimens for study, requesting that only one be returned to him; also, to Jean Cate, whose actual work on this paper was scarcely less than my own, I want to express my devotion and grateful appreciation.

Literature Cited

Allan, Joyce
1956. Cowry shells of world seas. pp. 1-170, pls. 1 to 15. Melbourne.

Cate, Crawford N.
1960. A new Hawaiian subspecies of Cypraea cernica Sowerby. The Veliger 3 (1): 3-7; pl. 1.

Cotton, B. C., & W. K. Steadman
1946. Key to the classification of the cowries. Rec. So. Austr. Mus., 8 (3): 503-530, pls. 8-13.

Iredale, Tom
1931. Australian molluscan notes. Rec. Austr. Mus., 18 (4): 217.

———, ———
1939. Australian cowries, Pt. II. Austral. Zoolog., 9 (3): 297-323, pls. 27-29.

Schilder, Franz Alfred
1930. Remarks on type specimens of some recent Cypraeidae. Proc. Mal. Soc. Lond., 19 (1): 49-58.

Schilder, Franz Alfred, & Maria Schilder
1938. Prodrome of a monograph on living Cypraeidae. Proc. Mal. Soc. Lond., 23(3): 119-231, 16 textfigs.

———, ——— & ———, ———
1945. Westpazifische Cypraeacea von den Forschungsreisen des Prof. Dr. Sixten Bock. Ark. Zool. Stockholm 36 A (2): 1-32.

Nomenclatural Notes on some West American Mollusks, with Proposal of a New Species Name

BY

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A. Concerning *Apolymetis*

The type species of *Apolymetis* Salisbury, 1934, is *Tellina meyeri* Dunker, 1846, a rare Oriental form. The original illustration shows a lenticular shell with a very long narrow ligament and regular concentric ribs. The only points of resemblance to West American species are a furrow down the posterior slope, a large pallial sinus, and muscle scars unequal in size. While revising the Tellinidae for the "Treatise on Invertebrate Paleontology", I came to the reluctant conclusion that the type species of *Apolymetis* is so unlike all American species that even if one made use of available subgeneric names for grouping, the result would be incongruous. Dr. Olsson in his "Mollusks of the Tropical Eastern Pacific" (1961, pp. 410-414) has suggested a lead by elevating *Psammotreta* Dall, 1900, to generic rank. This would seem to be a more plausible central group around which to arrange certain West Coast forms now called in part *Apolymetis*, in part *Macoma*. Olsson prefers to recognize two separate genera, *Florimetis* and *Psammotreta*, but my feeling is that more than two groups can be discerned, and to call each a full genus would be to subdivide more finely than we do in other pelecypod families. My rearrangement, then, would be:

Genus *Psammotreta* Dall, 1900

Type species, *Tellina aurora* Hanley, 1844; by original designation. Elongate to trigonal; ligament sunken; posterior end weakly to strongly bent.

Subgenus *Psammotreta*, *s. s.*

Elongate to ovate, smooth, flexure weak.

P. (*P.*) *aurora* (Hanley, 1844)
P. (*P.*) *mazatlanica* (Deshayes, 1855)
P. (*P.*) *pacis* (Pilsbry and Lowe, 1932) (Not a synonym, as Olsson concluded.)
P. (*P.*) *plebeia* (Hanley, 1844)

Subgenus *Pseudometis* Lamy, 1918

Type species, *Tellina truncata* Philippi, 1843 (*non* Linnaeus, 1767) = *T. praerupta* Salisbury, 1934; by subsequent designation, Salisbury, 1934.

More trigonal than *P.* (*Psammotreta*); flexure weak.

P. (*P.*) *dombei* (Hanley, 1844)
P. (*P.*) *grandis* (Hanley, 1844)
P. (*P.*) *gubernaculum* (Hanley, 1844)

Subgenus *Florimetis* Olsson and Harbison, 1953

Type species, *Tellina intastriata* Say, 1826; by original designation.

With subquadrate outline; flexure strong; anterior end somewhat inflated.

P. (*F.*) *asthenodon* (Pilsbry and Lowe, 1932)
P. (*F.*) *biangulata* (Carpenter, 1856)
P. (*F.*) *cognata* (Pilsbry and Vanatta, 1902)
P. (*F.*) *cognata clarki* (Durham, 1950)

B. *Tresus* versus *Schizothaerus*

For the past 40 years or more, *Tresus* Gray, 1853, has been considered unavailable, a homonym. I am grateful to Dr. J. Lockwood Chamberlin of the United States Bureau of Commercial Fisheries, Washington, D. C., for having pointed out to me that this is not true. Thus, my revision of the Mactracea for the "Treatise on Invertebrate Paleontology" is spared the error of accepting *Tresus* Walckenaer, 1833, as valid in Arachnida even though two modern nomenclators cite it (Sherborn's "Index Animalium" adds a query). Consulting Walckenaer's work, I found a French vernacular, "Trésus", that, moreover, is a *nomen nudum*, without cited species or description. This leaves Gray's *Tresus* available in Mollusca. Some question has arisen as to whether it preceded Conrad's

Schizothaerus, but the evidence seems clear that it has priority: *Tresus* Gray, Jan. 1853 (Ann. Mag. Nat. Hist., ser. 2, vol. 11, p. 42; type species, by monotypy, *Lutraria maxima* Middendorff, 1849 [*non* Jonas, 1844] = *L. nuttalli* Conrad, 1837) versus *Schizothaerus* Conrad, Feb. 7, 1853 (Proc. Acad. Nat. Sci. Philadelphia, vol. 6, p. 199; type species, by monotypy, *L. nuttalli*). Thus, the latter falls as a synonym.

Although *Tresus* is an unfamiliar name to younger workers, it represents a return to the usage of more than a half-century, and one advantage of it is that it is both easy to spell and easy to pronounce.

C. A New Species Name in EPITONIIDAE

My attention has been called by Mr. Richard E. Petit of Ocean Drive Beach, South Carolina, to the fact that the name *Epitonium* (*Nitidiscala*) *apiculatum* Dall, 1917 (Proc. U. S. Nat. Mus., vol. 54, p. 480) — gastropod species no. 106 in "Sea Shells of Tropical West America" — is a homonym of *Scala apiculata* Dall, 1889 (Bull. Mus. Comp. Zool., Harvard, vol. 18, p. 310), which has been cited and figured as *Epitonium* (*Asperiscala*) *apiculatum* (Dall) by Clench and Turner, 1952 (Johnsonia, vol. 2, no. 31, p. 290, pl. 132, figs. 1-2). As this is a secondary rather than a primary homonym, the name for the West Coast form could stand were *Asperiscala* and *Nitidiscala* treated as separate genera, for the original name combinations were not identical: *Scala* vs. *Epitonium*. However, as current practice does not favor such a fine subdivision of these epitoniids, we are obliged to supply a new name for the West American form.

The holotype of *Epitonium apiculatum* Dall, 1917, has not been figured. It was stated to be in the collection of the United States National Museum. Our concept of the species has been based upon some figures published by Baker, Hanna, and Strong in 1930 (Proc. Calif. Acad. Sci., ser. 4, vol. 19, p. 51, pl. 3, figs. 4-6) of specimens they identified by use of Dall's description. Not having seen the holotype (which evidently is an immature specimen) or any illustrations of it, I prefer not to replace the homonym but rather to bestow a name upon the form figured by Baker, Hanna, and Strong. Therefore, I propose *Epitonium* (*Nitidiscala*) *bakhanstranum* Keen, sp. nov., this specific name being an adjective coined by taking the first three letters in each surname. To commemorate the work of this team is a pleasure, for their joint paper on Epitoniidae is only one of a series of very useful systematic reviews on Panamic province molluscan groups.

A brief but adequate description of *Epitonium* (*Nitidiscala*) *bakhanstranum* was given by Baker, Hanna, and Strong (*op. cit.*, p. 52). The species is distinguished from the other Nitidiscalas with eight varices by the angular or spinose shoulders of the varices, the slender outline, the numerous whorls, and the angle at which the varices diagonally ascend the spire. The type locality is Carmen Island, Gulf of California, at the Salt Works. Height of the holotype is 9.2 mm., diameter, 3.3 mm. It is in the Paleontological Type Collection, California Academy of Sciences, No. 4'763; figured by Baker, Hanna, and Strong (*op. cit.*, pl. 3, fig. 4) and refigured by Keen, 1958 (*op. cit.*, p. 273, fig. 106). Hypotypes, Nos. 4'764 and 4'765 (Plate 3, Figures 5-6) are from the La Paz area, Gulf of California, as are some specimens in the Stanford collection.

D. Names in L. Oken's "Lehrbuch"

The International Commission on Zoological Nomenclature voted in 1956 (Opinion 417) to place "Okens Lehrbuch der Naturgeschichte, vol. 3 (Zoology)" on the Official Index of Rejected Works. There seems to be no ground for questioning the decision that this is a nonbinomial work, which means that all generic names proposed therein have no status in nomenclature as of the dates 1815-1816 and can be validated only by a correct later usage. As no summary list of Oken's names was published by the Commission, except for those in certain vertebrate groups, malacologists who do not have access to a copy of Oken's work have been slow to realize how many and which molluscan names now have no standing. Three such have recently come to my attention.

The name *Arcinella* Oken, 1815, is a synonym in Carditidae, so that its loss there is unimportant. However, it no longer preoccupies *Arcinella* Schumacher, 1817, of which the type (by absolute tautonymy) is *Chama arcinella* Linnaeus, 1758 — the species that also is type of *Echinochama* Fischer, 1887. Therefore, *Echinochama californica* Dall, 1903, now becomes *Arcinella californica* (Dall) and the Caribbean *E. arcinella* becomes *Arcinella arcinella* (Linnaeus).

The second necessary change, called to my attention by Dr. Joshua L. Baily, involves the name Irus Oken, 1815, in Veneracea, the type of which has been accepted as Donax irus Linnaeus, 1758, by tautonymy. This generic name could have been credited to Gray, 1847, with that species as type, but unfortunately Oken himself used it in 1821 in his "Naturgeschichte für Schulen", p. 647, with two species, neither of which is veneracean; one is the type species of Pandora Chemnitz, 1795 (Tellina inaequivalvis) Gmelin (= Solen inaequivalvis Linnaeus, 1758), the other Mytilus rugosus, a doubtful species of Hiatella, probably a variant of H. arctica (Linnaeus, 1758). The former, "Tellina inaequivalvis", is here designated as type of Irus Oken, 1821, which becomes a synonym of Pandora, reverting to the usage of Blainville, Deshayes, and other nineteenth-century writers. This leaves the veneracean group without a name unless, (a) one petitions the International Commission for protection of Irus Oken, 1815 — a procedure that on the average requires approximately five years — or, (b) elevates one of the named subgenera of the group to generic rank (these would take precedence over any new name that might be proposed). Three such names are available: Notopaphia Oliver, 1923, the type species from New Zealand, Venerupis elegans Deshayes, 1854; Notirus Finlay, 1928, type species, Venerupis reflexa Gray, 1843, also from New Zealand; and Paphonotia Hertlein and Strong, 1948, type species, Petricola elliptica Sowerby, 1834, from Tropical West America. The type of Notopaphia is elongate, with fine concentric ribs and a sinuous ventral margin. Perhaps this group might well be elevated to generic rank. Notirus would then be available as the generic name for the Irus group. Notirus, s. s., would include those ovate-quadrate forms with fine to coarse concentric ribs, and Paphonotia would include those with stronger radial sculpture. The genus ranges in time from Oligocene to Recent in Europe but in the Recent is mainly distributed in the Pacific, with only one species, Donax irus Linnaeus, in the Mediterranean. The Californian species presently known as Irus lamellifer (Conrad, 1837) probably should be considered to fall in Notirus, s. s., at least until such time as someone makes a thorough review of all known species in the group.

The generic name Clathrus Oken, 1815, in Epitoniidae, with Turbo clathrus [Linnaeus, 1758] as type by tautonymy, was (according to Dr. Robert Robertson, in litt.) validated by Oken in 1821.

Literature Cited

Baker, Fred, G Dallas Hanna, & A. M. Strong
1930. Some mollusca of the family Epitoniidae from the Gulf of California. Proc. Calif. Acad. Sci., ser. 4, 19 (5): 41-56, pls. 2-3.

Finlay, H. J.
1928. The recent mollusca of the Chatham Islands. Trans. Proc. New Zealand Inst., 59: 232-286, pls. 28-43.

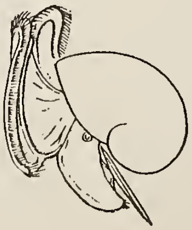
Hertlein, Leo G., & A. M. Strong
1948. Mollusks from the West Coast of Mexico and Central America, pt. 6. Zoologica 33: 163 - 198, pls. 1-2.

International Commission on Zoological Nomenclature
1956. Opinion 417, Rejection for nomenclatorial purposes of volume 3 (Zoologie) of the work by Lorenz Oken entitled Okens Lehrbuch der Naturgeschichte, published in 1815-1816. Opinions and Declarations rendered by the I. C. Z. N., 14 (1): 1-42.

Keen, A. Myra
1958. Sea shells of tropical west America; marine mollusks from Lower California to Colombia. Stanford, Calif., Stanford Univ. Press; xi + 624 pp., illus.

Oliver, W. R. B.
1923. Notes on New Zealand pelecypods. Proc. Malacol. Soc. London, 15: 179-188.

Olsson, Axel A.
1961. Mollusks of the tropical eastern Pacific, particularly from the southern half of the Panamic Pacific faunal province (Panama to Peru). Part I. Panamic-Pacific pelecypoda. Paleontol. Res. Inst. Ithaca, N. Y. pp. 1-574, pls. 1-86.



A New Method of Determining the Accuracy of Geotactic Orientation of the Snail *Helix aspersa* Müller

BY

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(3 Textfigures)

Helix aspersa Müller progresses upward when placed upon inclined surfaces. Thus, this animal strongly demonstrates negative geotactic orientation. Some of the work dealing with geotactic orientation has recently been reviewed by Carthy (1958). The accuracy of orientation was determined by the magnitude of the probable error of each animal's angle of orientation (Crozier and Pincus, 1927) but not directly by mathematical equations. Geotactic orientation of *H. aspersa* was found by Cole (1927) to be controlled by the equality of tensions produced within the proprioceptors in the body musculature by gravity. The accuracy of geotactic orientation of *H. nemoralis* has been found by Hoagland and Crozier (1929) to decline in proportion to an increase of the angle at which the surface is inclined from the horizontal. They also found that when this snail progressed on either a vertical or a horizontal surface, the longitudinal axis of the snail's body was parallel to the longitudinal axis of the shell, but when this alignment was changed by inclining the surface, the snail turned until the two axes were again parallel.

Equations have been used to describe directly the orientation paths of rats (Crozier and Pincus, 1926, 1927), mice (Crozier and Oxnard, 1927), slugs (Wolf, 1927), and snails (Hoagland and Crozier, 1929). The determination of an animal's accuracy of geotactic orientation directly by mathematical equations shows that this type of behavior is orderly and can be quantified. This is essential if behavior patterns are to be compared and if behavior patterns are to have taxonomic value.

The purpose of this study is to develop a series of mathematical equations that can be used to describe quantitatively the accuracy of geotactic orientation of an animal, and to determine the geotactic orientational accuracy of *Helix aspersa* by these equations. The first equation will describe the animal's true orientation path in terms of the angle between the animal and the horizontal, and the second equation will determine the animal's accuracy of orientation in terms of the difference in degrees between the animal's true orientation path, or true bearing, and the angle of inclination of the surface.

Materials & Methods

Specimens of *Helix aspersa* were collected in Richmond, Contra Costa County, California, from 24 September, 1960, to 29 May, 1961. The animals were maintained on oatmeal, calcium carbonate, and lettuce. Before being used for experimental purposes, each snail was confined for a period of between two and three days in a quart jar with a substrate of half an inch of small rock covered with one and one-half inches of moist soil.

An apparatus was developed to determine the angular deviations of the snail's path from the vertical on the surface (see Figure 1).

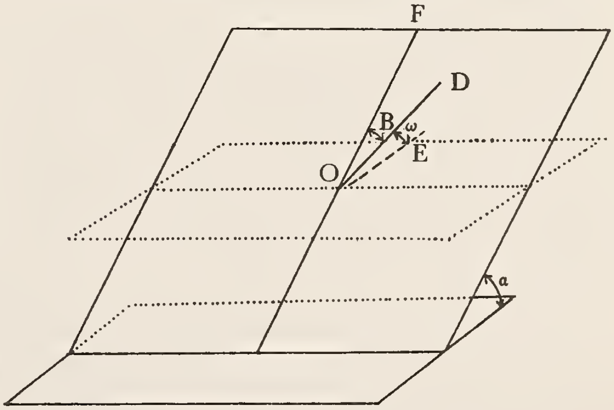

Figure 1: Diagram showing inclined surface and expressions used in finding the degree of accuracy of geotactic orientation: α = angle of inclination of the surface; B = the angular deviation; ω = angle between the snail's true path of orientation and the horizontal. Method of scoring angular deviation: O - D = path of snail; O - E = path of snail projected onto horizontal surface; O - F = line on the surface perpendicular to the horizontal when the surface is inclined 90°.

Pieces of brown paper, 24 inches square, were attached to a piece of cardboard the same size and inclined at angles of 0°, 15°, 30°, 45°, 60°, 75°, and 90° from the horizontal. The paper served as a substrate on which the snails moved.

To track the snail's path of progression, blue ink powder was dusted onto a piece of brown paper which was used as a master sheet. By pressing the master sheet on other sheets of paper, enough ink powder was transferred from the master sheet to these duplicates to show a snail's track easily on the latter. Ten duplicate sheets can be prepared without additional ink powder.

Each snail was placed upon the substrate at its center with no uniformity as to the position of the snail. At this time the snail was withdrawn into its shell, and the surface was in a horizontal position. After the snail had become attached on the substrate, but before it could extend itself, the surface was raised. While performing the preceding steps, a 25-watt red photographic safe-light bulb was used for illumination at a distance of ten feet. The animals were allowed to move for 30 minutes in total darkness. The room temperature (20.0° to 23.7° C.) was recorded at the beginning of each trial. To minimize adaptation, conditioning, or learning that may occur with repeated testing, no snail was allowed to score more than once.

One hundred Helix aspersa were recorded singly at each of the angles of inclination for seven angles. The angular deviations from the vertical on the surface (Figure 1, O-F) for each slope of the surface were scored and their mean calculated. These were plotted against the angle of inclination of the surface. Each angular deviation was scored at a distance of nine inches from the beginning of each run. This distance was obtained by the chance selection of a number from 1 through 12. The standard deviations and the range of each set of angular deviations were also computed.

Geotactic accuracy was determined by solving the following equation: $\alpha - \omega$ = degree of accuracy, where α is the angle of inclination of the surface, and ω is the angle between the snail's true orientation path and the horizontal (see Figure 1). The true orientation path of the snail was determined by solving the following equation: $\sin \omega = \sin \alpha \cos B$, where B is the mean of the angular deviation.

For each angle that the surface was inclined, the degree of accuracy was calculated by using the equations presented above. The degree of accuracy was plotted against the angle of inclination of the plane.

Results

The results of the study are summarized in Table 1, which shows the mean of the angular deviations, the range of the angular deviations, the value of ω, and the degree of accuracy of geotactic orientation for each angle of inclination of the surface.

For all the angles at which the surface was inclined between 15° and 75°, the degree of accuracy remained nearly constant with a value of approximately 2°; however, the degree of accuracy decreased to a value of 8° 53' when the surface was inclined at an angle of 90°. Since in the control situation (0°) there was no vertical component, it was not possible to score angular deviations. In this case the snails moved in an apparently random manner.

Figure 2, in which the means of the angular deviations were plotted against the angle of inclination of the surface (except at 90°), shows that as the angle of inclination of the plane increased, the mean of the angular deviations decreased. The standard deviations and the range of each set of angular deviations at each angle that the surface was inclined are also shown in Figure 2.

Table 1:

Mean and range of the angular deviations, values of ω, and degree of accuracy for each angle of inclination of the surface

Angle of inclination of surface in degrees	Mean of angular deviations	Range of angular deviations	Value of ω	Degree of accuracy
0 (control snails) moved in an apparently random manner				
15	28°21′	1-57	13°10′	1°50′
30	20°56′	1-51	27°50′	2°10′
45	15°38′	1-30	42°55′	2°05′
60	11°45′	1-27	57°59′	2°01′
75	7°41′	1-17	73°08′	1°52′
90	8°53′	0-39	81°07′	8°53′

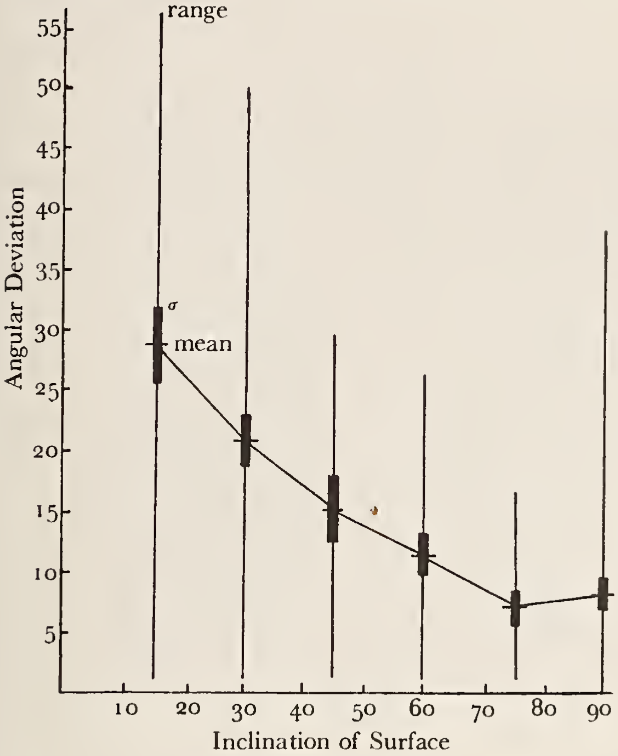

Figure 2: Mean angular deviation, standard deviation and range of each set of angular deviations at each angle of inclination of the surface. At each inclination of the surface the vertical line indicates the total range of the angular deviations; the broad portion of the line indicates the standard deviation on each side of the mean; and the crossbar, the mean.

Figure 3, in which the degree of accuracy has been plotted against the angle that the surface was inclined, shows, in graphic form, the relation between the degree of accuracy of orientation and the angle of inclination of the surface.

Discussion

When accuracy of geotactic orientation is determined by the equation $\alpha - \omega$, the orientation of Helix aspersa has been found to be consistently accurate if progression of the animal takes place on a surface inclined between the angles of 15° and 75° from the horizontal; but on a surface inclined at an angle of 90° from the horizontal, the orientation of this snail is relatively inaccurate. These results tend to disagree with those of earlier workers who found that orientational accuracy of various animals decreased in direct proportion to log sin α or to sin α when accuracy was determined in terms of the magnitude of the probable error of each animal's angle of orientation (Crozier and Pincus, 1927).

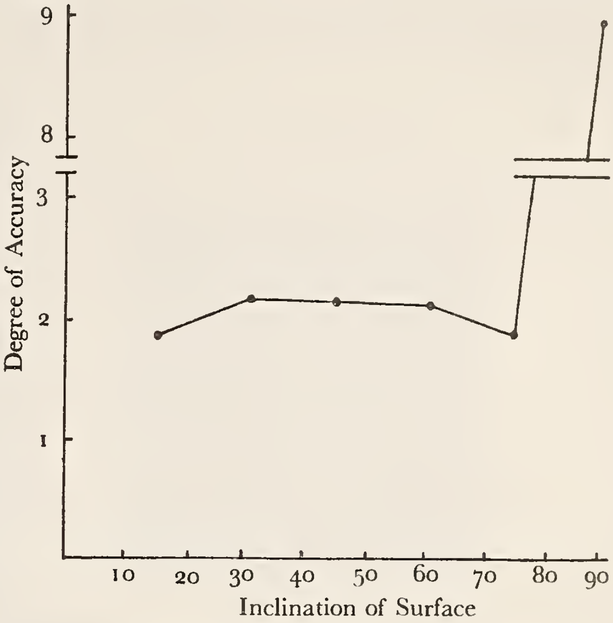

Figure 3: Degree of accuracy at each inclination of the surface.

The snail's true orientation path is a function of the snail's angular deviation at a given angle of inclination of the surface. The degree of accuracy is a function of the snail's true orientation path; therefore, these equations, $\alpha - \omega$ = degree of accuracy, and $\sin \omega = \sin \alpha \cos B$, can validly be used to determine the accuracy of a snail's geotactic orientation. The degree of geotactic accuracy measures a snail's response to gravity.

Summary

The geotactic accuracy of 700 specimens of the pulmonate snail, Helix aspersa Müller, was determined. One hundred determinations were made at each of the following angles: 0°, 15°, 30°, 45°, 60°, 75°, and 90°. Geotactic accuracy was determined by the equation: $\alpha - \omega$ = degree of accuracy, where α is the angle of inclination of the surface and ω is the angle between the snail's true orientation path and the horizontal. ω, in turn, was derived by the equation: $\sin \omega = \sin \alpha \cos B$, where B is the mean of the angular deviations.

Geotactic accuracy had a value of about 2° when a snail was orienting upon a surface inclined between the angles of 15° and 75° to the horizontal but had a value of 8° 53' on a vertical surface.

Acknowledgment

The author wishes to express his gratitude to Dr. Jack T. Tomlinson for his guidance and critical reading of the manuscript; also for the helpful suggestions of Dr. Robert E. Berrend,

Dr. Walter J. Coppock, and others; and to Mr. William Ho for assistance with the illustrations.

Literature Cited

Carthy, J. D.
1958. An introduction to the behavior of invertebrates. MacMillan Company, N. Y.

Crozier, W. J., & T. T. Oxnard
1927. Geotropic orientation of young mice. Journ. Gen. Physiol. 11: 141-149.

Crozier, W. J., & G. Pincus
1926. The geotropic conduct of young rats. Journ. Gen. Physiol. 10: 257-269.

——, —— & ——, ——
1927. Geotropic orientation of young rats. Journ. Gen. Physiol. 10: 519-524.

Hoagland, H., & W. J. Crozier
1929. Geotactic excitation in Helix. Journ. Gen. Physiol. 15: 15-28.

Wolf, E.
1927. Geotropism of Agriolimax. Journ. Gen. Physiol. 10: 757-765.

Observations on Three Species of *Vexillum* (Gastropoda)

BY

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(Plates 41 to 44; 2 Textfigures)

It is a truism that with only a few specimens from a given area, separate species may be easily recognized, but with additional material the lines of definition become less distinct and the supposedly separable "species" appear less so. This basic maxim of conchologists has again proved itself in the case of three mitrid forms all taken at one time in Philippine fishing trawl-nets. The three "separate species" recently collected in a series of five trawled specimens were described as from widely separated type localities (see map, Textfigure 1) and have heretofore been considered distinct.

Mr. Fernando Dayrit of Manila has from time to time sent me material for identification. About a year ago I published an illustrated note (The Veliger, 3(4): 105-107) on a form that I determined as Vexillum utravis (Melvill, 1925). Soon thereafter, two additional forms were collected and sent to me that I tentatively identified as V. formosense (Sowerby, 1890) and V. minahassae (Schepman, 1907), respectively. The determination of V. minahassae was based in part on the original description and type figure and in part on a subsequent illustration and discussion of the species (Schepman, 1911). (Later in the course of the present study, Miss G. E. de Groot of the Rijksmuseum van Geologie en Mineralogie in Leiden kindly furnished photographs of the holotype, which are reproduced here on Plate 41.) In the case of V. formosense, the identification was made not only from the original description and figure but also by a direct comparison (August 1961) with five specimens from the type locality of that species in the collection of the Academy of Natural Sciences of Philadelphia (ANSP No. 251122. Anpin,

Explanation of Plate 41

Figure 1: Typefigure of *Vexillum formosense* (Sowerby, 1890) (x 1.5)
Figure 2: Holotype of *Vexillum utravis* (Melvill, 1925) (x 1.5) Photo, courtesy of National Museum of Wales.
Figure 3: Holotype of *Vexillum minahassae* (Schepman, 1907) (x 3) Photo, courtesy of Rijksmuseum van Geologie en Mineralogie.
Figure 4: Subfossil specimen of *Vexillum minahassae* (Schepman, 1907) dredged in 15 fathoms, Arafura Sea (Siboga Expedition). (x 1.5) Photo, courtesy of Zoological Museum of Amsterdam.

Figure 1

© National Museum of Wales

Figure 2

© Rijksmuseum van Geologie en Mineralogie

Figure 3

© Zoological Museum of Amsterdam

Figure 4

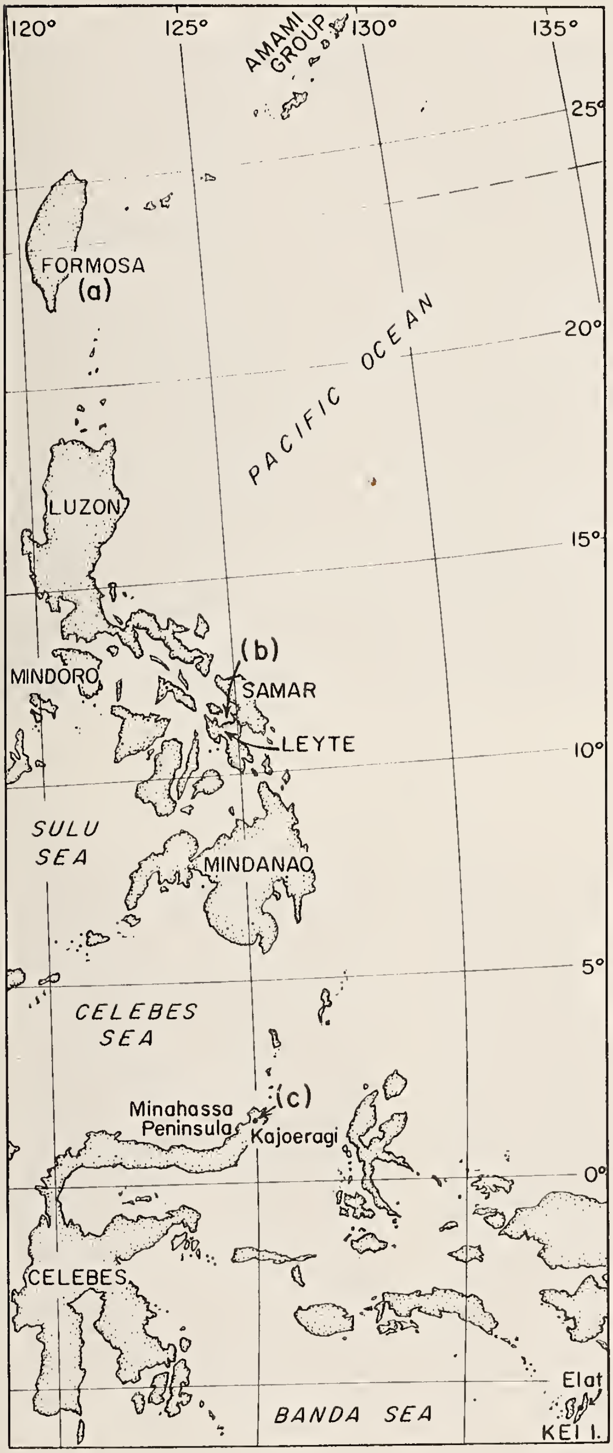

Figure 1: Map showing type localities of:
(a) *Vexillum formosense* (Sowerby, 1890)
(b) *Vexillum utravis* (Melvill, 1925)
(c) *Vexillum minahassae* (Schepman, 1907)

Formosa; *ex* Habe, Japan). These five specimens seem identical in form with one of mine; other Philippine specimens considered in the present study are shorter and more obese, though still falling within a range of variability that may reasonably be expected. All three species have been considered of rare occurrence, but during the past year *V. utravis* has been collected in fair numbers at several localities. With the exception of the ANSP shells already mentioned, however, and two specimens of *V. utravis* misidentified as *V. melongena* (Lamarck, 1811) in another large collection, I have seen few of them in United States collections other than my own, and they are seldom cited in the literature.

Vexillum formosense was described and figured from three specimens collected off Formosa; Sowerby (1890) compared it with *V. caffrum* (Linnaeus, 1758), saying its whorls were more rounded and the body whorl much shorter in proportion to the spire. It should be noted here that Sowerby concluded his remarks on his new species by saying, "Three specimens from the Island of Formosa, all similarly marked, and differing but little in form." That he noted any difference in form, however slight, is important, as will be pointed out later. Because of departmental reorganization currently taking place at the British Museum (Natural History), it is, unfortunately, not possible to obtain photographs of Sowerby's holotype, which is presumably at that institution. Consequently, the rather poor type figure from the Journal of the Linnean Society is here reproduced (see Plate 41, Figure 1).

Vexillum minahassae (see Plate 41, Figure 3) was described and figured by Schepman (1907) from fossil or subfossil material collected on Celebes. Apparently, the type lot consisted of at least one complete specimen and several fragments; it is not clear from his discussion whether Schepman had more material than this. One additional example, dredged in mud in 27 meters in the Arafura Sea (Elat, Great Kei Island, Moluccas) was later reported and figured by Schepman (1911, p. 280, Pl. 12, Fig. 7). The color shown in this figure represents the typical faded orange-red color of subfossil specimens, whereas the Philippine shells before me are live-taken, with fresh brown coloring. Although the photograph of the fossil holotype of *V. minahassae* seems to indicate a color-pattern similar to *V. formosense*, there is no mention of color in the original description. Schepman's discussion of the Recent specimen collected on the Siboga Expedition (Plate 41, Figure 4), however, mentions "...the shell is white, with a rather broad orange-brown band below the suture, another at the periphery, only partly visible on the upper whorls and a third at the base, occupying also the canal, though less clearly. The spirals of the base and partly the ribs, especially their upper part, are more or less white."

Vexillum utravis (see Plate 41, Figure 2) was described and figured from a single specimen of unknown locality; at that time Melvill (1925) mentioned its possible relationship to V. formosense, although obviously considering it worthy of specific separation. He further suggested that it might be a hybrid between V. caffrum (Linnaeus, 1758) and V. melongena Lamarck, 1811). The latter two species are compared briefly in J. Cate, 1961.

The morphological differences between Vexillum utravis and V. formosense consist of the relative obesity of V. formosense as compared with the slender shape of V. utravis and the ratio of spire-height to shell-length; this character is extremely variable in V. formosense, though in most of those I have seen the spires are shorter than the last whorl. In typical V. utravis the spire is usually longer than the last whorl or about equal to it. Color is identical in both species, though there is some variability in color-pattern among the slender specimens that have been assigned to V. utravis (see Plate 44, Figure 7). The most important difference between the two seems to be the obesity of V. formosense.

A close relationship between Vexillum formosense and V. minahassae is very apparent, the chief difference between them being the complete reversal of the color-pattern; V. formosense is predominantly brown with white spiral bands, while V. minahassae is mostly white with brown bands. Vexillum formosense is somewhat more obese in this instance also. The sculpturing of both species is very similar, at the same time matching that of the third species, V. utravis. These similarities puzzled me and were the basis for considering my identifications tentative, although each of the three forms seems unquestionably to match the respective descriptions and figures. The surface ornament is evidently the only truly constant character in the morphology of the three species. All three fall within the small vexillid group having the dorsum smooth, axial costae on the ventral surface or on the spire only, the last whorl or two being entirely smooth in adult specimens.

During the summer of 1961, Mr. Dayrit mailed for identification five additional specimens that had been trawled in the same area as the pair of Vexillum minahassae sent a year previously; that is, at Naval, Leyte. It was astonishing to see that of the five shells taken at one time, one specimen appeared to be a good example of V. formosense, though unusually short and obese (and possibly not fully mature), three could be identified as V. minahassae, and the fifth was somewhat intermediate between these two but at the same time with a strong resemblance to the typical V. utravis (see Plate 43, Figures 1-5).

Receipt of this remarkable series led me to request the loan of additional material. Mr. Dayrit very kindly responded with a large group of mixed specimens which had all been trawled in Maqueda Bay during 1961. The box contained five reasonably typical examples of Vexillum minahassae and 32 adult and juvenile examples of V. utravis; no specimens of V. formosense appeared in this shipment. Mr. James E. Norton, also of Manila, sent several shells from his collection that had been taken by divers in from two to five fathoms in three different localities: Baler, Quezon; Masbate; and Batangas Bay. I wish here to express my deep appreciation for the willing cooperation of both gentlemen, as any opinion I might have formed without their additional shells would necessarily have been based on a study-group too small for a fair evaluation of the species.

{It should perhaps be mentioned at this time that the loaned material from both collections contained also several examples of an indeterminate species possessing certain characters common to the other three under discussion. The major part of the Norton shipment, in fact, consisted of shells of this unidentified species, a few of these exhibiting a strong resemblance to Vexillum melongena (Lamarck),

Explanation of Plate 42

Figure 1: *Vexillum formosense* (Sowerby, 1890). Typical specimen resembling ANSP shells from the type locality. Trawled in 20 to 40 fathoms, Tayabas Bay, Quezon, P. I., 1960; ex Cate Collection. Figure 2: *Vexillum formosense* (Sowerby, 1890). Specimen resembling *V. minahassae* (Schepman). Trawled in 20 to 30 fathoms, Naval, Leyte, P. I., 1961; ex Cate Collection. Note similarity in form to *V. formosense* (fig. 1); the only difference is the arrangement of color pattern. Figure 3: *Vexillum formosense* (Sowerby, 1890). Series showing entirely ribbed specimens before starting smooth last whorl.

Figure 1

Figure 2

Figure 3

TAKEO SUSUKI, *photo.*

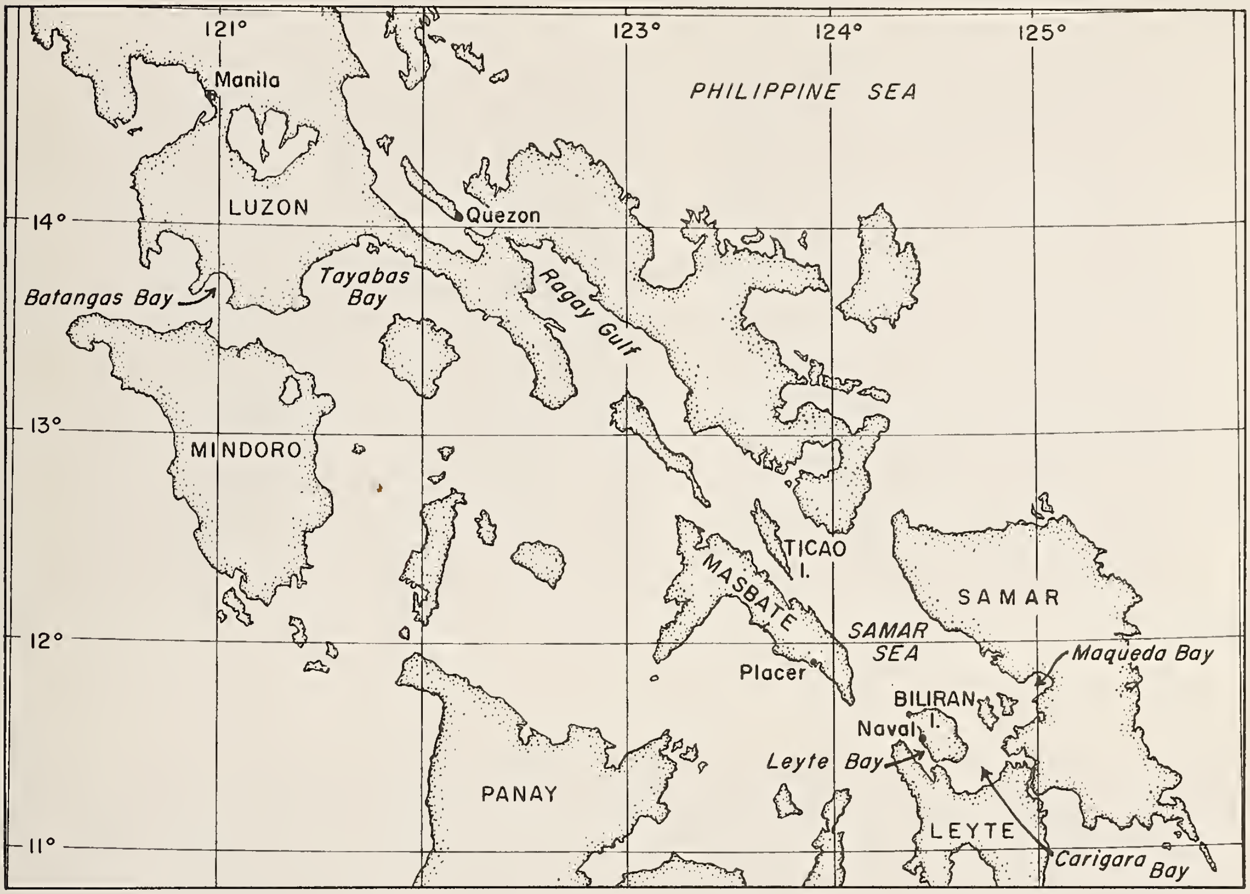

Figure 2: Map showing Philippine collecting areas discussed

although with some differences. The unknown form has been seen from time to time in other collections and in earlier shipments from the Philippines, but its identity has remained in question. It seems to be sufficiently distinct from the V. formosense - utravis - minahassae group to allow for disregarding it as a part of the current study, though it should not be overlooked as possibly belonging to a larger group of species closely related to these. Further work is indicated before it will be possible to place this species in its correct position with relation to other Vexillidae.)

The Philippine localities where examples of the three forms were collected encompass a limited area, within approximately three and one-half degrees of longitude and about two and one-half degrees of latitude, or roughly within a "circle" whose "radius" fluctuates between 90 and 125 miles. Typical specimens of all three species were taken in Carigara Bay, Maqueda Bay, Ragay Gulf, Tayabas Bay, Batangas Bay, Placer, and lastly, the locality where all three forms were taken together, Naval, Leyte (see map, Textfigure 2). According to Mr. Dayrit, the fishermen who have collected these shells do most of their trawling in Carigara or Maqueda Bays, going to the other localities only when the weather is bad or if the catch has been poor in these two places. The nature of the equipment used limits their trawling operations to depths of 20 to 40 fathoms; the three species were all taken at these depths on a mud substrate. Other mollusks collected at the same time in these areas include Tibia fusus (Linnaeus, 1758), T. powisi (Petit, 1842), Ficus gracilis (Sowerby, 1825), various species of Tonna and Turris, and others.

Outside the Philippine area, good examples of Vexillum utravis have been obtained in beach-drift along the shore of Nadi Bay, Fiji, by Mr. A. Jennings. This species seems to occur in reasonably large numbers there, as Mr. Jennings reported (March 1961) having taken approximately 40 dead specimens on one collecting trip. Only one living example has been reported at the present time, however (dredged in 10 feet of water on a weedy mud bottom in Nadi Bay, December 1961), and the Fiji material is mentioned here only to point out the occurrence of the species in at least one area remote from the Philippine Islands (a distance of approximately 4'300 statute miles). Much further study is needed of the Fiji specimens, and it is hoped that living populations will be discovered there in the near future. It will be of great value if collectors in other areas will report any occurrences, with full collecting data wherever possible, of any of the species illustrated in this paper, in order to help establish the extremes of range for these hitherto little-known forms.

In frequency of occurrence, Vexillum utravis is relatively the most common of the three forms and is collected in fairly large numbers at several locations; it has also been taken in shallower water (two to five fathoms) by divers, as seems not to be the case with either V. formosense or V. minahassae. Vexillum formosense is the second most frequently collected form, and V. minahassae the least often encountered in the areas mentioned (F. Dayrit, personal communication).

Most of the specimens of Vexillum formosense are entirely smooth on the last two whorls, while a few are ribbed ventrally and smooth dorsally as in typical apparently adult V. utravis (see Plate 44, Figures 4-6). The possibility exists that the specimens of V. formosense with completely smooth last whorls represent animals more mature and more fully developed than those whose shells are ribbed only on the ventral surfaces. There is obviously a point where the costae disappear altogether, in this case at approximately the tenth whorl (out of a total of 12). In V. utravis, of which I had a far greater number of specimens to study, the smooth dorsums (that is, the final whorls) seem to occur at about the eighth, ninth, or tenth volutions. A limited few are seen with entirely smooth final whorls, though these seem to be less mature than the smooth examples of V. formosense, as the outer lips are thin and underdeveloped, and the canals are less attenuate. It is possible that these specimens were collected while undergoing a period of growth when the outer lip had not yet thickened; this stage has been observed in specimens of various size-groups in other mitrid species; therefore, the presence of a thin outer lip does not necessarily indicate a completely juvenile specimen.

It is interesting to note that the majority of living specimens of Vexillum utravis I have seen have been collected at precisely the stage of transition from the ribbed to the smooth state. Out of 43 specimens studied, 28 were ribbed on the ventral side and smooth dorsally; nine were ribbed all around and appeared to be juveniles (see Plate 42, Figure 3), and six were entirely smooth on the final whorls though not yet fully mature as to the outer lip. One possible explanation for the imbalance in these statistics might be that the more mature (i. e., smooth-shelled) animals may seek a slightly different environment, such as a greater depth of water, which would be beyond the ordinarily limited trawling-depths of the fishermen who have taken most of the known partly-ribbed specimens. In each of the three species there appears to be a strong tendency to become rather exaggeratedly elongate with advancing maturity. Juveniles frequently appear relatively more obese in proportion to their length, and as the number of whorls increases, the canal becomes far more attenuate than formerly, bringing about a change in the spire-height/shell-length ratio. In other words, as the mollusk grows, the increase in length is more pronounced in the canal than elsewhere, resulting in a relatively shorter spire and a longer body whorl than in younger specimens.

Measurements of shell length, greatest diameter, aperture length, and spire angle were taken for all specimens of each of the three species, but these provided no helpful data except to prove that the proportions and angles of all three forms are as variable as their morphological characters; no other conclusions could be drawn from any of several approaches. The measurements are not included here, as they provide no conclusive data. The only noticeable trend resulting from this part of the study is that, in general, the spire-angle tended to decrease with increase of shell length in Vexillum formosense and V. utravis, while this was not evident in V. minahassae.

Since the Philippine shells were all trawled in depths from 20 to 40 fathoms, and the 1911 Schepman record of Vexillum minahassae indicates a depth of approximately 15 fathoms in the Arafura Sea, it would seem that all three forms live in relatively deep water as a rule and that the mud substrate is an ecological feature common to all. The surface ornament is nearly

Explanation of Plate 43

Vexillum formosense (Sowerby, 1890)

Series of five specimens collected together at Naval, Leyte, P. I., 1961.
Figure 1 resembles typical but obese *Vexillum formosense* (Sowerby); Figures 2 to 4 resemble typical *V. minahassae* (Schepman); Figure 5 shows a tendency toward typical *V. utravis* (Melvill).

Figure 1

Figure 2

Figure 3

Figure 4

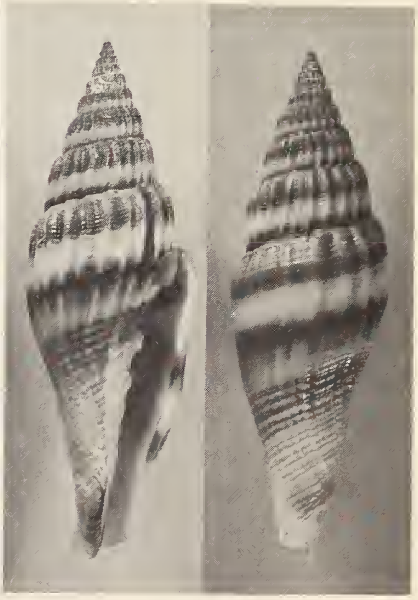

Figure 5

TAKEO SUSUKI, *photo.*

identical in each, there is a pronounced variability in shape among otherwise typical examples of V. formosense collected within a narrow range, and the reported collecting stations of all three forms are in very close proximity. On the basis of all these factors considered together, and particularly taking into account not only the evidence of close association of the three forms collected within the same area at one time, but also the strong suggestion that the transition between partly ribbed and entirely smooth specimens occurs at approximately the same growth stage in all "species", the conclusion that these forms constitute only one very variable species is almost inescapable, the many variations in color and shape possibly being the result of some unknown factor or factors of ecology. Vexillum formosense, therefore, would represent the northernmost phenotype within its range, V. minahassae the southern extreme, and V. utravis is intermediate, its typical locality being apparently midway between the other two.

The possibility that hybridization of two allopatric subspecies may be taking place here is not excluded; however, until further locality records for large numbers of specimens become available both to the north and to the south of the presently known collecting stations, it would be premature to draw a conclusion. Conversely, it might be considered equally possible that through reproductive isolation, separate species are presently evolving.

The additional possibility that sexual dimorphism may account for the variability among the three forms should not be overlooked, though the preponderance of the "utravis" form suggests that this is not the case. If sex differences were the chief basis for the morphological differences, it is likely that there would be a more equal balance in numbers among the different phenotypes. The present ratio of 43 utravis to 3 formosense would probably not apply to the relative distribution of males and females; as a hypothetical example, it seems an unlikely assumption that we would find 43 "utravis-type females" and only 3 "formosense-type males" (or vice versa) within a representative sampling of the population. It is hoped that a thorough anatomical study can be undertaken in the near future, to make possible a comparison of the physical features of the various animals.

A brief list of questions relating to Vexillum formosense was sent to Dr. Tadashige Habe in Japan, in an effort to ascertain whether he had noted any similarities to the other two species discussed here, either in morphology or in ecology. Dr. Habe very kindly responded to my queries with several interesting observations. I am very grateful to him for his attention to my problem and wish to express my thanks for his prompt and helpful reply. A color illustration of V. formosense has been included in Habe (1961; Pl. 34, fig. 18).

According to Dr. Habe's letter of December 30, 1961, Vexillum formosense appears to be rather common off Formosa. It is his belief that it is probably collected in about 20 to 50 meters (10 to 25 fathoms) on a fine sand substrate; it has been recorded from Okinawa (Kuroda); and Dr. Habe suggests the northern limits of the species may be the Amami Group of the Ryukyu Archipelago (28° 15' N. Lat., 129° 15' E. Long.). He had no data as to other mollusks actually collected with V. formosense but stated that he had received certain other species within the same shipments, which suggests that they might all have been collected together; these included V. melongena (Lamarck), Baryspira mammilla (Sowerby), Niotha clathrus (Lamarck), Ficus ficus (Linnaeus), Bezoardicella decussata (Linnaeus), Murex trapa (Röding), Murex rectirostris Sowerby, Hindsia sinensis (Sowerby), etc.

It is Dr. Habe's conclusion that Vexillum utravis and V. minahassae are not conspecific with V. formosense, but closely related to V. melongena (Lamarck) from Formosa, "...which has more numerous costae on the surface". In the light of the very recent evidence of several Philippine specimens of both V. utravis and V. minahassae also exhibiting entirely smooth last whorls, as in V. formosense (see Plate 44, Figures 4-6), my own conclusions remain as stated; however, the observations from Japan lend emphasis to my earlier statement that further work should be done regarding the relationships of other similar species, including V. melongena in particular. This species or a very closely related form seems to be associated with the others discussed here, in Fiji and the Philippines as well as Japan.

The different forms, taken separately, are easily enough accepted as three distinct species, but if all three can be collected within the confines of a single small bay, they must exist, at least in that area, as a single population and not as the remotely situated, separate species they were formerly thought to be.

If the different forms are to be combined as one very variable species, the earliest valid name should apply. It is my suggestion, therefore, that Vexillum minahassae (Schepman, 1907) and V. utravis (Melvill, 1925) be considered conspecific with V. formosense (Sowerby, 1890). If the theory of newly-evolving species is accepted, V. minahassae and V. utravis could be considered subspecies of V. formosense as a possible temporary solution until additional work may be done which can establish without further doubt the correct taxonomic position of these similar species. However, the evidence of overlapping populations, among other considerations, seems to support the conclusion that the three forms all belong to one variable species. In that case, an amendation of the original description of V. formosense is necessary in order to include the variants within the new interpretation of the species.

Vexillum formosense (Sowerby, 1890), amend.

Shell spindle-shaped, spire elongate, acute; whorls approximately 11, convex, separated by impressed sutures. First 8 or 9 whorls ribbed longitudinally, interstices between riblets finely spirally striate. Last 2 or 3 whorls very finely spirally striate but not ribbed; rounded, swollen at periphery; neck of shell spirally granulose, contracted, somewhat attenuate. Ratio of aperture length to spire height variable, aperture longer than spire in mature specimens, about equal in subadults. Peristome entire; pseudumbilicus present; parietal callus prominent; canal produced, recurved abaxially. Labrum sinuate in adult specimens, otherwise simple; finely lirate within. Columella with 3 or 4 plaits, the upper two somewhat grooved and flattened, the surface between plaits showing granulose structure underlying thin coating of nacre.

Shell color variable; typical specimens dark brown (Maerz & Paul Dictionary of Color, 2nd Edition, 1950: Pl. 8, C 9, London Smoke) to light brown (Pl. 7, A 11, Vandyke Brown) with one white band on each upper whorl, usually two on periphery of last whorl. Some specimens reversed in color, being basically white with brown bands. Aperture, columellar folds and parietal callus white, granulose neck of shell whitish.

Length of holotype 50 mm., greatest diameter 16 mm., aperture length 24 mm., and aperture width $4\frac{1}{2}$ mm.

Type locality: Island of Formosa (24° N. Lat., 121° E. Long.).

Acknowledgment

In the study reported on in the foregoing pages, I have received assistance from many persons. My thanks are expressed here to all of them; first, to Mr. Dayrit for providing not only large numbers of shells for study, but much background information as well; also, to Mr. James Norton and Mr. A. Jennings for additional specimens and information. Dr. Rudolf Stohler very kindly provided the necessary Schepman and de Man translations, as well as fundamental information in molluscan zoology; Mr. George Kanakoff translated Sowerby's Latin description; Miss Virginia Orr directed me to pertinent material at the Academy of Natural Sciences of Philadelphia; Dr. Myra Keen furnished welcome criticism of the preliminary manuscript; and Crawford Cate, as always, assisted in countless ways. Mr. Colin Matheson of the National Museum of Wales provided the photographs of Melvill's holotype; Miss G. E. de Groot of the Rijksmuseum van Geologie en Mineralogie in Leiden furnished photographs of Schepman's fossil holotype; and Mrs. W. S. S. Van der Feen-v. B. Jutting of the Zoological Museum at Amsterdam sent photographs of the Recent specimen of Vexillum minahassae collected on the Siboga Expedition. Dr. Tadashige Habe's important information should not be overlooked in this acknowledgment of the many kindnesses performed by all these people, nor should the help of Mrs. Emily Reid of The Veliger staff, who adapted the complicated maps into textfigures. Unless otherwise noted, the photographs are by Takeo Susuki. It is difficult to find words adequately to express the gratitude due to everyone mentioned.

Literature Cited

Cate, Jean M.
1961. Vexillum utravis (Melvill, 1925) trawled in Philippine waters. The Veliger 3 (4): 105-107; pl. 18, 1 textfig.

Explanation of Plate 44

Vexillum formosense (Sowerby, 1890)

Series showing variability in form and pattern. Note presence of only one white band in some specimens. Figure 1: a juvenile specimen, entirely ribbed. Figures 2, 3: in transitional stage, half ribbed, half smooth. Figures 4, 5, 6: entirely smooth on last whorls. Figure 7: series showing variability in color pattern; a to c, "*utravis*" form; d to f, "*minahassae*" form. All specimens of Plates 43 and 44, and of Plate 42, fig. 3 ex Dayrit Collection, trawled in 20 to 30 fathoms, Maqueda Bay, Samar, P. I., 1961.


Figure 1


Figure 2


Figure 3


Figure 4


Figure 5


Figure 6


Figure 7 a


Figure 7 b


Figure 7 c

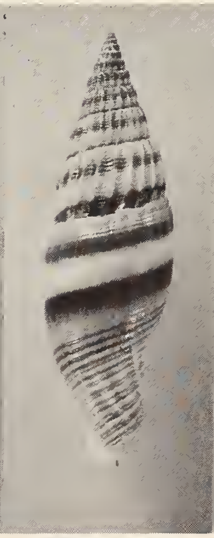
Figure 7 d


Figure 7 e


Figure 7 f

TAKEO SUSUKI, *photo.*

de Man, J. G.
1904. Beschreibung einiger brachyurer Krebse aus posttertiären Schichten der Minahassa, Celebes. Samml. Geol. Reichs-Mus. Leiden, Ser. 1, vol. 7: 254-278; pls. 9, 10.

Habe, Tadashige
1961. Colored illustrations of the shells of Japan (II). pp. 1-183; 66 pls. Osaka, Japan.

Melvill, James Cosmo
1925. Descriptions of nine new species of Mitridae. Proc. Mal. Soc. London, 16 (5): 215-219, pl. 10.

Schepman, M. M.
1907. Mollusken aus posttertiären Schichten von Celebes. Samml. Geol. Reichs-Mus. Leiden, Ser. 1, vol. 8: 153-203, pls. 10-13.

——, ——
1911. The Prosobranchia of the Siboga Expedition, pt. 4, Mitra: 266-290; pls. 18, 19, 22.

Sowerby, George Brettingham
1890. Descriptions of fourteen new species of shells. Journ. Linn. Soc., 20: 395-400, pl. 25.

Manometric Measurements of Respiratory Activity in *Tegula funebralis*

BY

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Tegula funebralis (A. Adams, 1855) is an abundant gastropod of the middle and upper intertidal zones on partially protected rocky shores in central California (Galli and Giese, 1959). It is uncommon on the exposed outer coast and does not occur in subtidal zones. Populations of Tegula are covered by the tide at least once during the daily tidal cycle. Individuals may also remain submerged in tide pools where temperature and salinity fluctuate.

In order to assess some of the limiting conditions in the environment of Tegula funebralis, I made brief laboratory measurements of oxygen consumption under varying conditions of temperature, salinity, and exposure to air.

I wish to thank Dr. Arthur C. Giese for helpful suggestions.

Materials & Methods

The Tegula were collected on rocks in the upper tidal zone near Hopkins Marine Station, Pacific Grove, California, and maintained in laboratory aquaria supplied with running seawater. Snails used in each experiment were collected at the same time and subjected to the same conditions. Oxygen consumptions were measured in a series of six Warburg manometers, using immature snails with shell diameters not exceeding 14 mm., the largest size which could be fitted into the manometer vessels. Each vessel was calibrated for use with three snails submerged in five ml. of filtered seawater. A 0.1 ml. drop of 30 percent potassium hydroxide in the sidearm of the vessel was used as the carbon dioxide absorbent. The vessels were gently agitated to the same extent during each run.

Size constants were determined with 18 snails, 10 to 14 mm. in diameter. The wet-shell weight of the 18 snails was 19.69 grams, and the wet-animal weight after removal of the shell was 2.30 grams. Dry weight of the snail tissue was determined with an analytical balance as 621 mg. The dry weight of the snails used in each experiment was therefore calculated as 0.058 of the wet-shell weight. During each experiment weight corrections were made, and oxygen consumption of the three snails in each vessel was calculated and averaged. Oxygen consumptions are given as microliters of oxygen per milligram of dry weight.

Experimental Results

1. Respiration while Submerged and Exposed to Air.

In its high intertidal environment Tegula funebralis spends long periods exposed to air. The respiratory activity of a series of snails was measured in three ways: while kept moist; submerged; and after five hours exposure to air. All runs were made at 19° C. during August, 1961, using 15 snails collected eight days previously. In the first experiment a thin film of water covered the snails, which remained attached to the walls of the vessels. A second series of readings was made 18 hours later with the same snails in 5 ml. of seawater per vessel. A third series of readings was taken with no water in the vessels, after the snails had been left to dry on paper towels at room temperature for five hours. The snails were able to attach to the walls of the vessels in this condition. Results are shown in Table 1.

Table 1:

Oxygen consumption (microliters per mg. dry weight) of *Tegula* while wet, submerged and after 5 hours drying.

Time (min.)	Wet	Submerged	After Drying
30	0.40	0.54	0.32
60	0.77	0.93	0.49
90	1.03	1.35	0.69

The data indicate that maximum respiration occurs while the animal is submerged. Although Tegula funebralis is strictly an intertidal animal, daily exposure to air is not necessary for survival. Twenty-two large specimens were kept submerged under glass dishes in an aquarium supplied with running seawater. All remained alive and active for over 40 days at the tops of inverted glass dishes. Thus, it appears that a negative geotropic response maintains Tegula in the intertidal zone.

2. Respiration under Varying Conditions of Salinity.

Salinities in tidepools in which Tegula often occur may fluctuate with the seasons. Snails in this series of experiments were held submerged in beakers containing seawater of different concentrations for 24 hours before the readings were made. Readings at each concentration were taken simultaneously in order to minimize other variables. The six vessels contained three snails at each of six different concentrations. The experiments were then repeated with different snails to verify data based on only three individuals at each concentration. Four experiments with four different series of snails were made: two experiments with concentrations ranging from 100 percent to 50 percent seawater and two experiments with concentrations ranging from 100 percent to 150 percent seawater. This series of experiments was conducted during November, 1961, on snails collected two to four days previously. Results are shown in Table 2.

The data show that respiration is relatively normal at salinities ranging from 80 percent to 130 percent seawater, while tapering off at concentrations of 70, 60, and 50 percent, and at 140 and 150 percent seawater. Respiration at 50 and 150 percent seawater was negligible. Snails at these concentrations did not attach to the vessel walls during the run. Kept at the same concentrations, they did not survive beyond one week. Snails in 60 percent seawater died within two weeks. Snails in 70 to 140 percent seawater survived longer than three weeks. These results suggest that Tegula can accommodate to a relatively wide range of salinities (80 to 130 percent) with little loss of activity.

Table 2:

Oxygen consumption (microliters per mg. dry weight) of *Tegula* at salinities ranging from 50% to 150% seawater. Figures are given for the original and the repeated run of each experiment.

Salinity	100%	90%	80%	70%	60%	50%
30 min.	0.29 | 0.36	0.31 | 0.39	0.31 | 0.35	0.10 | 0.23	00.4 | 0.17	0.02 | 0.03
60 min.	0.56 | 0.75	0.57 | 0.68	0.55 | 0.69	0.11 | 0.40	0.13 | 0.22	0.04 | 0.05
90 min.	0.87 | 1.02	0.90 | 0.96	0.81 | 1.01	0.33 | 0.55	0.18 | 0.27	0.07 | 0.09
120 min.	1.14 | 1 29	1.18 | 1.22	0.99 | 1.32	0.44 | 0.81	0.21 | 0.31	0.07 | 0.12
Salinity	100%	110%	120%	130%	140%	150%
30 min.	0.20 | 0.30	0.29 | 0.32	0.25 | 0.27	0.22 | 0.29	0.10 | 0.30	0.03 | 0.06
60 min.	0.43 | 0.52	0.50 | 0.60	0.49 | 0.50	0.38 | 0.55	0.16 | 0.53	0.04 | 0.09
90 min.	0.62 | 0.80	0.72 | 0.91	0.66 | 0.74	0.61 | 0.82	0.20 | 0.70	0.06 | 0.14
120 min.	0.95 | 1.06	1.10 | 1.12	0.86 | 1.01	0.73 | 1.04	0.25 | 0.81	0.10 | 0.15

3. Respiration under Varying Temperatures.

A series of 18 snails was run for one hour at temperatures of 11°, 19°, 27°, and 35° C. during August, 1961. One hour was allowed for equilibration between 11° and 19°, two hours between 19° and 27°, and four hours between 27° and 35°. Average oxygen consumption of the 18 snails at each temperature is shown in Table 3.

Table 3:

Oxygen consumption (microliters per mg. dry weight) of *Tegula* at temperatures ranging from 11° to 35° C.

Temperature		11°	19°	27°	35°
Time (min.)	30	0.31	0.48	0.76	0.45
	60	0.54	0.95	1.45	0.92

Between 11° and 27° the respiratory rate appeared to increase directly with temperature. The upper limit of respiratory efficiency was reached between 27° and 35°, for the rate at 35° fell off to slightly less than the rate at 19°.

4. Effect of Starvation upon the Respiratory Rate.

The oxygen consumption of six animals collected 20 days previously was compared to the oxygen consumption of nine animals collected one day previously (August, 1961). The results are shown in Table 4.

Table 4:

Oxygen consumption (microliters per mg. dry weight) of *Tegula*, starved and fresh

		Starved	Fresh
Time (min.)	30	0.40	0.76
	60	0.84	1.47

Starved animals respired at slightly more than half the rate of the freshly collected animals. These results emphasize the importance, in experiments of this kind, of using animals collected at the same time and subjected to the same conditions.

Conclusions

These short determinations have indicated that respiratory activity of Tegula varies not unexpectedly with conditions of exposure, salinity, temperature, and starvation. Basic rates of oxygen consumption are comparable to those given for molluscan tissues by Zeuthen (1947). Additional factors which have been shown to affect respiratory activities of gastropods are seasonal variations (Berg, Lumbye and Ockelmann, 1958) and tidal and diurnal rhythms (Sandeen, Stephens and Brown, 1954). The shortness of the manometric determinations used here served to obscure rhythms that might have been present. Respiratory activity may also be expected to vary with the intertidal height from which the snails are collected. Manometric determinations of oxygen consumption, therefore, are useful only with snails collected at the same time and measured in the manometer simultaneously.

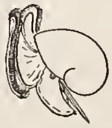
Literature Cited

Berg, K., J. Lumbye, & K. W. Ockelmann
1958. Seasonal and experimental variations of the oxygen consumption of the limpet Ancylus fluviatilis (O. F. Müller). Journ. Exp. Biol. 35: 43-75.

Galli, D. R., & A. C. Giese
1959. Carbohydrate digestion in a herbivorous snail, Tegula funebralis. Journ. Exp. Zool. 140: 415 to 440.

Sandeen, M. I., G. C. Stephens, & F. A. Brown, Jr.
1954. Persistent daily and tidal rhythms of oxygen consumption in two species of marine snails. Physiol. Zool. 27: 350-356.

Zeuthen, Erik
1947. Body size and metabolic rate in the animal kingdom with special reference to the marine microfauna. Compt. rend. Lab. Carlsberg, Sér. chim. 26 (3): 16-161.



A Study of Food Choices of Two Opisthobranchs, *Rostanga pulchra* McFarland and *Archidoris montereyensis* (Cooper)

BY

EMILY F. COOK

Department of Zoology, University of California, Berkeley 4, California

(4 Textfigures)

Several of the dorid nudibranchs of the west coast of North America feed on sponges which they resemble in color and texture. *Rostanga pulchra* MacFarland, a bright red nudibranch, 1.0 to 1.5 cm. long, feeds on an encrusting red sponge, *Ophlitaspongia pennata* Lambe, while *Archidoris montereyensis* (Cooper), a large yellow nudibranch, 6.0 to 10.0 cm. long, commonly feeds on a yellow sponge, *Halichondria panicea* (Pallas). Both the nudibranchs and the sponges on which they feed are found intertidally along rocky coasts.

In the Friday Harbor region (San Juan Island, Washington), where this work was done, the sponge, *Ophlitaspongia pennata,* is represented by the varietal form, *O. pennata* var. *californiana* de Laubenfels. In order to distinguish var. *californiana* measurements of the spicules must be made. Although this was not done, Mr. Gerald J. Bakus, who has worked on the sponges of the area, has assured me that the odds are about 100 to 1 that it will be the varietal form, since he has not found the typical form itself in the San Juan Archipelago.

In the field *Rostanga pulchra* is often found on red sponge and is seldom found far away from it. The sponge encrustations are 2 to 3 mm. thick and vary in area from 2 or 3 sq. cm. to over 100 sq. cm. It is scattered in its distribution along the coast.

Archidoris montereyensis is commonly found on *Halichondria panicea* but may be found where sponges appear to be absent. *Halichondria panicea* is a branching yellow sponge of a fairly loose composition, often found in large clumps. In the literature it is often referred to as the "bread crumb" sponge.

The purpose of this paper is to report on some aspects of feeding of *Rostanga pulchra* and *Archidoris montereyensis.*

This work was done at the Friday Harbor Laboratories, University of Washington, partially supported by N. S. F. Grant No. G-7045. I would like to express my appreciation to Dr. Gunnar Thorson for his many helpful suggestions during the course of this work, and to Dr. Cadet Hand for his criticism of the manuscript.

Materials & Methods

I. Three sets of experiments were done with *Rostanga pulchra* to determine factors important in location of food. A plastic bowl 10 inches in diameter was set up so that two currents could be directed into it. An overflow was placed between the two incoming currents (Figure 1). The bowl was covered with black rubber

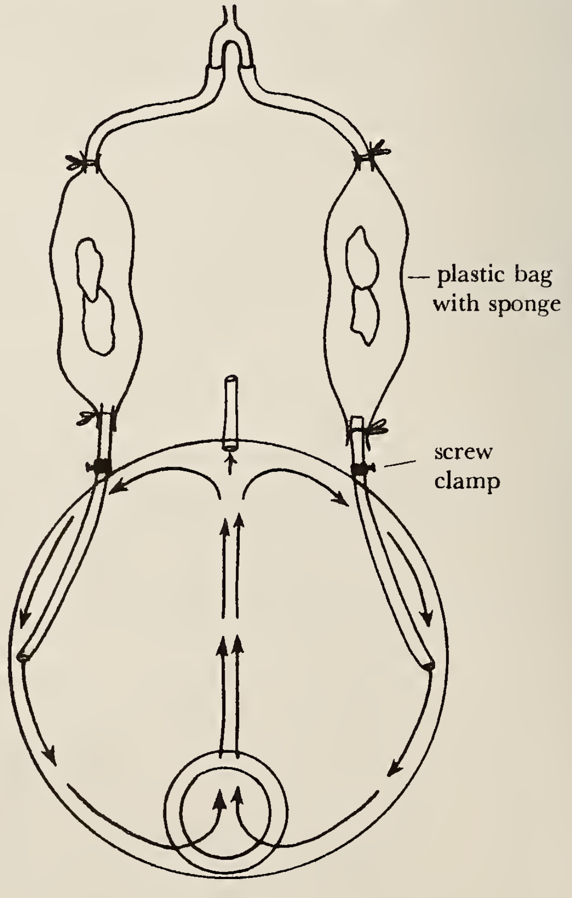


Figure 1

Apparatus used to test the response of *Rostanga pulchra* to food and current. The arrows indicate the direction of the current.

on the outside. During all experiments the bowl was covered with heavy cardboard to eliminate light. Screw clamps were used to adjust the flow of incoming water. For each experiment, except (a), 12 animals were started in a watch glass midway between the two currents. Each experiment lasted 30 minutes. The cover was lifted at 10-minute intervals to observe the progress of the animals.

(a) Two experiments, using 12 and 13 animals, were done to test the response of Rostanga pulchra to current. No sponges were used. The two currents were adjusted so that one was very weak, and the other was much stronger. For the second experiment the currents were reversed.

(b) Six experiments were done to test the ability of Rostanga pulchra to find Ophlitaspongia pennata. Plastic bags which contained O. pennata and Halichondria panicea were tied in the incurrent water. The currents were adjusted to equal size. Both currents were small to reduce swirling of water in the dish. The sponges were switched from one current to the other between experiments.

(c) In order to compare the response to current and to the sponge, an experiment similar to (a) was set up with Ophlitaspongia pennata in the weak current.

II. Since Archidoris montereyensis is much larger than Rostanga pulchra, a larger apparatus was required. A tank 16 by 20 inches was set up similarly to that used for R. pulchra. Responses to food and current were tested as described in I(a) and I(b).

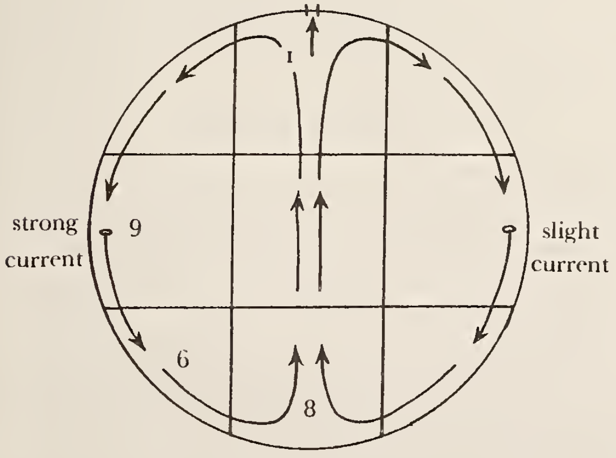


Figure 2

Distribution of *Rostanga pulchra* in response to current

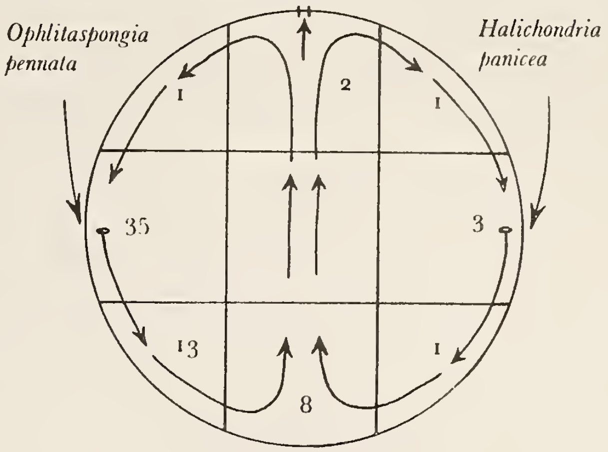


Figure 3

Distribution of *Rostanga pulchra* given a choice between *Ophlitaspongia pennata* and *Halichondria panicea*

III. Both nudibranchs were placed on different sponges to determine which they would eat. The sponges used were Halichondria panicea, Ophlitaspongia pennata, Syringella amphispicula, Aplysilla glacialis, and an unidentified suberitid.

Results

I(a) The results of experiments to determine the response of Rostanga pulchra to current indicate that it will move towards the current. The distribution of animals in the apparatus at the end of the experiment is shown in Figure 2. The specimen near the overflow was the first to leave the starting dish and it moved towards the current. Of a total of 25 animals 66 percent moved towards the current, 34 percent showed no detectable response.

I(b) The results of food selection experiments indicate that, in the laboratory, Rostanga pulchra is able to find Ophlitaspongia pennata by means of chemical sense. The results of six experiments are summarized in Figure 3. Of the 72 animals used, 8 were floating in the surface film at the end of the experiments and are not included. Of the remaining 64 animals, 76.7 percent showed a definite movement towards the current from O. pennata.

I(c) When the current was strong on one side of the apparatus and the red sponge was in the other current, the animals at first oriented into the current. At the end of the experiment, 83.3 percent of the 12 animals used had moved towards the current from the sponge (Figure 4).

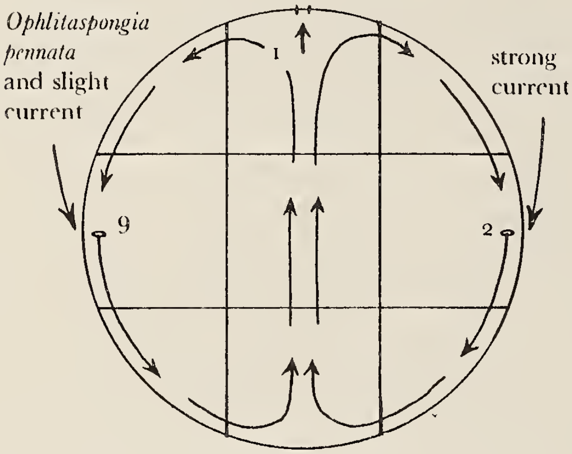


Figure 4

Distribution of *Rostanga pulchra* given a choice between current and *Ophlitaspongia pennata*

II. *Archidoris montereyensis* showed no response to current nor to the current from *Halichondria panicea*.

III. Of the sponges tested *Rostanga pulchra* would eat only *Ophlitaspongia pennata* and *Archidoris montereyensis* would eat only *Halichrondria panicea*.

Discussion

The results of these experiments indicate that *Rostanga pulchra* is able to find *Ophlitaspongia pennata* by chemotaxis. This chemotaxis probably helps the animal find its food in nature.

Although only *Ophlitaspongia pennata* was used in these experiments, there are other red sponges in the area. None were collected during this study. Occasional reports are found of *Rostanga pulchra* on red sponges other than *O. pennata*; however, they do not indicate whether or not the nudibranch was actually feeding on the sponge. Doran (1951) found *R. pulchra* on *O. pennata* and *Esperiopsis originalis*. Bakus (personal communication) finds *R. pulchra* mostly on *O. pennata* but has found it twice on *Polycamia karykina*. De Laubenfels (1927) reports that *R. pulchra* eats *O. pennata*, *Acarnus erithacus*, *P. karykina*, and *Isociona lithophoenix*. Whatever the relationship between *R. pulchra* and these other sponges, it seems to have a definite association with *O. pennata*.

Other species of *Rostanga* are reported to feed on red sponges. In Great Britain C. M. Yonge (1949) reports that *R. rufescens* feeds on *Ophlitaspongia*. Flattely and Watton (1922), also in Great Britain, state that *R. coccinea* lives on *Microciona altrasanguinea*.

Archidoris montereyensis fed only on *Halichondria panicea* in the laboratory but it does not seem to have a definite association with the sponge. It is not as consistently found with the sponge in nature as is *Rostanga*. Doran (1951) dissected specimens of *A. montereyensis* and examined gut contents. He found cells of *Macrocystis* sp. and sponge spicules. Other species of *Archidoris* have been reported to feed on sponges. Forrest (1952) states that *A. stellifera* has a preference for *Stylotella columella*. Miller (1961) found *A. pseudoargus* feeding on *H. panicea* and *Tethya aurantia*. There are other dorid nudibranchs which eat sponges. *Aldisa sanguinea* (Cooper) is found on *O. pennata* (Doran, 1951). Miller (1961) found *Jorunna tomentosa* on *H. panicea*. In the laboratory the author observed *Diaulula sandiegensis* feeding on *Haliclona* sp.

Summary

Rostanga pulchra has a positive rheotaxis. Under experimental conditions it is able to find *Ophlitaspongia pennata* by chemotaxis. It appears to be quite specific in its association with this sponge.

Archidoris montereyensis showed no rheotaxis or chemotaxis. Although it fed only on *Halichondria panicea* in the laboratory, it seems clear that it does feed on other things.

Literature Cited

de Laubenfels, M. W.
1927. The red sponges of Monterey Peninsula, California. Ann. Mag. Nat. Hist. (ser. 9)19: 258 to 266.
Doran, D. J.
1951. Observations on the distribution and feeding habits of nudibranchs. Zool. 112. Stud. reports Dept. Zool., Univ. California, Berkeley.
Flattely, F. W., & C. L. Watton
1922. The biology of the sea-shore. MacMillan Co., New York.
Forrest, J. E.
1953. On the feeding habits and the morphology and mode of functioning of the alimentary canal in some littoral nudibranchiate mollusca. Proc. Linn. Soc. London 164: 225-235.
Miller, M. C.
1961. Distribution and food of the nudibranchiate mollusca of the south of the Isle of Man. Journ. Animal Ecol. 30: 95-116.
Yonge, C. M.
1949. The sea shore. Collins, London.

Relationship of Living Weight to Shell Cavity Volume in *Helix aspersa*

BY

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(Plate 45; 2 Textfigures)

It has been suggested that the shell of the terrestrial snail *Helix aspersa* may be considered a probable biologic kymograph. Increases in the volume of the shell over a given time period can be determined and provide a quantitative measure of the growth of the animal during that period. The effect on growth of various environmental factors such as cold (Herzberg and Herzberg, 1960) can thus be easily studied. The technique by which the shell cavity volume is determined is a simple one, but it is time-consuming. The weight of the animal, however, is easily and quickly obtained. It has been shown that in *H. pomatia* and *Zebrina detrita* the cube of the shell width, the height of the shell, and the living weight of the animal are proportional to each other (Kienle, 1957), and it is known that in *Concholepas conchopas* the volume of the shell is directly proportional to the weight of the animal (Schwabe, 1959). The purpose of this study is to discover whether such a proportionality exists in *H. aspersa* and, if so, whether it is exact enough so that the weight of the living animal can be utilized to obtain the volume of the shell cavity or, in other words, whether the specific gravity of *H. aspersa* is constant.

Materials & Methods

One hundred and three specimens of *Helix aspersa* were collected from the wet soil of a garden in Woodland Hills, California, during the early evening hours of July 5, 1961, and July 12, 1961. Each animal was placed overnight in an individual compartment, measuring 3 x 3 x 3 cm., in an almost airtight plastic box and permitted to seal off against one wall of its compartment. The animals were then weighed and sacrificed by immersion in boiling water. Their shell cavity volumes were then determined, using a technique described earlier (Herzberg and Herzberg, 1960) and illustrated in Plate 45.

Results

The weight and the shell cavity volume were found to be roughly proportional, as shown in Textfig. 1, with an average specific gravity of 1.12. However, the specific gravities fall into a random distribution ranging from 0.81 to 1.42, as shown in Textfig. 2. The range of specific gravities bears no relationship to the size of the animal, so that two animals of either similar weight or similar shell cavity volume may have widely differing specific gravities.

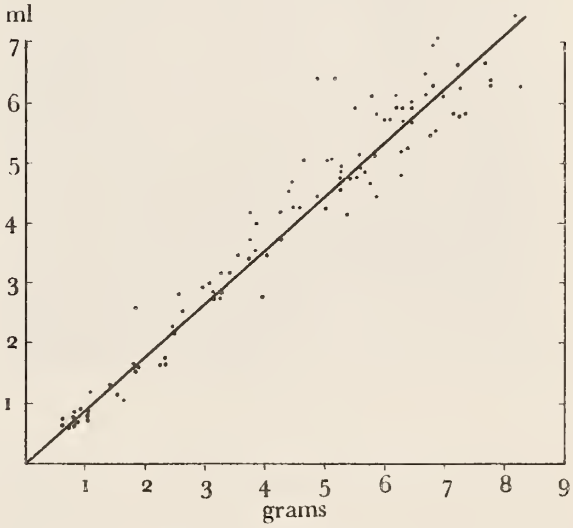

Figure 1: Graph showing relationship of live animal weight to shell cavity volume.

Discussion

It is not possible to multiply the weight of a specimen of *Helix aspersa* by a constant factor to determine the shell cavity volume, since the specific gravity of the animal is not a constant.

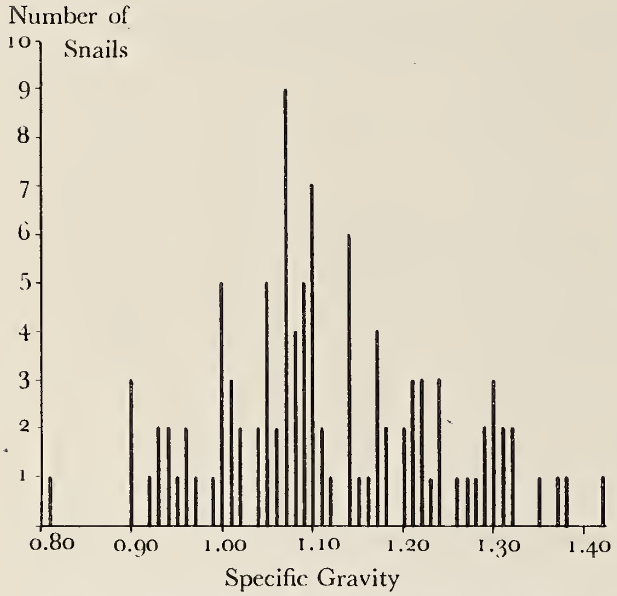

Figure 2: Graph showing random distribution of specific gravities of *Helix aspersa.*

It is interesting to note that the range of specific gravities is great, including specific gravities of less than one. The extent of the range may be due in part to the variations in hydration which have previously been noted to cause large variations in weight in individual shells within short time periods (Howes and Wells, 1934). All snails which we have observed to estivate, hibernate, or otherwise seal off, withdraw far into their shells. There is, therefore, a potentially large difference between shell cavity volume and soft tissue volume. In those snails which have an especially low specific gravity, it may be that this difference has been exaggerated. For example, a snail which has sealed itself off, slowly but progressively loses water and decreases in body weight (Howes and Wells, 1934) and therefore in specific gravity. The random collection of snails in this study may well have included some snails which had recently undergone such changes as well as some snails which were quite well hydrated and thus had very high specific gravities. Moreover, even snails kept under constant conditions may show large fluctuations in weight during short time periods (Wells, 1944). Such variations may be due in part to changes in hydration, to previous deposition of large numbers of eggs, as well as to other, unknown, variables. Snails showing a specific gravity of less than one may be accounted for by the presence of air in the shell cavity, the amount of air varying with the extent of withdrawal of the soft tissues into the shell. Likewise, the amount of air present in the lungs may be a factor in animals with low specific gravities.

Summary

The specific gravity of Helix aspersa is not constant but was found, in the 103 animals examined, to vary between 0.81 and 1.42 in a random distribution, with an average specific gravity of 1.12. It is not possible to multiply the living weight of a snail of this species by a constant factor to determine the shell cavity volume, and other methods must be employed to ascertain shell cavity volume when size increases in H. aspersa shell are used as an experimental criterion. Possible reasons for the wide range of specific gravities are discussed.

Literature Cited

Herzberg, Fred, & Andrea Herzberg
1960. The effect of cold on the growth of Helix aspersa. Journ. Exp. Zool., 145: 191-196.
Howes, N. H., & G. P. Wells
1934. The water relations of snails and slugs. Journ. Exp. Biol., 11: 327.
Kienle, M.
1957. Über Beziehungen zwischen Körpergrösse, Lungengrösse und Energiekonsum bei Pulmonaten, insbesondere Helix pomatia L. und Zebrina detrita Müll. Zeitschr. Vergl. Physiol., 40: 440-450.
Schwabe, G. H.
1959. Biometrische Daten zur Schale von Concholepas choncopas (Bruguière) (Moll., Muridae) an der chilenischen Küste und ihr ökologischer Indicatorwert. Internat. Rev. Ges. Hydrobiol., 44: 449-462.
Wells, G. P.
1944. The water relations of snails and slugs, III. Factors determining activity in Helix pomatia L. Journ. Exp. Biol., 20: 79-87.

Explanation of Plate 45

Technique for preparing shells to determine shell cavity volume.

Figure 1: Removing soft tissues from shell by forceps rotated in a counter-clockwise direction to avoid shell breakage. Figure 2: Wax poured into washed and dried shell held with apex down. Wax used of specific gravity of 0.9. Figure 3: Shell filled with wax at second pouring, showing shrinkage of wax after cooling. Figure 4: Final application of wax with hot metal spatula used to remove excess wax to rim of aperture.

Figure 1

Figure 2

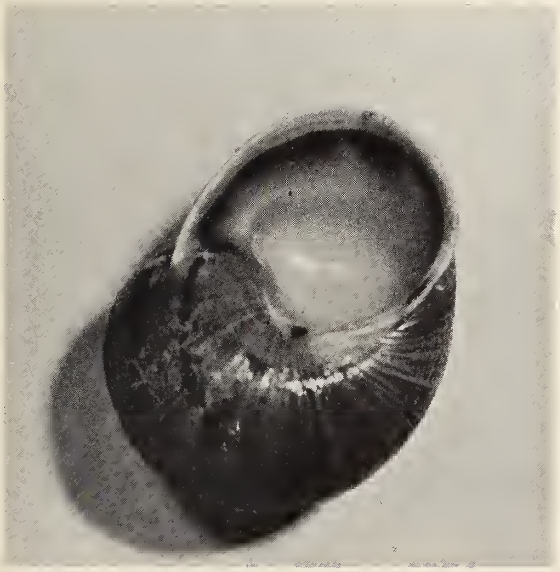

Figure 3

Figure 4

HERZBERG & HERZBERG, *photo.*

Type Localities

BY

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The type locality is a geographical term designating the area in which the holotype of a named lower taxon (species, subspecies = race, morphe, variety, etc.) lived.

The International Rules of Zoological Nomenclature do not concern themselves with this important, sometimes even decisive, addition to the description of a newly established taxon, though there are several analogies between the rules concerning the names, descriptions, and types of animals and the practice concerning their type localities as compiled in this paper.

An author establishing a new lower taxon by publication of its name and description should also indicate, as exactly as possible, the locality from which the holotype of the taxon is said to come.

This original designation of the type locality must be adopted by all later writers (see Note 1), except if it can be proven that the indication of habitat was evidently erroneous, by the following reasons:

1. The holotype really came from another locality than originally indicated: then, the previous type locality must be rejected (Note 2), even if the taxon may later on be proved to occur also in the locality erroneously named.

2. The exact description or figure of the holotype proves that it indeed belongs to the species recognized by later writers but evidently to a geographical race or variety restricted to an area which does not include the indicated locality (Note 3).

3. The species does not occur at all in the indicated geographical area, as can be proved by the fact that no living specimens have been collected later even in adjacent areas, and their having ever lived there is most improbable because of zoogeographical reasons (Note 4).

If there is no original designation of type locality at all, or if the indication of habitat is evidently too vague, or even quite wrong, the mistake should be corrected by a subsequent designation as follows:

1. The revising author may establish a new type locality, if the original description of a lower taxon does not contain any indication at all (Note 5), or if the original designation is evidently erroneous (Note 6).

2. The revising author may select a type locality, if two or more habitats have been named originally (Note 7).

3. The revising author may restrict an original type locality, if the geographical term used as habitat of the holotype is too vague with regard to the whole geographical range of the taxon (Note 8).

ad 1. The first correct subsequent designation of a new type locality is to be adopted by later writers in the same way as a correct original designation, provided that the locality chosen is the habitat of a real specimen of the species (Note 9) agreeing with the original description and figures in all characters distinguishing allied species, races, varieties, stages, etc. (Note 10); otherwise, the subsequent designation should be rejected and replaced by a second subsequent designation with the same prospect to become final, and so on (Note 11).

ad 2. In selecting a type locality from several simultaneous correct indications of habitat, no word priority should be decisive, but rather the probability that the original author has examined real specimens from one locality only (which should be selected) and added the remaining ones from papers consulted, or personal communications received (Note 12); if no locality can be preferred by such reasons, that indicated habitat should be selected as type locality which is situated most centrally in the whole area of distribution of the taxon (Note 13). The selected type locality is to be adopted by later writers, even if these recommendations have not been followed.

ad 3. In restricting a type locality, the new type locality must surely lie within the limits of the original one (Note 14), best in the centre of the area inhabited by the taxon. The restriction of a type area by the original author of the taxon himself in a later paper, in which the holotype is indicated exactly, should be regarded as valid, I think, even if another writer has restricted it in another way in the meantime (Note 15). It is not advisable to restrict type localities in a too particular way, but such hyperexact indications are not allowed to be generalized later on (Note 16).

If a preoccupied name becomes replaced by a name new to science without indication of type locality, the type locality of the invalid name should be adopted (Note 17), even if the second author has quoted figures of specimens coming from other localities merely to explain the meaning of the taxon by additional illustrations; if, however, the second author expressly established another type locality for his new name, this locality should be considered valid.

There is some difference between the mere mentioning of the locality where the just established taxon has been collected, and the explicit formal calling of it "type locality". But as the latter term is rather modern in taxonomy and unknown to ancient writers, no first correct or restricting indication of habitat should be rejected by the only reason that it lacks the term "type locality" (Note 18).

These proposed general rules may be illustrated by some examples in cowries (Cypraeidae):

(1) Linnaeus, 1758, has indicated Mauritius as habitat of Erosaria caputserpentis (Linnaeus, 1758), adopting the locality named by Lister, 1688; therefore, Iredale, 1935, and Steadman & Cotton, 1946, were right in adopting Mauritius as type locality expressly; the habitat Tahiti of Sowerby, 1837, however, must be rejected as type locality, as it has been indicated later than Mauritius of Linnaeus, 1758. — But Iredale (1935) was wrong in rejecting "in Maldivis" indicated as habitat of Palmadusta asellus by Linnaeus, 1758, in the same way and in establishing Amboina as type locality on account of Linnaeus' quoting Rumphius' Amboinsche Rariteitkamer (1705) in his synonymy list, the more so as many shells described by Rumphius do not live in Amboina at all. Therefore, Maldive Island must be restored.

(2) Schilder, 1927, indicated Palawan as habitat of the holotype of Erronea vredenburgi, misreading the original label "Palabuan"; this error has been corrected by Schilder, 1929, the more so as E. vredenburgi lives on the southwest coast of Java only. Steadman & Cotton, 1946, have erroneously indicated Nusa Kambangan as type locality (which is about 300 kilometers east of Palabuan), only for word priority in our "Prodrome" of 1938.

(3) Lamarck, 1810, described Erronea adusta from "Oceanus Asiaticus": this term usually means Indonesia where the bluish white typical E. onyx (Linnaeus, 1758) lives; but as Lamarck clearly described the chestnut race living from East Africa to Tenasserim only, Steadman & Cotton, 1946, were right to replace the type locality by Zanzibar.

(4) Gaskoin, 1849, described Cribraria cribellum from the Mediterranean, but it really occurs in the Mascarene Islands only; therefore, Weinkauff, 1881, corrected the habitat into Mauritius which has been adopted by Steadman & Cotton, 1946, as type locality.

(5) Linnaeus, 1758, Gmelin, 1791, and Lamarck, 1810, described Erosaria ocellata (Linnaeus, 1758) without indicating any habitat; Gray, 1825, mentioned the "Indian Ocean" (from Martini, 1769) and China (from Humphreys, 1797), but E. ocellata does not live in the latter country; Sowerby, 1837, figured E. ocellata from Ceylon, and as it is rather frequent in this island, Steadman & Cotton, 1946, fixed Ceylon as type locality also formally.

(6) Lamarck, 1810, described Cypraea ventriculus from New Holland; as it does not occur in Australian waters at all, and as it has been mentioned from Annaa Island by Sowerby, 1837, first, Steadman & Cotton, 1946, were right to list Annaa as type locality.

(7) When describing Luria isabella, Linnaeus, 1758, named two islands as habitat: Mauritius and Madagascar; as Reeve, 1845, repeated Mauritius only, Ladd, 1945, was right to select Mauritius as type locality; however, the type locality "Amboina" of Iredale, 1935, must be rejected, as it is not included formally in Linnaeus' original description of the species.

(8) Gray, 1828, described Naria irrorata from the "South Sea" generally, but Sowerby, 1837, indicated Elizabeth Island as habitat; this island should be regarded as type locality though Iredale, 1935, and Steadman & Cotton, 1946, retained "Pacific Is." and "Polynesia", respectively, an area which covers almost a greater part of the globe than the range of N. irrorata in its entirety.

(9) Linnaeus, 1758, described *Erosaria poraria* without habitat; Lamarck, 1810, quoted Senegal; and Gray, 1825, added Jamaica (from Martini, 1769); but both habitats are wrong as *E. poraria* is restricted to the Indo-Pacific Ocean; Sowerby, 1837, was the first to name possible localities, Ceylon and Pacific Ocean. Nevertheless, Iredale, 1935, established Amboina as type locality, but it must be rejected as *E. poraria* never has been collected at Amboina nor in adjacent islands: it spreads from the Eastern Pacific Islands (race *E. p. scarabaeus* Bory, 1827) and from the western Indian Ocean (*E. poraria s. str.*) to the outer borders of Indonesia only, and it does not occur between the southern coast of Java and North West New Guinea (Skroe). Therefore, Iredale's designation of the type locality of *E. poraria* must be replaced by Ceylon, as Schilder & Schilder, 1938, restricted *E. poraria* to the Indian race.

(10) Gray, 1825, described *Palmadusta humphreysii* without habitat; Iredale, 1939, designated Amboina as type locality, though Schilder & Schilder, 1938, had shown that this clearly separable race of *P. lutea* Gronow, 1781, is restricted to the area between Torres Strait, Tonga, and Sydney, whereas *P. lutea s. str.* occurs from Malaysia to Japan; therefore, if specimens of *P. lutea* (*s. lat.*) should be found in Amboina in future (they have not yet been found in the southern Moluccas at all!), they undoubtedly would belong to *P. lutea* and not to *P. humphreysii*. Therefore, I designate Lifu as type locality, from which Melvill & Standen, 1895, received *P.* "*lutea* var. *humphreysii*" and from which I possess a specimen myself (*ex coll.* Hervier).

(11) Reeve, 1835, described *Erronea subviridis* without habitat; in 1845 he described and figured a shell from Dupuch's Island as *E. subviridis*, which does not agree with the original description but represents the West Australian race *E. s. dorsalis* Schilder & Schilder, 1938; the more eastern typical *E. subviridis* has been first figured by Sowerby, 1870, from New Caledonia; therefore, New Caledonia should be treated as type locality of *E. subviridis* (instead of North Queensland designated as type locality by Iredale, 1935), and Dupuch's Island as that of *E. s. dorsalis*.

(12) Iredale, 1939, was right in restricting the type locality of *Blasicrura kieneri schneideri* Schilder & Schilder, 1938 (originally described from Melanesia and East Australia) to New Britain, supposing that we had received specimens from P. J. Schneider who collected there; later on, Schilder, 1958, named Ulamona in New Britain as habitat of the holotype.

(13) Reeve, 1845, established *Palmadusta diluculum* with the erroneous habitat Philippine Islands; according to Schilder & Schilder, 1938, it spreads from "Natal to Zanzibar". Steadman & Cotton, 1946, selected Natal as type locality evidently by word priority, though *P. diluculum* is more common farther north than on its southernmost border; nevertheless, the selected type locality Natal must be retained.

(14) Sowerby, 1832, named no habitat of *Cribraria cumingii*, but Gray, 1833, added "Raie tea", which was designated as type locality ("Raietea") by Iredale, 1935; Steadman & Cotton, 1946, however, incorrectly quoted Tahiti as type locality which is a better known island in the Society Islands, but which belongs to another group of islands more than 200 kilometers off.

(15) *Palmadusta punctata iredalei* Schilder & Schilder, 1938, was originally established with the range from "S. Melanesia to Manokwari, Queensland, Tonga, and Samoa"; the figure of a shell from Lindeman Island (Queensland) published by Iredale, 1935, was quoted among the illustrations of the new race. Steadman & Cotton, 1946, established Lindeman Island as type locality, but Schilder, 1958, designated a shell from Mope (New Britain) as holotype, which was examined personally in 1938, whereas the identity of the Lindeman shell should be regarded as not demonstrable. Therefore, Mope should be retained as type locality, I think.

(16) The holotype of || *Erronea sophiae* (Brazier, 1876) has been described from Makeira Harbour at San Christoval, Solomon Islands; Iredale, 1935, and Steadman & Cotton, 1946, were not justified in generalizing the exact original indication into the "type localities" San Christoval Islands and even Solomon Islands, respectively.

(17) Schilder, 1932, rechristened the invalid name *Mauritia reticulata* (Martyn, 1784) into *M. maculifera*, without naming a type locality; but as Martyn's shell is said to come from the Friendly Islands, this habitat (=Tonga Island) should be retained for *M. maculifera* too.

(18) Gray, 1824, described *Erronea pyriformis* without habitat, but in 1828 he added New Holland, whereas Sowerby, 1837, and Reeve, 1845, both quoted Ceylon. Iredale, 1935, accepted Ceylon because it "is more likely" and expressly designated Ceylon as type locality in 1939; but *E. pyriformis* lives also in Queensland

(where it seems to be more frequent than in India: Sowerby, 1870, Iredale, 1939, Schilders' collection); therefore, the original habitat (New Holland) must be restored, but it should be restricted to "Queensland", as Gray's description fits to the East Australian E. pyriformis (s. str.) but not to the West Australian race E. p. smithi Sowerby, 1881.

A revised list of the type localities of all living Cypraeidae will be published in another paper.

A Preliminary Report on Spawning and Related Phenomena in California Chitons

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(3 Textfigures)

The California Coast has one of the richest associations of chiton species found in the world, the total number of species occurring here being exceeded only by that of the Australian chiton fauna. In the diversity of the groups making up the fauna and the large number of unique species present, the California chiton fauna perhaps surpasses that of any other area. Although they present a rich field for investigation, our California chitons have been the subjects of relatively little biological research. In the area of breeding habits, almost all our knowledge comes from four papers by Heath (1899, 1905, 1907, and 1912).

The present paper reports observations I have made during the period from 1956 to mid-1961. Fourteen species of chitons have been observed to release gametes under laboratory conditions. As far as I can determine, there have been no previous reports in the literature concerning the breeding activities of 11 of the 14 species. The larvae of six species have developed for limited periods of time in the laboratory, but I have been unable to carry the larvae of any species through to maturity. Evidence is also presented indicating that for two species the time of gamete release is correlated to the tidal cycle.

Method

My procedure for collecting and handling chitons is very simple. The animals are pried off rocks with a dull paring knife and placed in collecting jars filled with sea water. The jars are kept closed and placed in a closed collecting bag while I am in the field and when returning from the field. Unless injured, the chitons will almost invariably uncurl and attach themselves to the sides of the collecting jars. Neither individuals nor species are ordinarily segregated following collecting.

The sea water in the collecting jars is changed just before leaving the field. In the laboratory the chitons may be left in the collecting jars with the lids off or may be manually transferred into flat, open pyrex dishes. In either case fresh sea water is generally used.

Gamete release has occurred while the animals were in the closed collecting jars and while being transported between the field and laboratory; in open collecting jars in the laboratory before and after the sea water has been changed; and in open pyrex dishes. Gamete release has occurred in the laboratory when the chitons were in total darkness, and also when they were exposed to rather bright electric lights. There is no reason to believe that one, or a combination, of these laboratory variables induces gamete release.

Whole mount preparations were made for studying the larval development. Bouin's solution and 5 percent formaldehyde in sea water were used as fixatives. The formaldehyde solution gives good preservation of the calcareous structures in larvae over a week old. It also partially dissolves the egg cases in a matter of a few days.

Grenacher's borax carmine and Heidenhain's iron hematoxylin stains were used. I obtained the best results with the carmine stain, particularly in the early larval stages where the larvae are still surrounded by their egg cases. The cytoplasm of the larval cells is quite receptive to the hematoxylin stain and does not destain easily.

Data

Tables 1 and 2 summarize my observations of gamete release. The date following the locality is that on which the specimens were collected. The specimens were collected not more than one and one-half hours before nor more than two hours following the low low tide. The "Next High Tide" is the low high tide following the low low tide. The "Next Low Tide" is the high low tide following the low high tide. All times after 2400 hours are on the date following collecting of the specimens in the field. Some of the localities shown in the tables are not listed in the tide tables. In such instances an estimate of the high and low tides has been made by extrapolation. The estimates are believed to be accurate to within 15 minutes in all cases.

1 The water was over-cooled, and the specimens behaved peculiarly.
2 The specimen was collected in a tide pool high in the intertidal zone, an unusual habitat for this species.
3 Observations were made by Mr. Daryl Sweeney.
4 The specimens released gametes while isolated in individual jars.
4a The specimen was the only one of its species collected on that date.
4b All specimens collected on this date were females.
5 The start of gamete release was not observed.
6 The specimen was killed before gamete release had ceased.
7 The eggs or the sperm were seen, but gamete release was not observed.
8 The water became so cloudy that it was very difficult to determine when any one individual began or ceased to release gametes.
9a Egg laying occurred between 0400 and 0800, October 29, 1957.
9b Egg laying occurred between 0040 and 0830, February 28, 1957.
9c Egg laying occurred between 0215 and 0730, February 15, 1957. Some of the eggs were fertilized although no cloudiness from sperm discharge was detectable in the water.
9d Gamete release occurred between 1730 and 1915, December 26, 1956.
9e Gamete release occurred between 1400 and 1700, April 19, 1957.
10 The five males started to release sperm at various times between 2130 and 2330. The exact time at which any individual started was impossible to determine due to the cloudiness of the water.
11 More than one male may have released sperm.
12 The specimen was still releasing gametes at 0130, October 15, 1961.
13 Gamete release occurred between 0130 and 0930, October 15, 1961.

Observations

The bulk of my observations has been made on various species of the genus Mopalia, and the following descriptions are based primarily upon observations of this genus. Except where specifically noted, the descriptions apply equally well to males of the genera Ischnochiton, Chaetopleura, and Placiphorella, and to the larvae of Ischnochiton (Lepidozona) californiensis (Berry, 1931) through about the third day of development.

Gamete Release

Female chitons appear to be loosely attached to the substrate during the first part of spawning. They are generally quiescent during this period but quite frequently will move several inches during the later part of spawning. The behavior of the males is less predictable. Most frequently they will remain stationary the entire time they are releasing sperm, but on

Table 1: Mopaliidae

Location	Date	♀	♂	Gamete Shedding Time Start	Gamete Shedding Time Finish	Tide Next High	Tide Next Low	Note
Mopalia ciliata (Sowerby, 1840)								
South Side, Pigeon Point[3]	30 Nov. 1956	1		2230	2330	2220	0250	
South Side, Pigeon Point[3]	30 Nov. 1956		1	2320	2430	2220	0250	
North Side, San Pedro Point[3]	25 Feb. 1957		1	2000	2030	2130	0235	
North Side, San Pedro Point[3]	25 Feb. 1957	1		2100	2215	2130	0235	
North Side, San Pedro Point[3]	25 Feb. 1957		1	2130	2220	2130	0235	
North Side, San Pedro Point[3]	27 Feb. 1957	2		2200	0100	2235	0400	1
Pescadero Point[1]	21 Mar. 1957		1	1815	1900	1600	2030	2
Sausalito[1]	25 Sep. 1957		1	0230	?	0225	0726	3, 4
Sausalito[1]	22 Oct. 1957		1	2100	?	2335	0430	3, 4
Sausalito[1]	22 Oct. 1957	1		2245	?	2335	0430	3, 4
North Side, San Pedro Point[3]	25 Oct. 1957	1		2400	0200	0130	0615	3, 4
Mission Point[1]	21 Feb. 1960	1		2100?	2200	1915	2400	5
Franklin Point[3]	22 Feb. 1960		1	2130	2200	2015	0110	6
Franklin Point[3]	27 Feb. 1960		1	2330	2430	2340	0530	
Tiburon[1]	20 Nov. 1960	1		2130?	2345	0200	0645	
Tomales Bay[1]	11 Mar. 1961	1		1900?	2130	2100	0130	5
Tomales Bay[1]	11 Mar. 1961		1	1900?	2130	2100	0130	5, 6
Tomales Bay[1]	11 Mar. 1961		1	2030	2200	2100	0130	6
Aquatic Park, San Francisco[2]	15 July 1961		1	1530	1640	1530	2020	
Mopalia, spec. nov.								
Marina, San Francisco[2]	30 Apr. 1961		1	1130?	1400	1300	1815	5
Marina, San Francisco[2]	13 May 1961		1	1530	1700	1215	1735	
Marina, San Francisco[2]	13 May 1961	2		1800	1915	1215	1735	
Marina, San Francisco[2]	13 May 1961		2	1800	1915	1215	1735	
Marina, San Francisco[2]	13 May 1961	1		1900	2010	1215	1735	
Marina, San Francisco[2]	14 May 1961		1	1200	1215	1310	1815	
Marina, San Francisco[2]	14 May 1961	1		1900	2010	1310	1815	
Aquatic Park, San Francisco[2]	15 July 1961	2		1930	2200	1530	2020	
Aquatic Park, San Francisco[2]	15 July 1961		1	1930	2200	1530	2020	
Aquatic Park, San Francisco[2]	15 July 1961	1		2230	2300	1530	2020	
Aquatic Park, San Francisco[2]	15 July 1961		1	2200	2300	1530	2020	
Mopalia lowei (Pilsbry, 1918)								
Tomales Bay[1]	11 Mar. 1961		1	2100	2200	2100	0130	6
Tomales Bay[1]	3 June 1961	1		1600	1730	1740	2240	4 a
Mopalia porifera (Pilsbry, 1892)								
Pescadero Point[3]	10 Nov. 1958	2		2130	2200	2230	0330	
Pescadero Point[3]	10 Nov. 1958		2	2145	2300?	2230	0330	8
Pescadero Point[3]	10 Nov. 1958		3?	2200?	2400	2230	0330	8
Pescadero Point[3]	5 Mar. 1959	1		2425	2450	2050	0205	
Pescadero Point[3]	5 Mar. 1959	1		0125	0210	2050	0205	
Pescadero Point[3]	5 Mar. 1959		1	2345	2415	2050	0205	
Pescadero Point[3]	14 Oct. 1961		1	2400	2425	0315	0740	
Pescadero Point[3]	14 Oct. 1961		1	2430	0100	0315	0740	
Pescadero Point[3]	14 Oct. 1961	1		2445	0105	0315	0740	
Pescadero Point[4]	14 Oct. 1961		1	0105	?	0315	0740	13
Pescadero Point[4]	14 Oct. 1961	1		?	?	0315	0740	7, 14
Franklin Point[4]	12 Mar. 1960	2		2230?	2320	2235	0420	5

[1] = Marin County [2] = San Francisco County [3] = San Mateo County
[4] = Monterey County [5] = Los Angeles County

Table 1: Mopaliidae (continued)

Location	Date	♀	♂	Gamete Shedding Time Start	Time Finish	Tide Next High	Next Low	Note
Mopalia hindsi (REEVE, 1847)								
San Pedro Point[3]	25 Oct. 1957	1		?	2345	0130	0615	3, 4, 6
Moss Beach[3]	28 Oct. 1957	1		9 a	9 a	0315	0730	3, 4, 7
Mopalia imporcata (CARPENTER in PILSBRY, 1892)								
Franklin Point[3]	26 Feb. 1961	1		1840	2000	2120	0220	4 b
Franklin Point[3]	26 Feb. 1961	1		1900	2000	2120	0220	4 b, 6
Franklin Point[3]	26 Feb. 1961	1		1930	2000?	2120	0220	4 b, 6
Mopalia muscosa (GOULD, 1846)								
Aquatic Park, San Francisco[2]	15 July 1961	1		1500?	1730	1530	2020	
Aquatic Park, San Francisco[2]	15 July 1961		1	1530?	1730	1530	2020	
Mopalia lignosa (GOULD, 1846)								
North Side, San Pedro Point[3]	27 Feb. 1957		1	2300	2400	2235	0350	
North Side, San Pedro Point[3]	27 Feb. 1957		1	2400	2440?	2235	0350	
North Side, San Pedro Point[3]	27 Feb. 1957	1		9 b	9 b	2235	0350	7
Muir Beach[1]	12 Mar. 1957	1		2000	2100	2100	0220	4 a
Bolinas Point[1]	13 Mar. 1957		1	2000	2110	2145	0320	4 a
Placiphorella velata (CARPENTER in PILSBRY, 1892)								
Mission Point[4]	28 Sep. 1959		1	2100?	2240	2315	0445	5

Table 2: Other Chiton Species

Location	Date	♀	♂	Gamete Shedding Time Start	Time Finish	Tide Next High	Next Low	Note
Ischnochiton radians (CARPENTER in PILSBRY, 1892)								
North Side, San Pedro Point[3]	14 Feb. 1957	1?		9 c	9 c	2325	0455	7
North Side, San Pedro Point[3]	14 Feb. 1957		?	9 c	9 c	2325	0455	7, 10
Ischnochiton mertensi (MIDDENDORFF, 1846)								
Año Nuevo Bay[3]	13 Feb. 1957	1		2200?	2315	2215	0330	5
Ischnochiton regularis (CARPENTER in PILSBRY, 1892)								
Mission Point[4]	21 Feb. 1960		5	2130	2400	1915	2345	8, 11
Ischnochiton californiensis BERRY, 1931								
North Side, Resort Point[5]	26 Dec. 1956	1		9 d	9 d	1800	2235	7
North Side, Resort Point[5]	26 Dec. 1956		1?	9 d	9 d	1800	2235	7, 12
White's Point[5]	30 Dec. 1956		2?	2130?	2230	2130	0200	5, 8
Chaetopleura gemma (CARPENTER in PILSBRY, 1892)								
Tomales Bay[1]	3 June 1961		2?	1530?	1615	1740	2240	5, 8
Tonicella lineata (WOOD, 1815)								
North Side, San Pedro Point[3]	19 Apr. 1957		1	9 e	9 e	1600	2030	7

[1] = Marin County
[2] = San Francisco County
[3] = San Mateo County
[4] = Monterey County
[5] = Los Angeles County

other occasions I have seen them move intermittently and, more rarely, move continuously throughout the entire time they are releasing sperm.

The ejection of eggs and sperm from the body cavity seems to be aided by rhythmic movements of the foot. This may explain why the females seem loosely attached to the substrate at the beginning of spawning.

Egg laying is a two-stage process. The eggs are first ejected into the mantle cavity where several hundred may accumulate on each side of the foot. The eggs are carried posteriorly, presumably by ciliary currents, and emerge through an upraised portion of the hindmost part of the girdle. Frequently, the eggs emerge as two "streams", one from each side of the mantle cavity. As they first emerge from the mantle cavity, the eggs are propelled at considerable speed but slow down almost immediately and seldom travel more than two to three centimeters. The eggs accumulate in a pile behind the female.

Initially, the sperm is discharged in spurts and has a coagulated appearance, as if enclosed in mucus. The sperm disperses very slowly at this stage. As the male continues to release sperm, the discharge becomes more continuous and the product no longer appears coagulated. Dispersion of the sperm at this time is more rapid. In all cases which I have observed, the male extends the lateral edges of his foot to cover the mantle cavity in the area of the genital opening. It has not been possible to determine whether the sperm accumulates in the mantle cavity of male chitons as the eggs do in the mantle cavities of the females.

I have gained the impression that once gamete release has begun, rather drastic conditions are required to cause the chiton to cease. A very strong light which gives off considerable heat will cause interruption of spawning, if the light is placed close to the chiton. On the other hand, I have removed both males and females, in the process of releasing gametes, from collecting jars and transferred them into dishes filled with sea water, where gamete release continued with little or no interruption. On other occasions, female chitons have fallen off the sides of a jar or dish in which they were spawning, been turned over (as they had landed foot uppermost), and resumed spawning without interruption. One male _Mopalia_ _ciliata_ (Sowerby, 1840) released sperm for over half an hour while partially curled upon his back. Finally, in an experiment, the water in a jar in which two male _Ischnochiton_ (_Lepidozona_) _californiensis_ were releasing sperm was violently agitated. The water was emptied, replaced, and once again violently agitated. The water was again emptied from the jar but this time was not replaced for a period of three minutes. When the jar was refilled, the chitons were almost immediately releasing sperm again, and I doubt if any interruption of sperm release had occurred.

Sexual Products

The eggs of _Mopalia_ appear to be shed individually without any visible trace of an albuminous sheath or envelope. However, the eggs do not disperse in sea water as easily as one would expect. When eggs are fixed in formaldehyde and sea water soon after they have been shed, they seem to be enclosed in an amorphous, slightly translucent mass. Individual eggs can be removed from this enclosing mass only with difficulty. This mass enclosing the eggs is most noticeable with unfertilized eggs but gradually disappears or disperses 12 to 15 hours after fertilization. The exact nature of this "envelope" is unknown.

All chiton eggs I have seen are spherical in shape. Each egg is enclosed in its own individual egg case. Numerous spine-like or plate-like processes project from the surface of the egg cases, giving the cases the appearance of transparent, short-spined sea urchins. The projections of the egg cases of _Ischnochiton_ _radians_ (Carpenter in Pilsbry, 1893) are spine-like. Those of the egg cases of _I._ _mertensi_ (Middendorff, 1846) are plate-like and may be either wavy or curled. The projections of the egg cases of the species of the genus _Mopalia_ are intermediate, between those of _I._ _radians_ and _I._ (_L._) _mertensi_.

The eggs of the species of _Mopalia_, _Nuttallina_, _Cyanoplax_, _Katharina_, _Cryptochiton_, and _Placiphorella_ are a light grey-green. Those of _N._ _californica_ (Reeve, 1847) and _M._ _lignosa_ (Gould, 1846) are a brighter green. The eggs of the species of the subgenera _Lepidozona_ and _Stenoplax_ of the genus _Ischnochiton_ are pinkish or tawny-buff in color. _Ischnochiton_ (_S._) _fallax_ (Carpenter in Pilsbry, 1892) is an exception among the Ischnochitons, the eggs of this species being green in color.

The average diameters of the unfertilized eggs of several species of chitons are listed in Table 3. Measurements were made on eggs preserved in formaldehyde and sea water and do not include the egg case.

Table 3:

Species	Diameter in microns
Mopalia porifera (Pilsbry, 1892)	170
Mopalia imporcata (Carpenter in Pilsbry, 1892)	180
Mopalia ciliata (Sowerby, 1840)	200
Mopalia spec. nov.	200
Mopalia lowei (Pilsbry, 1918)	200
Mopalia lignosa (Gould, 1846)	240
Ischnochiton mertensi (Middendorff, 1846)	200
Ischnochiton radians (Carpenter in Pilsbry, 1893)	180

Heath (1899) reports that the eggs of Ischnochiton (Stenoplax) magdalenensis (Hinds, 1844) [= I. (Stenoradsia) heathiana Berry, 1946] average about 400 microns in diameter. I find it curious that the eggs of various species of Mopalia are so much smaller than those of I. (S.) heathiana, when it is considered that the latter species has a free-swimming larval stage that lasts less than 5 percent as long as the free-swimming stage of Mopalia larvae. One would expect that the species with the longer free-swimming stage would require more stored food and therefore possess the larger eggs.

Larval Development

The development of Mopalia ciliata follows quite closely that of Lepidopleurus asellus (Spengler) as described by Christiansen (1954) and that of Chaetopleura apiculata (Say) as described by Grave (1932) in general pattern and the timing of development. The larval development of M. ciliata differs from that of Ischnochiton (Stenoradsia) heathiana as described by Heath (1899) in having more rapid initial cleavage after the egg is fertilized, in emerging from the egg case at a much earlier stage of development, and in possessing a much longer free-swimming larval stage. Table 4 summarizes some of the principal events in the larval development of M. ciliata in chronological order.

Discussion

All of the ten species considered in this paper which have laid eggs can be described as free spawning for, although as I have indicated in the case of Mopalia ciliata, some mucus is present, the eggs can be dispersed fairly easily in sea water. This would also seem to be the case for Ischnochiton (Lepidozona) cooperi (Carpenter in Pilsbry, 1892) as described by Heath (1905). Heath (1905) describes the eggs of Katharina tunicata (Wood, 1815) as being enclosed in a ?visible mucus secretion. According to Grave (1932), the eggs of Chaetopleura apiculata are also enclosed in a mucus secretion, and Christiansen (1954) describes a similar condition for the eggs of Lepidopleurus asellus. The greatest development of a mucus or albumen secretion surrounding the eggs occurs in I. (Stenoradsia) heathiana, where, according to Heath (1899), the eggs are enclosed in long albuminous sheaths, which are of sufficient strength to hold the eggs together for several days after spawning.

Both Nuttallina thomasi (Pilsbry, 1898) and Trachydermon (= Cyanoplax) raymondi (Pilsbry, 1894) do not release their eggs into the surrounding water but retain them in the mantle cavity until after the larvae have gone through metamorphosis (Heath, 1905). The latter species is unique in being the only one thus far described which is hermaphroditic (Heath, 1907).

I began to suspect rather early that there might be some correlation between the time that both sexes of Mopalia ciliata released gametes and the tidal cycle. Figure 1 shows the gamete release times for M. ciliata. The reference point for this species is the low high tide occurring after collection. Figure 3 shows the gamete release times for Mopalia spec. nov. (see Thorpe, 1961). The reference point for this species is the next high low tide following collection. Figure 2 represents the average spring tide tidal cycle since the times between the successive high and low tides do not remain constant throughout a month or a year, and the data cover a period of several years. The low high tide for the day was selected as the reference point, which introduces a maximum error of not more than 5 percent in the times shown between the low low tide and the low high tide and a maximum error of not more than 9 percent in the times shown between the low high tide and the high low tide. The gamete release times for each species are in the same order and represent the same individuals shown in Table 1, except that the last 15 individuals in Figure 1 and the last four individuals in Figure 3 represent recent observations which were not included in Table 1.

Although not perfect in detail, there seems to be a reasonably good correlation between the time that individuals of Mopalia ciliata release gametes and the low high tide for the day. Mopalia spec. nov. follows a different pattern. The females apparently spawn on a low tide, while the males show a less predictable pattern. The difference shown by the two species is of particular interest because they are believed to be very closely related.

Table 4:

The development of *Mopalia ciliata* (Sowerby, 1840)

Time After Fertilization	Features of Development or Behavior Typical for the Time Period Shown
0 hours	Fertilization. Polar body minute and transparent.
1-1½ hours	First cleavage occurs.
2 hours	Second cleavage occurs.
3- 6 hours	Third and subsequent cleavages are somewhat more rapid in the micromeres. Macromeres tend to be slightly larger than micromeres.
10-12 hours	Gastrulation beginning. The first cilia of the velum are developed and beating at about 12 hours.
18-24 hours	Cilia of velum encircle larvae and beat in wave-like motions. Gastrulation apparently complete at 24 hours.
24-48 hours	Larvae emerge from egg cases during this period. Development to this stage temperature dependent, i. e., larvae developed at 12-15° C. above normal ocean temperature emerge from egg cases in 12 to 24 hours; those developed at 3-5° C. above normal emerge at 24 hours. Larvae developing at normal ocean temperature emerge in 36 to 42 hours. Apical cilia develop just prior to emergence from the egg case.
2- 4 days	Larvae are free swimming in aerated water; in non-aerated water they remain at the bottom and move only slightly. Photonegative. Larvae most active at the end of this period; swimming may be in a loose spiral, with the larvae rotating rapidly, or in a straight line without rotation.
4- 5 days	The anlagen of the ocelli and the valves begin to develop towards the end of the fourth day. The anterior valves are the first to be apparent. Larvae becoming elongated in the antero-posterior axis and flattened dorso-ventrally.
5- 8 days	Larvae noticeably less active. The predominant movement towards the end of this period is creeping. All eight valves and $CaCO_3$ spicules of the girdle present on the eighth day. End of free swimming stage.
8-16 days	"Metamorphosis" complete at 16 days where the larvae are not retarded by unfavorable conditions. The anus has developed. Ocelli still present. Valves are still covered by epithelium. Velum and apical cilia have been lost. Anlagen of the radula develop during this period. When examined under a microscope, the larvae attach to the slide by posterior portion of the foot, which portion in stained preparations has a glandular appearance.

Brewin (1942) has shown that Cryptoconchus porosus (Burrow, 1815) releases gametes every 15 days for a period of 2 to 2½ months, and spawning is apparently correlated with the phases of the moon. Gamete release by C. porosus occurred regularly during the middle of the day and was not correlated with the tidal cycle. Brewin was also able to show that the results obtained in the laboratory coincided with the dates and times of gamete release by the animals in their natural habitat.

Christiansen (1954) and Heath (1905) have reported that egg laying in chitons occurs only after males have released sperm. Their statements were apparently based upon small numbers of observations. From experiments with Mopalia lignosa and Ischnochiton heathiana, Heath (1905) concluded that sperm or some hormonal product released by the male chiton was necessary if spawning was to occur.

On the other hand, Grave (1932) states that *Chaetopleura apiculata* females will spawn when isolated from the males. Brewin (1942) observed that females of *Cryptoconchus porosus* would spawn prior to sperm release by the males of the same species. In the first case Grave was working with a fairly large number of animals, while Brewin's observations were made over a prolonged period of time. The results obtained by Mr. Daryl Sweeney and myself are shown in Table 5.

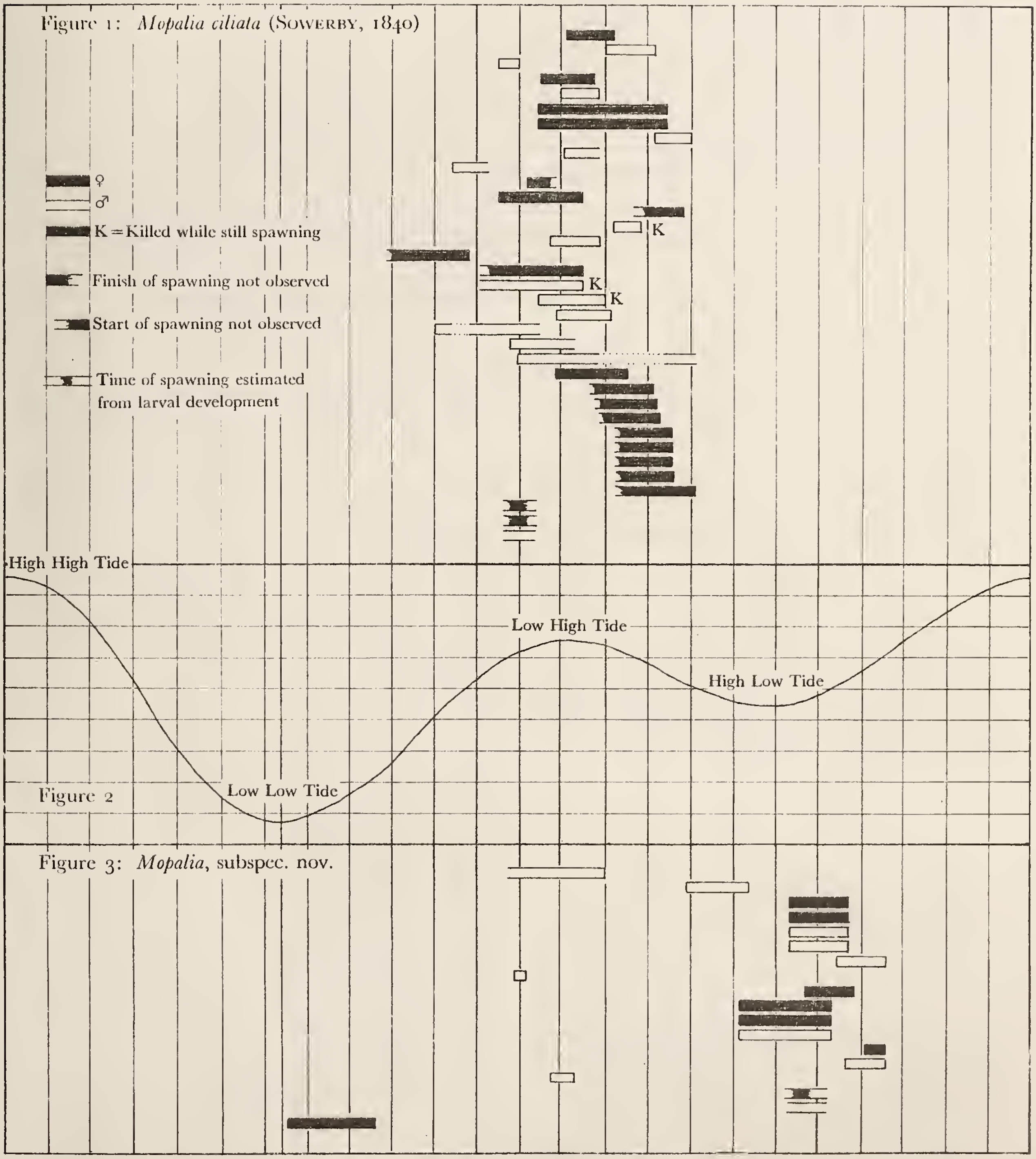
Figure 1: *Mopalia ciliata* (Sowerby, 1840)

Figure 2

Figure 3: *Mopalia*, subspec. nov.

each division = one hour

Table 5:

Species	Total	Females Spawning before males began to release sperm or when males did not release sperm	 when isolated from the males for periods of 3 to 6 hours
Mopalia porifera (PILSBRY, 1892)	8	4	
Mopalia imporcata (CARPENTER in PILSBRY, 1892)	3		3
Mopalia ciliata (SOWERBY, 1840)	8	5	2
Mopalia spec. nov.	5	1	
Mopalia hindsi (REEVE, 1847)	2		2
Mopalia lowei (PILSBRY, 1918)	1		1
Mopalia lignosa (GOULD, 1846)	2		1
Ischnochiton mertensi (MIDDENDORFF, 1846)	1	1	
Totals:	30	11	9

The ten females not accounted for in columns 3 and 4 are those which spawned after one or more males had released sperm

It seems to me that the evidence, although admittedly rather scanty, fails to support the hypothesis that the release of sperm is the immediate cause for spawning. The effects of sperm release, or the effect of some as yet undetermined male hormone upon the females over longer periods of time, is unknown.

Summary

Observations of gamete release by 14 species of California chitons are reported. Details of behavior during breeding and of the development of the larvae are given for *Mopalia ciliata*. Gamete release in this and one other species shows correlation with the tidal cycle.

Acknowledgment

I am most grateful to Mr. Daryl Sweeney for permission to use some of his data in this paper. They form an integral and important part thereof. My thanks also to Mr. Allyn G. Smith for his many helpful suggestions and encouragement.

Literature Cited

Berry, S. Stillman
1946. A re-examination of the chiton *Stenoplax magdalenensis* (Hinds), with the description of a new species. Proc. Malacol. Soc. London 26 (6): 161 to 166.

Brewin, B. I.
1942. The breeding habits of *Cryptoconchus porosus* (Burrow). Trans. Proc. Roy. Soc. N. Zealand 72 (2): 186-190.

Christiansen, M. E.
1954. The life history of *Lepidopleurus asellus* (Spengler)(Placophora). Nytt Mag. Zool. 2: 52-72.

Grave, B. H.
1932. The embryology and life history of *Chaetopleura apiculata*. Journ. Morph. 54 (1): 153-160.

Heath, H.
1899. The development of *Ischnochiton*. G. Fischer, Jena, 1-90, pls. 1-5.

——, ——
1905. The breeding habits of chitons of the California coast. Zool. Anz. 29 (12): 390-393.

——, ——
1907. The gonad in certain species of chitons. Zool. Anz. 32 (1): 10-12.

Heath, H., & R. M. Higley
1912. The development of the gonad and gonoducts in two species of chitons. Biol. Bull. 22 (2): 95-97.

Pilsbry, Henry A.
1892. Manual of Conchology, 14. Philadelphia. pp. 1 to 350, pls. 1-68.

——, ——
1893. Manual of Conchology, 15. Philadelphia. pp. 1 to 133, pls. 1-17.

——, ——
1894. *Trachydermon raymondi* in British Columbia. Nautilus 8: 57.

Thorpe, Spencer R., Jr.
1961. The species of *Mopalia ciliata*. Abstr. in Ann. Rept. Amer. Malacol. Union, Bull. 28: 40.

Notes & News

Busycotypus (B.) canaliculatus in San Francisco Bay

BY

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Although the channeled whelk has been found sporadically in San Francisco Bay presumably ever since 1938, it is only within recent years that it seems to have become relatively abundant, at least in certain localities. The first observation is attributed by Dr. Leo G. Hertlein of the California Academy of Sciences to an unnamed collector who is alleged to have obtained living specimens of this species while dredging for "oyster shell", a dietary supplement for chickens, in 1938. This report is quoted both in Puffer and Emerson (1954) and in Hollister (1958), from a personal communication by Dr. Hertlein. However, the earliest recorded specimens (three) in the collection of the California Academy were obtained by Rogers on December 20, 1950, "at about the foot of Gilman Street" in San Francisco (2 on map, textfig. 1). Four additional specimens in the same collection were obtained by C. H. Roof at Coyote Point (4 on map, textfig. 1) in San Mateo County, on March 27, 1954. In the collection of the Geology Department at Stanford University is a specimen which was dredged off Bay Farm Island (1 on map, textfig. 1), Alameda County, by P. J. Gambetta in February 1948. This seems to be the earliest record of the species in San Francisco Bay, as far as I have been able to ascertain. It seems logical to suggest, therefore, that the year 1938 is either a typographical error or an error of memory and that actually the year 1948 represents the first occurrence of the species. In the collection of the Department of Zoology at the University of California in Berkeley, there are additional records, as follows:

A young specimen from Point Bluff (3 on map, textfig. 1), Marin County, collected by Earl Barnawell on June 14, 1953.

A mature specimen snagged with a fishhook off Belmont Slough (5 on map, textfig. 1), San Mateo County, by H. A. Dalton on June 29, 1958.

A mature specimen brought in alive by Mr. Charles Barry, from Alameda (7 on map, textfig. 1), Alameda County, in May 1960.

While all the instances of observations recorded thus far concern only one or very few individuals, there are now available also observations on larger numbers of individuals. On December 22, 1958, Miss Laura Cantrel of Oakland collected 26 specimens at the foot of San Mateo Bridge (6 on map, textfig. 1), San Mateo County. During the year 1961 two members of the Northern California Malacozoological Club, Mrs. Wanda Martin of Albany and Mrs. Verna Wegner of El Cerrito, collected over 100 specimens, ranging from very small to apparently fully mature specimens, near Alameda (7 on map, textfig. 1) in Alameda County. These two collectors also picked up several strings of egg capsules. On November 16, 1961, Mrs. Martin brought two living whelks and one egg string to the Department of Zoology for exhibit in the hall aquaria. The string, about 22 inches long when gently extended (but still somewhat coiled) consists of 98 typical egg capsules. From these capsules about 40 to 50 young have emerged within the first two weeks in the aquarium.

Only one or two additional young specimens have been observed between December 1, 1961,

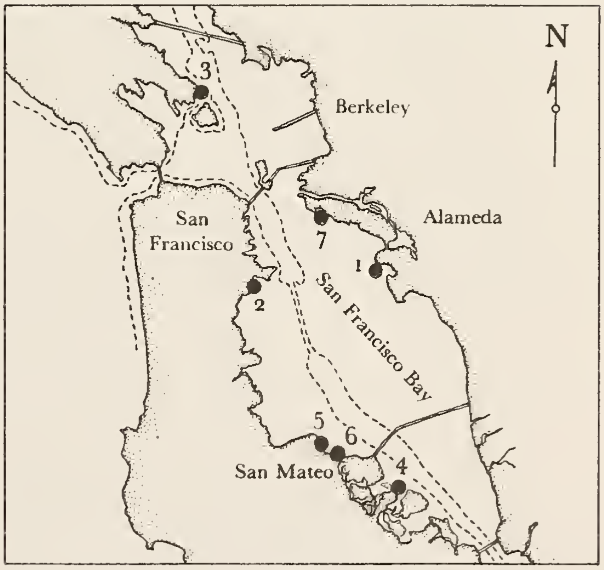

Figure 1

Map of the central and southern portions of San Francisco Bay, showing collecting stations of *Busycotypus (Busycotypus) canaliculatus* (LINNAEUS, 1758)
1: Bay Farm Island; 2: foot of Gilman Street, San Francisco; 3: Point Bluff; 4: Coyote Point; 5: Belmont Slough; 6: foot of San Mateo Bridge; 7: Alameda
(broken line is -28 foot contour)

and January 13, 1962.

Through the generosity and cooperation of Dr. Leo G. Hertlein, Dr. Myra Keen, Mrs. Martin, and Mrs. Cantrell, I have been able to measure a considerable sample of all specimens collected. In Table 1 I have summarized the results.

There are several interesting points to be observed from the map and the table. Busycotypus canaliculatus (Linnaeus, 1758) is reported from the east coast of the United States as occurring in shallow waters. Yet there are three distinct areas within San Francisco Bay where Busycotypus has been obtained, namely, the west shore and the east shore, respectively, of the southern portion of the Bay, and the west shore of the northern portion of the Bay. These three portions are separated from each other by relatively deep channels. The San Francisco Bay Pollution Investigation project under the direction of Mr. R. A. Wagner has carried out numerous dredgings in these channels, particularly in the southern portion, but no living or dead specimens of Busycotypus have been recovered (personal communication from Mr. Wagner). This poses a puzzle regarding the distribution of the species. Possibilities coming to mind are: separate introductions; accidental transport of egg strings or young specimens by logs floating across the Bay. Since the young are fairly large when they emerge from the egg capsule – i. e., about a quarter of an inch in greatest length – and are not free swimming, the disrupted distribution cannot be explained by the migration of a "free-swimming" larval stage.

Reports on Busycotypus from the east coast of the United States indicate a maximum length of 7½ inches. The largest specimen in Mrs. Martin's collection, measuring 185 mm., just about equals this maximum length. It seems interesting to note the more or less gradual increase in the maximum length observed over the years.

It is apparent that Busycotypus canaliculatus is to be regarded as well established in San Francisco Bay, and if our amateur collectors do not eradicate the species by over-collecting, this may prove a welcome addition to the Bay fauna. There are no common native shallow water species which equal Busycotypus in size, except Polinices lewisii (Gould, 1847). Therefore, Busycotypus may be most welcome as dissection material for the many classes in elementary zoology taught around San Francisco Bay.

Acknowledgment

The generous cooperation of Drs. Leo G. Hertlein and A. Myra Keen, who made the collections under their care available to me, and of Mrs. Wanda Martin and Miss Laura Cantrell is gratefully acknowledged.

Literature Cited

Hollister, S. C.
1958. A review of the genus Busycon and its allies - Part I. Paleontographica Amer. 4 (28): 59-126, pls. 8-18.
Puffer, Elton L., & William K. Emerson
1954. Catalogue and notes on the gastropod genus Busycon. Proc. Biol. Soc. Wash. 67: 115-150.

Table 1:

Measurements (in millimeters) of Specimens of *Busycotypus* (*Busycotypus*) *canaliculatus* (Linnaeus, 1758) from San Francisco Bay

Date	Collection	Number of Specimens	Smallest	Largest	Locality (see Map)
1948 Feb.	Stanford University	1		96.6	Bay Farm Island
1950 Dec. 20	Cal. Acad. Sci.	3	64.4	102.0	San Francisco
1953 June 14	U. C. Zoology	1		36.8	Point Bluff
1954 Mar. 27	Cal. Acad. Sci.	4	105.1	161.8	Coyote Point
1958 June 29	U. C. Zoology	1		165.0	Belmont Slough
1958 Dec. 22	Cantrell	26	30.1	136.5	San Mateo Bridge
1960 May	U. C. Zoology	1		140.0	Alameda
1961	Martin	over 100	34.0	185.0	Alameda

Recent Uses of Non-binomial Works

BY

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The erroneous use and implied adoption of early, non-binomial works on mollusks by recent authors have prompted this note of warning (see Jean Cate, 1960, and T. A. Garrard, 1961). Although there are many nomenclatorially invalid works which employ descriptive polynomials, I think four are worthy of mention because some workers are likely to use them in the future.

The eleven volumes of the Neues Systematisches Conchylien-Cabinet (1769-1795) written by Martini and Chemnitz were declared non-binomial and invalid nomenclatorially by Opinion 184 of the International Commission on Zoological Nomenclature in 1944. Evidently issued as part of volume 10 was an index, the "Namen Register" (1788), which was assembled by J. S. Schröter. Although not specifically mentioned in Opinion 184, this index is merely an alphabetically arranged list of vernacular and Chemnitzian descriptive Latin names. Such entries as *Buccinum ex sanguine adspersum* and *Bulla achatina sinistrorsa* speak for the Index's unavailability. Cate (1960, p. 49) used the name *Mitra nigra* (Schröter, 1788), but the earliest valid usage appears to be *Mitra nigra* (Gmelin, 1791). It might be mentioned that Pfeiffer's "Kritisches Register" (Kassel, 1840, 112 pp.) is binomial.

Another non-binomial work, deceiving at first glance, is G. Karsten's Museum Leskeanum, vol. 1, 320 pp., 3 pls., Leipzig, 1789. In the main, Karsten follows the Linnaean binomial system and gives good descriptions and figure references for species now credited to Gmelin, 1791. Fortunately, for the sake of stability, a few polynomials appear, a fact which I believe renders the entire work unavailable. Examples are: (p. 152) *Mya Vulsella minor* Chemnitz; (p. 173) *Arca Rhomboidalis J. Orient*. Chemn.; and (p. 186) *Pinna haud ignobilis* Chemn. His described and figured *Nerita reticulata* is therefore invalid, although it is listed in Sherborn's Index Animalium for 1758 to 1800, p. 825.

Quite recently (T. A. Garrard, 1961, p. 32) erroneously credited the authorship of the genus *Turris* to P. L. S. Müller, 1766. Müller authored in 1766 a folio edition of Knorr's Deliciae Naturae Selectae – Naturalien - Cabinet, Nürnberg, vol. 1, 132 pp., with colored plates on mollusks. The molluscan names on page 129 in the explanations to the plates are binomial and would normally replace some well-known names in *Cypraea*, *Mitra*, *Voluta*, etc. Fortunately, Müller was merely quoting Rumphius' 1705 pre-Linnaean names, and, if one looks on page 128, one can find such polynomials as *Sertularia pennata folliculis bidentatis* and *Corallium acarbaricum nigrum ramosum*. Incidentally, were Müller's name valid, the type species would be by monotypy and not by original designation as stated by Garrard. I believe the earliest author for *Turris* is Röding, 1798.

The fourth non-binomial work worth mentioning is the once-controversial Index to Gronovius' Zoophylacium Gronovianum published by F. C. Meuschen in 1781. It was rejected in Opinion 261 on August 10, 1954, by the International Commission on Zoological Nomenclature.

Literature Cited

Cate, Jean M.
1960. Range extension and synonymy for *Mitra nigra* (Schröter, 1788). The Veliger 3 (2): 49-51.

Garrard, T. A.
1961. Mollusca collected by M. V. "Challenge" off the East Coast of Australia. Journ. Malacol. Soc. Austral. 5: 2-36.

New Name for *Strombus granulatus* subsp. *acutus* DURHAM, 1950, not PERRY, 1811

BY

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Dr. Robert Robertson of the Academy of Natural Sciences of Philadelphia has kindly called my attention to the fact that my *Strombus granulatus* subsp. *acutus* (1950, Geol. Soc. America, Mem. 43, pt. 2, p. 118, pl. 27, figs. 1, 2, and 5) from the Pliocene and Pleistocene of the Gulf of California, is a homonym of *Strombus acutus* Perry, 1811. Accordingly, my *acutus* is herein renamed *cortezianus*, after the "Sea of Cortez".

The W. Mack Chiton Collection

BY

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A brief account of the Wilfred Mack collection of chitons, now preserved in part in the Mollusk and Invertebrate Zoology Collections at the California Academy of Sciences, may be of some value for future reference. Moreover, the circumstances under which the collection was made have some interesting aspects.

Mr. Wilfred Mack, a garden specialist in Pacific Grove, California, became interested in collecting chitons through friendship with the Rev. Elwood B. Hunter of Pacific Grove who had been collecting chitons in the Monterey area for some time and had become a specialist in knowing where and how to collect them. Although a beginner with no knowledge of chiton ecology, Mr. Mack soon became an expert collector himself under the tutelage of Elwood Hunter.

Mr. Mack was an enthusiastic collector – just how enthusiastic becomes evident on reading the notes he kept of his collecting activities. This forms a particularly valuable record which beginning conchologists all too often do not take the pains to prepare. These notes were penwritten in a 5 x 8 inch spiral-bound notebook. They begin (somewhat edited) as follows:

> "1. On 12/12/40, Thursday – Day clear – low at 3:05 PM. Became interested in collecting chitons after seeing Elwood Hunter's collection. First trip with Elwood to rocks about 0.3 mile south of Pt. Joe [on the] 17-Mile Drive [Monterey Peninsula near Asilomar]. Tide about 0.3 ft. Have beginner's luck collecting: Mopalia ciliata, Tonicella lineata, Lepidozona mertensi (a lovely red-purple), Ischnochiton regularis (a perfect blue [rare color phase] and many others), Chaetopleura gemma (orange), Stenoplax heathiana (in quantity), one Basiliochiton heathi (red and green, Cyanoplax dentiens, Mopalia muscosa. Rocks granite – quite encrusted generally."

Chiton names in the above account have been changed to modern equivalents as Mr. Mack was not familiar at the time with chiton taxonomy or the correct spelling of specific names. This is unimportant and certainly no criticism of his excellent job of note-taking.

Mr. Mack's notes cover a total of 69 separate entries, beginning 12 December, 1940, and ending around 10 July, 1941. Just how persistent he was is attested by his almost continuous collecting efforts during moderate to low tide periods, day after day, rain or shine, and in heavy surf as well as in calm weather. Methods used were the usual ones for collecting chitons, especially small ones, by turning rocks and investigating their undersides carefully. A great deal of wading was done, occasionally out to shoulder depth in the cold water of the Monterey area, in order to bring in rocks from below the intertidal zone. Having done considerable collecting in the area myself over past years, I can vouch for the degree of hardihood this type of collecting demands without benefit of modern-day swim-suits worn by SCUBA divers!

Both Mack and Hunter had their favorite hunting spots in the area, especially along the western flank of the Monterey peninsula from Pt. Pinos (including the famous Great Tide Pool at Lighthouse Point) to Fan Shell Beach and Cypress Point. Another favorite spot was what they called the "Carmelite Intrusion", open seashore area extending for some distance along the shore of Carmel Bay beginning at the south end of the long Carmel sand beach. A few visits were made to the area between Yankee Point to the mouth of Malpaso Creek, south of Point Lobos, in the area now called the "Carmel Riviera." One entry reads as follows:

> "60. May 22 - 23. Chas. Jones brings me in 2 rocks – and one on 23rd – taken about 3 miles out of slightly south of Pt. Joe at between 60-70 fathoms (300-400 ft.), rocks catching on [fishermen's set-line] hooks. 10 specimens (one white) mostly the same apparently."

The chitons from these rocks are of unusual interest as there are possibly two or more new species among them, illustrating the value of getting the cooperation of friendly fishermen.

Here is another interesting entry:

> "23. Sat. Jan. 25 – Tide, -0.8 and plenty low. Do not have much time so go just inside gate of lighthouse reservation. WOW – find one black specimen with white stripe

down back, slightly mottled. [possibly a color phase of Ischnochiton radians]; 7 Callistochiton palmulatus and mirabilis; 4 Placiphorella velata; 2 Mopalia ciliata; several nice Lepidozona mertensi, including one deep purple [color phase]; a couple of Ischnochiton regularis; several Stenoplax heathiana; Nuttallina californica all over rocks; and 1 blue Ischnochiton radians (deep blue). — Weather threatening but ocean not rough."

Mack finally lost interest in collecting and turned over his entire collection, mostly all still preserved wet, to the California Academy of Sciences on 5 July, 1947. They could not be worked on immediately for lack of time, but in March 1948 all specimens (a few had dried up) were washed for several days in running water to leach out the formalin and then transferred to alcohol. In spite of the unfortunate effect of the formalin, many specimens are still in good condition and have been placed in the collection of the Department of Invertebrate Zoology at the Academy where they are available, along with the collecting notes, for subsequent reference and research.

California Brown Cowrie in Central California

BY

ALLYN G. SMITH

California Academy of Sciences, San Francisco 18, California

Mr. Robert P. Sikora, University of California Zoology student supplies information to the effect that the California Brown Cowry (Cypraea spadicea Swainson) was taken alive in the summer of 1961 by members of the Marin Skin Divers Club. According to the report, about 20 specimens were collected with SCUBA equipment in a depth of 80 feet on a rock off Cypress Point, Monterey County, California. One of these specimens, measuring 57.7 mm. in length, 35.8 mm. in width, and 29.3 mm. in height, has been placed in the collection of the California Academy of Sciences through the generosity of Mr. Al. Giddings, a member of the Marin Club. This specimen is a rather light-colored one and is normal in all respects.

The finding of this cowry alive in an area considerably to the north of its published range is notable. It confirms an old record of a living specimen found at Pacific Grove in 1910 or thereabouts by Nettie (Mrs. Charles S.) Fackenthall, which has been cited several times in the literature. The location of this particular shell, formerly in Mrs. Fackenthall's collection, is now not known.

Arion ater (LINNAEUS) in California

BY

ALLYN G. SMITH

California Academy of Sciences, San Francisco 18, California

The large, black European slug, Arion ater (Linnaeus), has so far been reported from the West Coast only in Washington and Oregon. It now becomes an unfortunate duty to record that this garden pest has reached California.

California specimens were collected by field men of the Del Norte County Department of Agriculture in nurseries in Crescent City and vicinity, and inland five miles northwest of Gasquet, Del Norte County.

They were forwarded to the California Academy of Sciences for identification by Mr. L. J. Garrett, Agricultural Commissioner of Del Norte County, whose vigilance in the apparently early discovery of this new and potentially injurious agricultural and garden pest is to be commended. One can only hope that the Del Norte County infestation can be eradicated before the species spreads farther south in the State.

Arion ater reaches an expanded length of 4.5 to 5 inches. It may be recognized rather easily by the rugose mantle and the coarse, elongated tubercles over the back and sides of the body. Like other Arions and the greenhouse slug [Milax gagates (Draparnaud)], it contracts into a semicircular shape when inactive or disturbed. An excellent figure may be found in Pilsbry (1948, p. 668, fig. 365). There are several color phases, the most prevalent being black or brownish.

My first collecting experience with this species was on October 9 and 10, 1943, in the garden of Mr. Linsley W. Ross, 12223 Eighth Avenue, Seattle NW, when a total of 19 were taken in moist to rainy weather conditions. Many more were crawling among garden plants. There were two color phases:

1. Back and mantle reddish-brown. Foot-fringe a brilliant terra-cotta, crossed by alternate thin black lines and wider black stripes. Occasional dark blotches on the mantle occurred on some specimens of this lighter colored phase. Sole light colored.
2. Back and mantle dark chocolate brown. Mantle with occasional small, variable-sized, black blotches but not prominent enough to take away from the generally dark, unicolored aspect. Foot-fringe not differently colored from the back, with the same type of black striping described for the lighter phase. Striping of the foot-fringe extends around and under the sole for 2 or 3 mm. on some specimens. Sole slate colored.

These colors fade out almost entirely after specimens have been preserved in alcohol for a day or so. Mr. Ross stated he first recognized this large slug as a garden pest in Seattle about 1940 because of its depredations on bearded iris and succulents.

Pilsbry (1948, p. 670) includes an occurrence of Arion ater in Portland, Oregon, in 1946 (B. G. Thompson, July 9, 1946).

Methods & Techniques

Notes on Cleaning Mollusks

BY

ALLYN G. SMITH

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After reviewing recently the excellent suggestions contained in the Second Edition of the AMU's "How to Collect Shells", it occurred to me to record several cleaning methods that have been used successfully at the California Academy of Sciences that may be helpful to some shell collectors.

1. There is on the market a supersonic device with the trade name "Sonblaster". While rather expensive (it costs around $120.- for the unit), it is the only equipment used so far that will clean many kinds of shells. The container is filled with water, which is agitated by a power unit transmitting high-frequency sound waves. The power is adjustable. Hands or fingers are not affected except for a slight tingling sensation. For larger shells we merely dip the shell to be cleaned into the agitated water several times with the result that all loose dirt and detritus is literally shaken off, falling to the bottom of the container in a cloud. Tiny shells we place in a small water-filled glass tube and dip this in and out several times. The method is especially fast and efficient for cleaning shells with a heavy periostracum which one wishes to preserve intact; it is excellent for cleaning the girdles of chitons, especially Mopalias and others with hairy or spiculose decoration; and it does a beautiful job on the sutures of small land species like Vertigo and Gastrocopta as well as "cleaning their teeth" if they have any within the apertures. For more solid, heavy shells, full power is needed, but for more delicate specimens reduced power is recommended to prevent shattering. (Incidentally, this equipment cleans eyeglasses and all sorts of small parts and gadgets, being an excellent remover of grease as well as of dirt.)

2. Leslie Hubricht's method (p. 77) of preserving slugs by anesthetizing and killing in water with five to ten percent chloretone in solution also works well with some marine species before final preservation. This is even better than the old method of "killing by drowning" in fresh water, which has been used on specimens of Onchidella with fully expanded specimens as a result. This same method also works well on Velutina and Lamellaria when the shell is to be preserved with the fully expanded animal.

3. A strong household bleach is a useful cleaning agent, if used judiciously. I have found that cleaning freshwater mollusks, such as Goniobasis, Fluminicola, Amnicola, and Hydrobia with a bleach used at full strength for one or two minutes only will remove all adhering algal or other extraneous detritus, leaving clean, bright, shining shells that are a credit to any collection. Leaving in strong bleach too long, however, will remove the periostracum, an undesirable result unless there is good reason for removing it purposely to expose the outer shell layer. Preliminary trial to determine just how long to leave specimens in the bleach solution is recommended. Unfortunately, this method will not work on old, long-dried-out freshwater specimens; it is effective only on shells fairly recently collected. Killing in alcohol prior to cleaning with bleach seems not to inhibit this cleaning process.

Information Desk

What's the Difference?

Holotype - Paratype - Syntype - Hypotype

BY

R. STOHLER

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In the 200 years that have passed since the first species of plants and animals were described by Linnaeus, a great many designations for type material have been invented. Some of these refer to what may be classed as "primary" types while others are concerned with "secondary" types.

Primary type material would include all the specimens which were used by the original author in preparing his original description. Secondary type material, on the other hand, would encompass those specimens which were used by other authors—and, of course, possibly even by the original author at a subsequent date—to either amplify or emend the original description, or to replace the original type specimen(s) if lost or destroyed. To the first group should be counted the holotype, the paratype(s), the syntype(s), and, under certain circumstances, the hypotype(s), while the second includes the neotype(s), the lectotype(s), and others.

The holotype is defined as the single specimen taken as "THE TYPE" by the original author of a species or subspecies. The paratype is a specimen or one of several specimens which were used by the original author as the basis of a new species or subspecies, in addition to the holotype. A syntype is one of several specimens of equal rank used in the original description without, however, being singled out as "holotype"; the word "cotype" is, fundamentally, a synonym of syntype; it is no longer used. A hypotype, finally, is a described, listed or figured specimen whether or not it is included in the discussion of the new taxon.

Early authors were rather lax in their attitude toward type specimens. It was not an uncommon practice to replace the original type specimen with a better "type" specimen, when it became available. Also, it was a fairly frequent practice for a museum to exchange type material, retaining one or two specimens of a given species. Today, when we are aware of the many difficulties attendant upon inadequate documentation, there is no excuse for less than the utmost care in selecting and preserving type specimens. This is true even where a species may have been found to be invalid for one of several possible reasons. However, the discovery of the so-called sibling species has added further strength to the need for care. Sibling-species are morphologically identical with each other, or at least so nearly so that even fairly careful examination does not reveal the fact that they are different species; yet sibling-species are reproductively isolated in spite of the great similarity of the adult individuals. Often, too, sibling-species may occur in the same locality and it is not impossible that they might even occupy the same habitat. From this it becomes evident that the conscientious taxonomist must base his description of a new taxon upon a single specimen—the holotype. This specimen thus becomes actually the name-bearer. No matter what discoveries may be made at a later time, the holotype remains the ultimate authority regarding that particular species and its name. It is not impossible that even with great care exercised in the examination of the type population, a sibling species might be inadvertently drawn in and included in the description. Later students will have the task of separating out the specimens which belong to the one, the original species, and the specimens properly assigned to the sibling-species. If the original author did not select a "holotype", there would be uncertainty as to which is the original species and which is the sibling-species, which latter must, of course, be given a different name.

There seems to be a growing trend to include as part of the description of a new species as full an appraisal as possible of the variability in the original population. This is actually most desirable, although not always possible. All specimens from this particular population become paratypes, except for the one select specimen, the holotype. The paratypes, as pointed out above, may, however, include specimens of a different species. But this possibility is more or less implied by the very fact that these specimens are designated as paratypes. Sometimes it is possible for an author to include in his appraisal of the variability of the new species material other than the original group collected at the type locality. Many authors call such specimens also paratypes. This is, to our way of thinking, unfortunate since it does not clearly distinguish between the non-holotype specimens from the type locality and the non-holotype specimens from other places. Since it is possible that paratypes encompass sibling-species—and we refer here to paratypes from the type locality—it is even more probable that specimens from other localities may include sibling-species. Therefore, it seems only fitting that such subordinate "paratypes" be clearly distinguished in the original description. The term "hypotype" seems to fit the requirements well. And there seems to be no ruling by the International Commission on Zoological Nomenclature against this use of the term which allows a clear separation of specimens with different probabilities of uncertainty as to proper identity. If there is nothing more to recommend this differentiation than the fact that it may be of assistance to future workers, we think it sufficient justification to use the term "hypotype" in this sense. The definition of the paratype would then necessarily include the specification that it must come from the type locality while the hypotype does not.

Books, Periodicals, Pamphlets

THE GIANT AFRICAN SNAIL— A PROBLEM IN ECONOMIC MALACOLOGY

by Albert R. Mead
Professor of Zoology
University of Arizona

University of Chicago Press. 257 pp.,
15 photographic illustr. November 28,
1961. $7.50.

This book is unique. It is the only one of any scope dealing with the growing economic problems caused by land snails in general, and by the Giant African Snail in particular. There are good and timely reasons for such a reference work, which is the first in any language assembling knowledge of the economic effect of land mollusks, both snails and slugs. For this field of biological study, the author uses the term "Economic Malacology".

The Giant African Snail is a growing menace to be reckoned with. This five to six inch monster, while not a champion for size among land snails, is an "exceedingly hardy, tenacious, variable and adaptable molluscan pest with a high reproductive potential and remarkably few natural enemies". Once started it is practically impossible to eradicate, and most man-devised methods for its control have not met with any signal success. The spread of this snail pest during World War II, including its build-up on the Hawaiian Islands, its fantastic ability to reproduce causing population explosions in the species, and its consequent depredations resulting from its omnivorous food habits all have served to create a "Giant African Snail Problem" of primary importance to the world.

Much has been written about the Giant African Snail in the world press and in scientific and agricultural journals. In recent years it has been the subject of considerable research and has led to the expenditure of much money to determine its present and potential economic danger and to develop successful means of control. Mead brings all of this scattered information together in organized form. This is a task for which he alone is preeminently qualified, having been personally associated with the Giant African Snail Problem for more than ten years. He has traveled many thousands of miles to gather firsthand data, has investigated the possible use of the snail as a food for people and animals, and is now studying a means of control by infecting it with a specific virus disease.

The book opens with a well-documented chapter on the present wide dispersal of the Giant African Snail, mainly by man, from its original home in East Africa. It continues with chapters on the factors favoring dispersal and survival, on its economic status as an agricultural pest, and on the various methods of control—chemical, mechanical, biological, legislative, and last, but by no means least, its control through human use as a possible food for poultry and livestock. There is an exceedingly interesting chapter on the phenomenon of decline following population explosion, the causes of which are not thoroughly understood and which could well be a subject for future intensive biological investigation leading, perhaps, to more effective control measures. The bibliography at the end of the book is a veritable gold mine of source information, covering over 40 pages, including 563 author listings and 881 separate titles.

Mead's work serves to bring into full focus the various attempts to control other snail and slug pests, with their successes and more frequent failures, together with the dangers inherent in approaching control problems without sound scientific research by qualified experts to determine the possible future effects of the means used. The fact that the State of California alone has spent over half a million dollars to date on the unsuccessful eradication of three exotic snail species points to the importance of the whole snail pest problem and its potential effect on man's future food supply.

This book is highly recommended as required reading for all workers in the field of economic entomology and other types of agricultural pest control. Conchologists and malacologists interested in this very practical side of their special field will welcome it as an important contribution. In fact, all zoologists and biologists interested in the broad ecological and other problems created by the introduction of exotic species as exemplified by the lesson provided by the Giant African Snail will find it a source of valuable information and ideas.

AGS

FOUR SPECIES OF CHITONS FROM THE PANAMIC PROVINCE (MOLLUSCA: POLYPLACOPHORA)

by Allyn G. Smith

Proc. Calif. Acad. Sci., Fourth Ser.,
Vol. 30, No. 4, pp. 81-90, pls. 8-9.
August 31, 1961.

Four species of chitons, two of which are described as new, are discussed in this paper. Three are from western Mexico, one from Panama. The species are: *Nuttallina crossata* Berry (= *N. mexicana* Pilsbry in Pilsbry and Lowe), *Chaetopleura* (*Pallochiton*) *euryplex* Berry (= *C. raripustulosa* Pilsbry in Pilsbry and Lowe), *Ischnochiton colimensis* A. G. Smith, new species (= *I. lowei* Pilsbry in Pilsbry and Lowe), and *Acanthochitona tabogensis* A. G. Smith, new species (= *A. panamensis* Pilsbry in Pilsbry and Lowe). This work adequately disposes of the four *nomina nuda* of Pilsbry, 1932. The discussions include the known occurrences of the species and a comparison of them with similar forms. The four species are beautifully illustrated in color on two plates.

LGH

LARGE TEREBRAS (MOLLUSCA) FROM THE EASTERN PACIFIC

by G Dallas Hanna and Leo G. Hertlein
California Academy of Sciences

Proc. Calif. Acad. Sci., Fourth Ser.,
Vol. 30, No. 3, pp. 67-80, Pls. 6-7.
August 31, 1961.

This important paper brings the taxonomy of the larger Terebras of the West Coast up-to-date and is a valuable addition to our knowledge of the family Terebridae. Five species are discussed in detail with a thoroughness for which the authors are noted. These are:

T. lingualis Hinds: Upper Gulf of California to northern Ecuador, in 13-110 m. (7-60 fms.).

T. ornata Gray: Gulf of California (Santa Margarita Island to Puerto Peñasco) south to Panama and the Galapagos Islands, in 9-143 m. (5-80 fms.).

T. robusta Hinds: Guaymas, Mexico, to Rio Esmeralda, Ecuador, and the Galapagos Islands, in 7-33 m. (8-14 fms.).

T. strigata Sowerby: Gulf of California (Magdalena Bay to Puerto Escondido) and south to Paita, Peru; Socorro Island; Galapagos Islands; in 18-22 m. (10-12 fms.) and perhaps deeper.

T. dumbauldi, n. sp.: Type locality: Panama.

Included is a key to these species, which will be useful in identification, together with a list of Terebras that have at times been referred to the foregoing species.

Outstanding features are the two three-color-process plates illustrating each species. These are the work of Dr. and Mrs. Hanna, with printing done in the California Academy's Shop. These plates exemplify the great advantage of the use of color illustrations for scientific work.

AGS

CONTRIBUTIÓN A UN CATÁLOGO DE LOS MOLOSCOS GASTERÓPODOS CHILENOS DE AGUA DULCE

by J. Stuardo

Gayana-Zoologia, No. 1, pp. 1-32, text-figs. (distributional maps) 1-5, 10 drawings of shells. 1960.

Gayana is a new publication by the Instituto Central de Biología, Universidad de Conceptión, Casilla 301, Conceptión, Chile, of which the director is Hugo Barrales. There are two departments: Botany, headed by Mario Ricardi; and Zoology, headed by José Stuardo. The publication (in Spanish) is named for Claudio Gay (1800-1873), "eminente Naturalista Francés y Ciudadano Honorario de Chile", whose portrait appears in the frontispiece.

The present paper is a welcome contribution, bringing together scattered information on the ranges of Chilean freshwater gastropods in the form of a catalogue of species with references to the original publication of each species name. This fills a distinct need, for, as Stuardo points out, there are no existing lists of Chilean land or freshwater mollusks. Two lists dealing with marine mollusks of the area are cited: one by Dall (1910, Report on a collection of shells from Peru, Proc. U. S. Nat. Mus., vol. 37); the other by Carcelles and Williamson (1951, Catálogo de los moluscos marinos de la Provincia Magellánica, Rev. Inst. Nat. Inv. Ciencias Naturales, Zool., vol. 2, no. 5). Now, there is a need for distributional catalogues of land gastropods and freshwater pelecypods, as well as a complete list of Chilean marine mollusks, which Gayana hopes to supply.

AGS

GASTROPODIA

Vol. 1, Nos. 4-5. Dr. Glenn R. Webb, Ed. (Route 3, Box 361, Conway, South Carolina). Issued November 27, 1961.

Contains the following articles by Dr. Webb:

"Studies on the Sexology and Development of the Genitalia of Glyptostoma gabrielense Pilsbry" (pp. 29-30).

"The Phylogeny of American Land Snails with Emphasis on the Polygridae, Arionidae, and Ammonitellidae" (pp. 31-52, pls. 15-23). To be continued.

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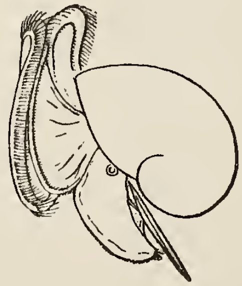

THE VELIGER is open to original papers pertaining to any problem concerned with mollusks from the Pacific Region.

This is meant to make facilities available for publication of articles from a wide field of endeavor. Papers dealing with ecological, morphological, anatomical, physiological, distributional, taxonomic, etc. aspects of marine, fresh water or terrestial mollusks from any region bordering on or situated within the Pacific Ocean, will be considered. Even topics only indirectly concerned with mollusks may be acceptable.

It is the editorial policy to preserve the individualistic writing style of the author; therefore any editorial changes in a manuscript will be submitted to the author for his approval, before going to press.

Short articles containing descriptions of new species or lesser taxa will be given preferential treatment in the speed of publication provided that arrangements have been made by the author for depositing the holotype with a recognized public Museum. Museum numbers of the type specimens must be included in the manuscript. Type localities must be defined as accurately as possible, with geographical longitudes and latitudes added.

Short original papers, not exceeding 500 words, will be published in the column "NOTES & NEWS"; in this column will also appear notices of meetings of the American Malacological Union, as well as news items which are deemed of interest to our subscribers in general. Articles on "METHODS & TECHNIQUES" will be considered for publication in another column, provided that the information is complete and techniques and methods are capable of duplication by anyone carefully following the description given. Such articles should be mainly original and deal with collecting, preparing, maintaining, studying, photographing, etc., of mollusks or other invertebrates. A third column, entitled "INFORMATION DESK," will contain articles dealing with any problem pertaining to collecting, identifying, etc., in short, problems encountered by our readers. In contrast to other contributions, articles in this column do not necessarily contain new and original materials. Questions to the editor, which can be answered in this column, are invited. The column "BOOKS, PERIODICALS, PAMPHLETS" will attempt to bring reviews of new publications to the attention of our readers. Also, new timely articles may be listed by title only, if this is deemed expedient.

Manuscripts should be typed in final form on a high grade white paper , 8½" by 11", double spaced and accompanied by a carbon copy.

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